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TO BE CONSUMED WITHOUT MODERATION

A trans-disciplinary approach to drinking, senses and belongingness in Late Bronze Age Mesopotamia through the analysis of ancient organic residues

Elsa Perruchini

BA,
MRes in Cultural Heritage Materials and Archaeometry, University of Bordeaux-Montaigne

Submitted in fulfilment of the requirements for the Degree of PhD in Archaeology

Archaeology
School of Humanities
College of Arts
University of Glasgow

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Abstract

The consumption of alcoholic beverages is a multi-sensorial experience which was in many past societies a fundamental part of everyday life as well as integral to ritual practices. And yet, this topic has been understudied in Archaeology, although the study of alcohol in ancient Mesopotamia has been slowly gaining in popularity over the last two decades, with an emphasis on the capacity of alcohol access to create power and status differences.

Advances in the field of archaeological organic residue analysis over the past three decades have particularly become crucial to obtain significant additional data and information, unreachable through texts and iconography. Yet, to date the analysis of residue remains of alcohol recovered in ancient ceramic vessels have been restricted to a small number of cases related to alcohol production rather than its consumption due mainly to the current lack of a secure approach that allows the identification of alcoholic beverages in a consumption context.

This thesis aims to distance itself from the common view of beverages as a social distinction tool by reflecting on the sensory and emotional experiences of social drinking based on strong archaeological evidence to create new narratives on social-cultural identity, sense of belonging, and community building in the Late Bronze Age (ca. 1500-1100 BCE) site of Khani Masi, located in the Upper Diyala region of Iraq.

In order to be able to recreate elements of the sensory experience of social drinking at Khani Masi, the first aim was to formulate a new multi-disciplinary approach consisting of combining ancient texts, iconography, contextual archaeology and a refined organic residue analysis protocol that allowed us to identify confidently alcoholic beverages in drinking vessels. The results not only highlighted the strong preference for beer but also unveiled information on the ingredients incorporated in its production as well as the practices, paraphernalia and social contexts of its consumption. Based on these results, this study establishes that the highly sensual experience of social drinking at Khani Masi would have inculcated and reinforced a sense of community, accentuated by the communal activity of sharing this experience with other people in a same space.

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List of Accompanying Material

Doi : 10.5525/gla.researchdata.875
Url : dx.doi.org/10.5525/gla.researchdata.875

The dataset consists of:

A. A folder that contains my results presented and summarized using excel sheets (.xlsx):
Table 1 - Table of compounds with important information regarding each compound identified in my samples
Tables 2 - Summary of analysis results tables presenting the presence or absence of compounds in each archaeological samples and control samples
Tables 3 - Compounds quantification tables

B. A folder that contains the raw data of my thesis:
The data obtained on the Shimadzu MS can be opened using GCMSsolution Postrun Software.
The data obtained on the Agilent FID can be opened using Agilent ChemStation Software.
The data obtained on the Agilent MS can be opened using Agilent MassHunter Workstation Postrun Software.

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Finally, I am so grateful to my significant other, Narimane Dorey, for her love and support. Thank you for giving me strength and keeping me grounded every day.

Author's declaration

I declare that, except where explicit reference is made to the contribution of others, that this dissertation is the result of my own work and has not been submitted for any other degree at the University of Glasgow or any other institution.

Elsa Perruchini

List of Abbreviations

BCE: Before the Common Era

CE: Common Era

CDLI: Cuneiform Digital Library Initiative (https://cdli.ucla.edu/)

OIP: Oriental Institute Publications

CUSAS: Cornell University Studies in Assyriology and Sumerology

Hh Ḫar-ra = ḫubullu : Lexical List

ORA: Organic Residue Analysis

NIST: National Institute of Standards and Technology

TLE: Total Lipid Extract

DCM: Solvent dichloromethane

GC-MS: Gas chromatography-Mass spectrometry

GC-FID: Gas chromatography – Flame Ionization Detector

GC-IRMS: Gas chromatography - Isotope ratio mass spectrometry

1 Introduction: I Drink, Therefore I Am

1.1 Research topic

This thesis seeks to create and present a new multi-disciplinary approach to investigate beverages and drinking practices in Late Bronze Age Mesopotamia and examine their potential in strengthening social bonds and fostering community identity. This approach consists of combining organic residue analysis (ORA) with ancient texts, iconography, and contextual archaeological information to determine beverage preferences and to recreate certain elements of the sensory and emotional experiences of social drinking, and the sense of belonging they evoke.

The subject of food and foodways has long been a topic central to social sciences. Since the 19th century, anthropologists and ethnologists have established that food has a social significance and the study of foodways could bring new insights on socio-economic organisation and cultural identity in modern and ancient societies (e.g. Goody, 1982; Fischler, 1988; Dietler, 1990; Goody and Goody, 1995; Wood, 1995). However, it is more recently, in the late 20th century, that the symbolic meaning of food really entered the archaeological discourse (Hastorf, 2016c). New analytical methods have been particularly instrumental in the development of the field of study. The application of archaeological sciences and the increasing number of techniques and methods that can be applied to archaeological materials have enabled archaeologists to obtain significant additional data and information about food from the past and gain new insights on its social significance. Particularly relevant to this study, direct evidence of food, such as residue remains in ancient vessels, can be analysed today in multiple ways using increasingly efficient methods and high-performance techniques such as Gas- and Liquid-chromatography.

Yet, despite all these great advancements, archaeological research tends to focus on certain aspects of food in the past and to disregard others.
Firstly, while a growing number of studies today seek go beyond diet and provisioning to investigate, among other things, the role of food in the formation and development of early economies and social organization (Twiss, 2012a), the

majority of archaeological studies addressing the subject of food concentrate on the access to food resources. Notably, advances in the field of archaeological organic residue analysis over the past three decades have opened up new ways of exploring ancient diet and the development of subsistence practices, such as dairying (Dunne *et al.*, 2012; Nieuwenhuyse *et al.*, 2015).

Secondly, not every food item is treated equally. Compared to dairy products, alcoholic beverages have been understudied in archaeology primarily due to the difficulty of identifying alcoholic beverages in the archaeological record, especially in a consumption context. To date, organic residue approaches to alcoholic beverages have been restricted to a small number of cases in very specific circumstances where compounds in storage and production vessels presented a high degree of preservation (e.g. Michel, McGovern and Badler, 1993; Otto, 2012). For instance, low-oxygen and/or low-humidity conditions have been established to provide the best conditions for ancient organic preservation (McGovern and Hall, 2015: 594). Furthermore, cooking and storage vessels are more likely to preserve higher quantities of organic material than consumption vessels as the content tends to sit longer in production vessels. Consequently, archaeological studies tend to focus on the material record of food storage and production. By contrast, evidence of consumption settings and practices are still scarce as they are challenging to identify archaeologically (Hastorf, 2016b: 135) and difficult to correlate with the ethnographic data (Dietler and Herbich, 2006: 395). And yet, the identification of the contents of consumption and serving equipment is crucial for the reconstruction of daily and more exceptional consumption practices as well as the social and cultural communities that were shaped by the choice of a particular beverage (over alternatives) and its combination with specific consumption equipment. It is particularly true with regards to alcoholic beverages, for which a secure approach that allows the identification of alcohol in consumption vessels and vessels not directly associated with the production process is currently lacking. In order to investigate residues found in consumption vessels, we need to establish a rigorous organic residue protocol allowing us to identify securely the contents, the type of consumption vessel and the context in which food was consumed. While, this issue so far has remained challenging, this thesis presents a new organic residue approach enabling us to answer those questions.

Finally, archaeological studies – for the most part - have disregarded the fact that eating and drinking are, first and foremost, sociable, sensorial and emotional experiences (Hamilakis, 1998; 2011: 208; Hamilakis and Sherratt, 2012; Hamilakis, 2014; Hastorf, 2016c). Sensory experiences are often seen as too ephemeral and subjective, and the intangibility of senses and emotions is seen as incompatible with the concrete material world of archaeology. However, in the last decade, scholars have slowly started to reassess the potential of a sensuous archaeology. Hamilakis has argued that "sensory experience is material, it requires materiality in order to be activated" (Hamilakis, 2011: 209). This material evidence can be archaeologically uncovered and analysed, allowing us to reflect, for instance, on the taste, aroma, texture and colour of food, and to try to translate the emotions and memories they could evoke in the individual that lived in the past. The exploration of the multi-sensuous dimensions of food and drink consumption through the narrative interpretations of concrete data aims to open new discussions and expand the horizons of archaeology. By looking at the sensual and emotional aspects of food, we can "complete an archaeology of human experience" (Hastorf, 2016a: 5).

In this thesis, I argue that by distancing ourselves from the common ways of exploring food and drink as social distinction tools in the past, and by reflecting on the sensory aspects of drinking based on strong archaeological evidence, we can create new narratives on social organisation, cultural traditions and identities in ancient societies.

1.2 Research questions and aims

1.1.1 Research questions

In order to unlock these key aims, I developed a set of research questions to provide a path through my research and writing process:

Research question 1 - How can organic residue analysis provide new insights on vessels and practices used in the consumption of food and drink?
Research question 2 - What evidence is needed to allow us to recreate the sensorial experience of social drinking in the past?

Research question 3 – How can a focus on sensorial experiences contribute to our understanding of ancient social organisation and community identity?

1.1.2 **Research aims**

This thesis uses chemical analysis of residues in ancient vessels in combination with textual and iconographic evidence and comparative data from other archaeological sites to achieve two central aims, one methodological and one interpretive/theoretical:

1) In order to be able to recreate parts of the sensory experience of drinking, it formulates a new organic residue analysis methodology enabling the secure identification of alcoholic beverages in consumption vessels through the use of Gas chromatography. My choice of analytical methodology was guided by two main factors. First, I lacked any indication of what could be the contents of the vessels; thus we opted for Gas chromatography because it allows for a large range of compounds to be separated and identified. Secondly, Gas chromatography has been presented as an efficient and reliable method and has become a valuable part of the archaeological toolkit since the 70's (Heron and Evershed, 1993; Reber, 2014; Roffet-Salque *et al.*, 2017). However, a major concern in the use of Gas chromatography in archaeology is the high potential of archaeological samples to be contaminated and the difficulty to discern archaeologically significant compounds from contamination (Steele, 2013).

In order to address these challenges, I developed a novel, field-based sampling strategy that minimises sample contamination from excavation and post-excavation handling and enables a straightforward distinction to be made between archaeologically significant chemical compounds and others likely presenting contamination. The secondary methodological aim was to present more grounded ingredients identification by analysing authentic material of additives and beverages that we know were used in ancient times from textual and iconographic evidence, as well as faunal and ethnobotanical remains.

2) A second aim was to gain insights into aspects of the sensory and emotional experience of drinking alcohol in the past based on these results of scientific analyses. As such, my study responds to the call for new ways of exploring the meanings of food in ancient times (Hurcombe, 2007), in particular alcohol consumption. This study aims to expand the horizons of archaeology, discussing

and evaluating how a broader spectrum of human sensory experiences as they appear through taste, smell, sight, hearing, and touch can be understood through the materiality of the past and can bring new insights on social identity and organisation. To achieve this, I draw on anthropological and ethnographic studies, psychology and research on the biological/physiological effects of alcohol consumption on the body.

The central case study for both methodological innovation and interpretive exploration in this study is the Late Bronze Age (ca. 1500-1100 BCE) (**Figure 1.1**) site of Khani Masi (SRP 46), located in the Upper Diyala Region of Iraq (**Figure 1.2**). Here, a magnetic gradiometer survey in 2014 revealed the presence of a monumental structure comprising a series of large rooms, as well as the presence of another large, albeit smaller, trapezoidal structure to the northwest of the monumental compound (Glatz *et al.*, 2019). A program of large-scale excavations was initiated in the summer of 2016 and is still ongoing today. The data for this study derives from the monumental complex, where a large collection of morphologically diverse drinking cups and goblets was discovered, suggesting a combination of ritual activities and commensal feasting. This study, therefore, presents a significant advance in our understanding of ancient Near Eastern drinking practices and socio-cultural identity in the Middle Babylonian Period (ca. 1500-1150 BCE), in particular the Late Kassite period (ca. 1350-1150 BCE) (Glatz *et al.*, 2019). This is a period crucial in Mesopotamia's history, but a scarcity of textual and iconographic sources and systematic excavations has resulted in the Kassite social organization and cultural practices to remain woefully understudied.

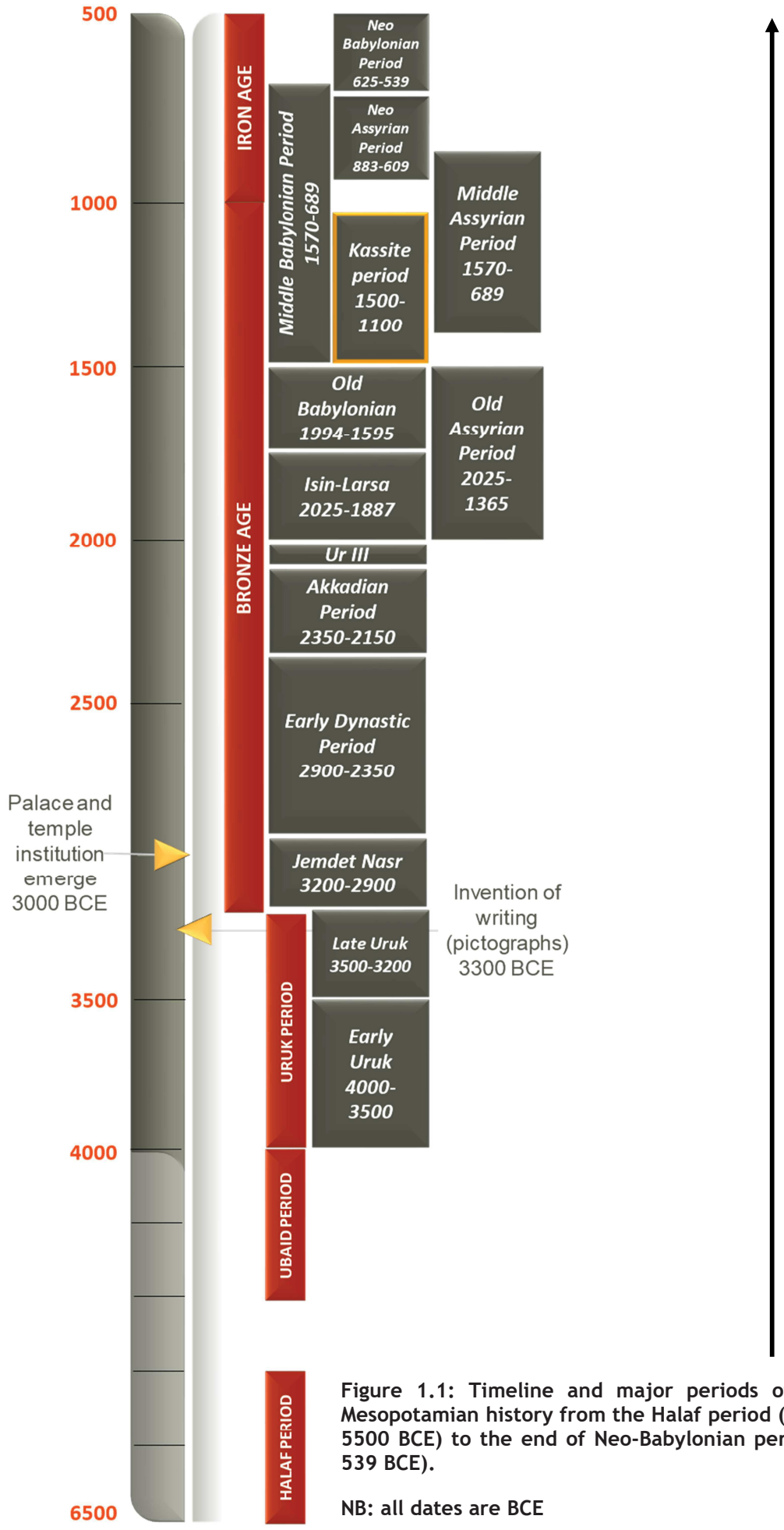

Figure 1.1: Timeline and major periods of ancient Mesopotamian history from the Halaf period (ca. 6500-5500 BCE) to the end of Neo-Babylonian period (625-539 BCE).

NB: all dates are BCE

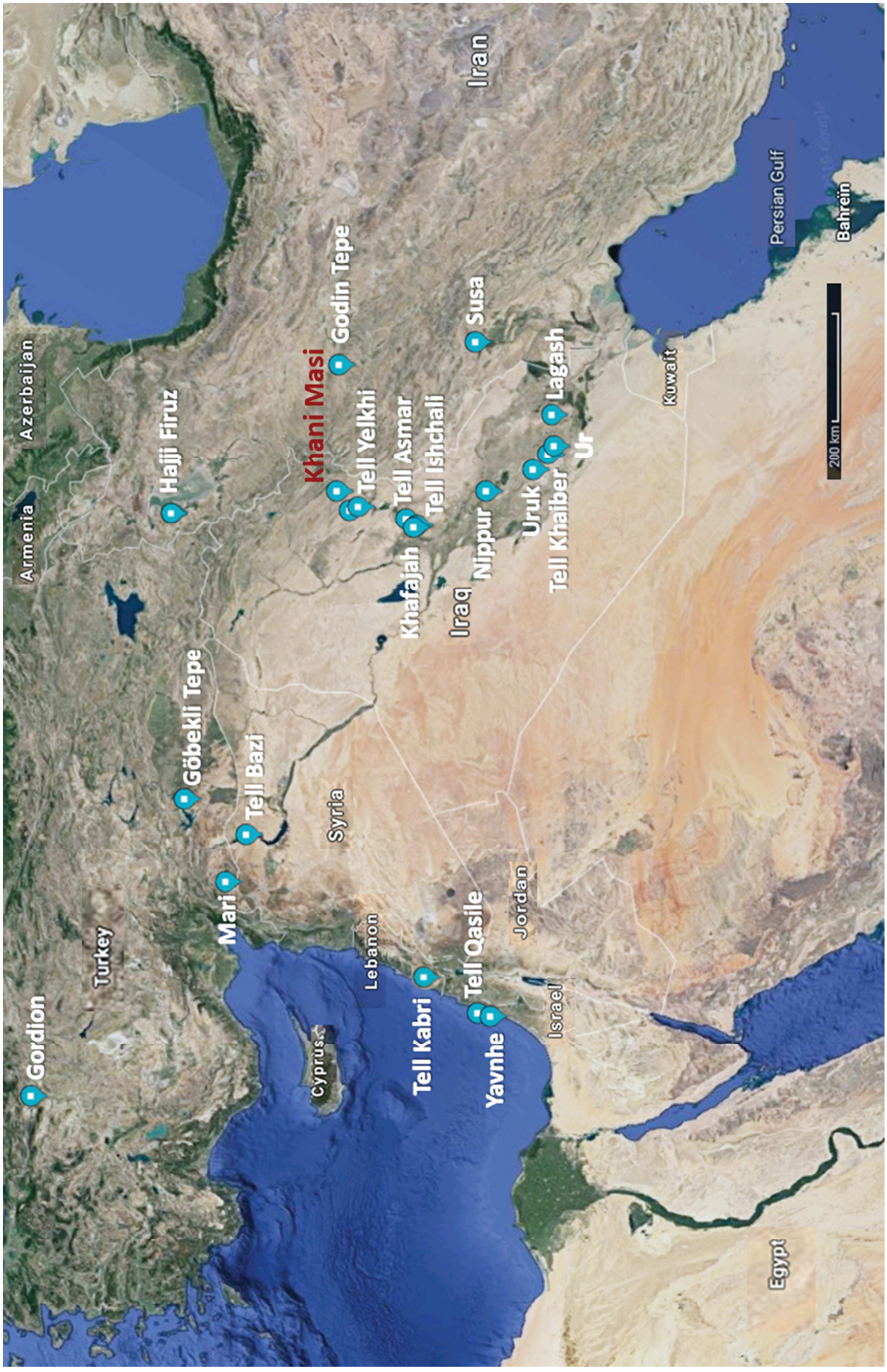

Figure 1.2: Map of Mesopotamia (corresponding to modern Iraq, southeast Turkey, southwest Iran, northeastern Syria and Kuwait) and surrounding regions, showing the location of the main sites mentioned in the text (Khani Masi in red).

1.3 Overview of the structure of the thesis

This thesis is divided into seven chapters and is structured in the following way. **Chapter 1**, the Introduction, establishes the topic and purpose of my research and offers a brief summary of the relevant research/literature to demonstrate the need for this particular type of research and its timeliness. It also defines the key aims and objectives and the research questions that I will address as well as the methodological and conceptual contributions and limits of my research.

Chapter 2 provides a review of the literature relating to the three foci of this study: scientific approaches allowing us to identify food in archaeology (e.g. archaeobotanical, zooarchaeological and organic residue evidence), human senses and social drinking. **Section 2.1** considers how food has been approached so far in archaeology with an emphasis on the contribution of archaeological sciences. **Section 2.2** highlights the key concepts and subjects that have been touched upon so far when looking at food in archaeology. I also review subjects that have been rarely explored in archaeology in this context, that I wish to investigate in this thesis, such as the sensory experience of eating and drinking (**Section 2.3**), particularly those associated with alcoholic beverages (**Section 2.4**).

Over the last two decades, the topic of beverage consumption has become a burgeoning field of research and inquiry in the study of social complexity in the ancient Near East, largely studied through the use of textual and iconographic evidence, and less so through material culture. **Chapter 3** gives an overview of what we know so far of alcoholic beverages in Mesopotamia and the wider Near East, i.e. beer (**Section 3.1**) and fruit wines (**Section 3.2**). It also highlights the limits and gaps in our current knowledge. In a nutshell, archaeological research so far has been focused mainly on identifying evidence of alcohol production. New archaeological research and approaches are crucially needed to investigate contexts of alcoholic beverages consumption in Mesopotamia and the sensory experience drinking can create.

This is what this thesis aims to achieve in the central case study presented in **Chapter 4**. It comprises a brief description of the site of Khani Masi (**Section 4.1**), particularly the ceramic assemblage and its archaeological contexts (**Section 4.1.4**). I then move to rationalising the decisions that I made in the course of the project on how to investigate these vessels' contents, through a discussion of theory and practice of organic residue analysis (ORA) in archaeology (**Section 4.2**). In particular, I focus on the limitations of previous approaches in ORA, thus drawing attention to *lacunae* which this thesis intends to explore and find solutions to (**Section 4.2.2.3**). This work improves the reliability of scientific results and provides a firmer empirical base for theorisation and interpretation.

Analytical results are presented in **Chapter 5**. This chapter offers a description of the ceramic assemblage analysed here, which includes a large number of different types of drinking vessels, other small vessels such as bowls and larger vessels used in production and storage. It also provides a summary of the results (presented in two tables in Appendix G) and an interpretation of the organic residue analysis of these vessels, in particular the beverages and their ingredients.

Chapter 6 discusses the results presented in the previous chapter: the beverage preferences (**Section 6.1**) and consumption practices (**Section 6.2**). The choices in practices and vessels involved in drink consumption, alongside the beverage itself, will have an impact on sociability and the overall sensorial experience. In the final section (**Section 6.3**), I will first explore the role of the five senses involved in the individual experiences of food and try to recreate certain details of the sensory experience of drinking at Khani Masi. I will also investigate how the sensual experience of consuming specific beverages at Khani Masi would have inculcated and reinforced a sense of community. Belongingness would have been further accentuated by the communal activity of sharing this experience with other people in a same space.

Finally, in the concluding **Chapter 7**, I present a brief synthesis of my study, returning to my research questions and reflecting on the original contributions, and promising areas for further and future research emerging from this study.

2 Beyond subsistence: a review of food-related studies in archaeology

Up until the 1980's, few scholars in the social sciences concerned themselves with food (Murcott, 1988; 2013; Mennell, Murcott and van Otterloo, 1993: 1–2). Those who did suggested that food reflects primarily geographical access as well as nutritional and biological needs (Harris, 1985). Over the past three decades, however, food has become an important area of research in sociology, ethnography, anthropology and archaeology (Murcott, 1988; 2013; Mennell, Murcott and van Otterloo, 1993: 5). Today, there is a consensus among scholars researching modern and past foodways that while nutrition is an important aspect of food choices, food has a profound symbolic and social significance and its study can bring new insights into socio-economic organisation and identity among modern and ancient societies (Dietler, 1990; Fischler, 1988; Goody, 1982; Goody and Goody, 1995; Wood, 1995).

In this chapter I provide a review of food-related studies in archaeology highlighting the key concepts relevant to this study as well as the main challenges and research gaps that still remain to be explored.

First, I will review archaeology's increasing and diversifying interest in food by examining and discussing current evidence and methods used in the identification of food in the archaeological record (**Section 2.1**). Particular emphasis is placed on the significant contribution of sciences to archaeology. This section illustrates the wide variety of new and not so new techniques from different fields that can identify evidence of food often invisible to the eyes, such as biomolecular analysis. However, this section also highlights the challenges faced by archaeologists wishing to explore food's place in ancient societies, in particular the greater difficulty inherent in approaching food consumption compared to production.

These challenges will have a direct impact on how the theme of food has been so far treated in archaeology; a point that I will develop in **section 2.2** in which I will discuss the development of the archaeological study of food from subsistence to the increase interest in implications that go well beyond diet such as the role food in social organization.

This chapter will also highlight the fact that archaeological research has neglected the abundant sensory dimensions of food. Yet, at the beginning of the twenty-first century, a growing body of works in archaeology is demonstrating the potential of the sensory and sensuous approaches to look at food consumption and production in order to create and enrich narratives about social and cultural identities in ancient times (**Section 2.3**).

Finally, compared to food, alcoholic beverages have been understudied in archaeology due mainly to the difficulty of identifying alcoholic beverages in the archaeological record particularly in a consumption context (**Section 2.4**). Yet, many communal activities involved the consumption of alcohol. The consumption of specific alcoholic beverages and the multi-sensorial and emotional experience created through the ingestion of these psychoactive substances may have had an impact on sociability and levels of social bonding.

2.1 Sources of information and challenges

In addition to ancient texts and iconography, food is a material artefact of human existence and significant quantities of archaeological evidence related to its production, distribution, consumption, and disposal are recovered and studied. More and more methodologies are employed to look at and interpret these pieces of evidence. Food remains and the methods used to identify them can give us a direct testimony of ancient diets and help us build new inquiries towards ancient people's lives.

2.1.1 The contribution and limits of textual and iconographic evidence

Available written sources provide us with diverse information on foodstuffs and their production as well as their distribution. Iconographic sources depict scenes of hunting, fishing, and rearing of livestock and agricultural activities but also provide insights into the social settings of food consumption and their participants, the materials and gestures involved. But despite the wealth of information given by these two types of sources, written documentation and iconography also present important limitations that need to be acknowledged. One primary issue is the difficulty of interpreting the exact meaning of many of

the linguistic terms and illustrations used. A second problem concerns the fact the depth of information may vary and it is often difficult to estimate who had access to these commodities as well as how and in which contexts certain food and drinks were consumed. Written documents and iconography do not always reflect the reality and do not cover all aspects of ancient lives but only those which have been deemed valuable to represent at that time. Scenes of everyday life food consumption are rarely depicted. Overall, these food representations and mentions tend to be: 1) agricultural scenes (e.g. Gouin, 2010), 2) food in state sponsored public religious ceremonies (e.g. Smith, Wharton and Olson, 2003: 247) and finally 3) food presented during elite banquets (e.g. Ermidoro, 2015), and feasts. Feast is generally defined by scholars as a "communal food consumption event that differs in some way from everyday practice" (Bray, 2003: 1; Brian Hayden and Villeneuve, 2011: 434; O'Connor, 2015; Twiss, 2015). It could include the use of special food (whether through the kind, quality, quantity or processing of food presented) (Hayden, 2001: 28) or a special event, not necessarily restricted to a ritual (in the sense of sacred) activity (Dietler, 2001: 65 and 67).

With little information about food given by imagery and textual evidence, professionals in the field need to refer themselves to other sources of information.

2.1.2 The contribution and limits of archaeometric approaches to food

In addition to ancient texts and iconography (e.g. Schmandt-Besserat, 2001), which offer an important source of information on food production and consumption, zooarchaeological (e.g. Greenfield, 2015) and archaeobotanical remains (e.g. Curtis, 2013; Hastorf, 1991), ceramics and lithics typology and use-wear (e.g. Dubreuil and Nadel, 2015), human and animal coprolites (fossilized feces) (Boenke, 2007; Søe *et al.*, 2018), human remains (bones/teeth) (e.g. Hastorf, 1991; Sealy, 2016; Warinner *et al.*, 2015; Pearson *et al.*, 2015) are well known sources of information about ancient diets.

Other recent evidence and methods used in food-related studies include parasite analysis in soil samples (e.g. Flammer *et al.*, 2018), as well as microfossils

analysis such as phytoliths, pollen, and starch. Phytoliths, also known as "plant stones", are silica skeletons from plant tissue that can remain after a plant has died (Wendrich and Ryan, 2012) and their analysis can provide valuable information about subsistence economy (e.g. Saul *et al.*, 2013) and more specifically on plant domestication and agricultural practices (e.g. Ball *et al.*, 2016; Neumann, Chevalier and Vrydaghs, 2017; Dal Corso *et al.*, 2018; Esteban *et al.*, 2018) such as cereal crop processing (e.g. Tsartsidou *et al.*, 2008; Dal Corso *et al.*, 2018). The analysis of phytoliths can also bring new insights on techniques on tools used in food processing when recovered from artefacts (e.g. Ross, 2004). Pollen, the reproductive agent of flowering plants, is also a good indicator of ancient environments as well as diets (Day, 2013). Palynology has mostly been used as a tool to reconstruct ancient landscapes and vegetation (e.g. Sadori, Mercuri and Mariotti Lippi, 2010). In rare cases, pollen has also been used to bring new insights on ancient diet (e.g. Azzazy, 2018), such as whether plant matter was cooked (Hunt *et al.*, 2001). Starch analysis associated with archaeological artefacts provide insights into the use of plants in ancient times for food-related activities and techniques (e.g. Copeland and Hardy, 2018).

Biomolecular studies are increasing in prominence and accuracy. It now seems possible to isolate DNA from human remains but also perform isotope analysis (e.g. Forshaw, 2015; Pearson *et al.*, 2013; 2015; Weyrich *et al.*, 2017). Dietary information can be accessed through ratios of stable isotopes of carbon ($^{13}C/^{12}C$) by providing an indication on the contribution of C_3 (e.g. wheat) and C_4 vegetation (e.g. maize and marine products) to ancient diets. Similarly, the ratio of nitrogen stable isotopes ($^{15}N/^{14}N$) provides an indication on the trophic level of food in the diet, such as a more vegetarian (i.e. vegetable and plant based) or carnivore diet (i.e. meat or fish based). The ratio of strontium and calcium (Sr/Ca) in human bones is also a good indicator of a person's diet (e.g. the proportion of foods high in calcium such as leafy vegetables or dairy products).

Furthermore, DNA analysis may be applied to vestiges of plants, animals and fungi (e.g. Schlumbaum, Tensen and Jaenicke-Després, 2008) with the aim to precisely identify them.

Finally, organic residues remaining on lithic tools or found inside ceramic vessels (further explored in **Section 4.2**) are being analysed to enhance our understanding of ancient diet and culinary practices, such as the apparition of

secondary products such as dairy products (e.g. Evershed *et al.*, 2008; Dunne *et al.*, 2012; Nieuwenhuyse *et al.*, 2015). Compounds, such as proteins (e.g. Hendy *et al.*, 2018; Solazzo *et al.*, 2008) and lipids (e.g. Evershed *et al.*, 2008), in those residues may be chemically identified to discover the content of ancient vessels and thus determine what food and beverages were produced and consumed in ancient times.

While researchers' call to scientific methods in archaeology has increased and their ability to integrate quantitative and qualitative data has improved, integrating scientific data in an archaeological interpretation is still a challenge today.

First, these molecular and chemical studies require specialised knowledge and costly and specialized equipment and lab spaces. Thus, the use of the aforementioned methods is not consistent. Furthermore, the reliability of the data depends greatly on the preservation of the material and their susceptibility to contamination. For instance, archaeobotany and zooarchaeology "are used to reconstruct key aspects of human societies, such as past agricultural systems, human impact on vegetation, dietary breadth, trade in foodstuffs, and social access to specific foods" (van der Veen, 2008: 83), but the accuracy of the results and their interpretation depends greatly of the preservation of bones and fragile plant remains (van der Veen, 2008: 83).

Twiss also points out that these remains "represent different stages of food's interaction with humans" (Twiss, 2015: 90) often related to production, processing, storage and discard (Twiss, 2012a: 362-363 and 365). Ethnobotanical remains largely reflect production or processing before consumption while zooarchaeological remains are usually leftover debris from preparation processes as well as consumption (Twiss, 2015). Furthermore, archaeobotanical remains, depending on their state of preservation are often used to provide information on vegetation on a regional level rather than site-specific information (Day, 2013).

Archaeology, through the discovery of identifiable vessels and utensils used for transportation, storage, preparation and more rarely consumption of food, in certain cases found in context, provides us with crucial information on food in ancient times. And yet, organic residue analysis in ancient vessels are usually performed on production or storage vessels rather than consumption vessels as

the possibilities for the absorption of lipids are deemed higher in these types of vessels. Scholars have argued that a large number of processes could have been carried out in production vessels (e.g. repeated heating of animal and plant products) and this activity would leave chemical evidence. In the same way, there is a higher chance for products to sit longer in storage vessels than consumption vessels (Heron and Evershed, 1993: 256). However, it is also important to note that favourable outcomes of organic residue analysis will depend greatly on the content of the vessels. Dry grains or seeds - compared to liquids which are absorbed easily in the pores of ceramics - may yield no detectable residue on analysis (Heron and Evershed, 1993: 256).

Archaeologists often work with incomplete materials and ambiguous remains to tackle the highly complex subject of food. As a result, "tracing the role of food within ancient cultures is an enormous task" (Samuel, 1996a). The extent of data available is also logically tied to the major questions and interests of scholars and will have an impact on the subjects usually explored in archaeological food-related research.

2.2 The theme of food in archaeology

Food and foodways have attracted the attention of many scholars in archaeology, particularly in the last two decades (**Figure 2.1**) with the creation of archaeological projects involving the investigation of evidence of food and new journals such as the journal *Archaeology of Food and Foodways*[1] that will publish its first issue in 2020. This section highlights the major questions of interest related to the study of food in archaeology.

[1] https://www.equinoxpub.com/home/archaeology-food-foodways/

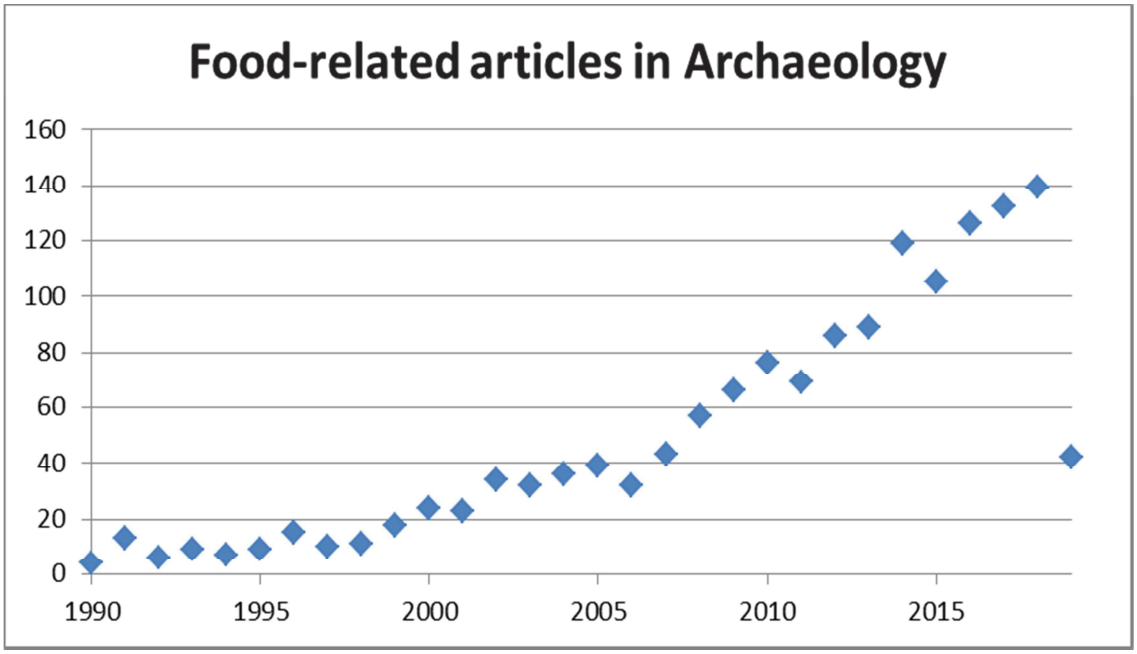

Figure 2.1: Graph presenting the 1471 results obtained on the 15/05/19 for the research on Scopus (https://www.scopus.com) of articles between 1990 and 2019 with the query ""food" AND "archaeology"". The results show an increase of food-related studies in archaeology in the last two decades.

2.2.1 Diet and Subsistence

2.2.1.1 Nutritional aspects

Humans are omnivores; they can nourish themselves and eat from a large variety of food items. A large body of literature has been dedicated to the study of ancient subsistence systems, diets and their nutritional value (e.g. Richards, 2002; Cramp *et al.*, 2014; Whelton *et al.*, 2018). One particular theme emphasised in these studies is the link between food and the development of modern human physiology. For instance, the consumption of milk is regarded as the result of our ancestors' gene-evolution. Consequently, researchers are particularly interested in finding archaeological evidence for the exploitation of animals for milk in the past (Copley *et al.*, 2005; Evershed *et al.*, 2008; Dunne *et al.*, 2012; Nieuwenhuyse *et al.*, 2015; Warinner *et al.*, 2015; Debono Spiteri *et al.*, 2016).

2.2.1.2 Food access and production

Another central theme is what food can tell us about ancient environments. Consumers choose to consume foods within the context of the available sources to which they have easy access, particularly with the increase of trade and movements of populations through time (Fischler, 1988; Hamilakis, 2014: 82). However, the environmental factor includes as well knowledge and skills. Growing food, cultivating land, raising stock as well as preparing meals from basic ingredients are activities that require specific knowledge, skills and tools. Certain foods need to be prepared and cooked correctly in order to be safe to eat (e.g. potatoes, pufferfish, etc.). Food production and processing techniques have always received the most archaeological attention of any food-related activity (e.g. Twiss, 2012a; Binford, 1967; Hillman, 1984; Atalay and Hastorf, 2006)

Key secondary themes such as food consumption, practices and social implications, often have been relegated to the background (Hastorf, 2016c, 4) but are now becoming more popular.

2.2.2 Food consumption and social organisation

Food consumed has been studied in some detail as material components to cultural identity as well as socio-economic organisation in modern and ancient societies (e.g. Dietler, 2007; 1990; Goody, 1982; Twiss, 2012; 2003; Wood, 1995; Woodward, 2012). Indeed, historical and sociological studies have demonstrated that people formulate their identities by making particular choices about food consumption. Food choices and preferences are a medium for social relations and the food consumed establishes consumers' identities (e.g. selfhood, status, gender roles, etc.). Sociological and historical perspectives on food have greatly influenced archaeological interpretations.

2.2.2.1 Sociological and historical treatises on food

In their work on the Situational Motivation Scale (SIMS), Guay and his co-authors categorize motivations behind activities into different types: 1) intrinsic motivation, or the act of performing an activity solely for the pleasure and

satisfaction derived from conducting the activity; 2) extrinsic motivation, or when the goal of performing the activity is extended beyond performing the activity itself, such as gaining financial incentive or achieving fame, avoiding negative consequences, etc.; and 3) amotivation which corresponds to activities with no associated motivation (Guay, Vallerand and Blanchard, 2000). Sociologists and historians in food studies have pondered and discussed at great length why people spend so much time, energy, money, and creativity on eating (Kittler, Sucher and Nahikian-Nelms, 2012). Bourdieu (1977) and Levi-Strauss (1965; 1968; 1969), among many other sociologists, have noted that our relationship with food is not solely a requisite for subsistence (Connolly and Waltham, 2015) or a means of survival (Certeau, Giard and Mayol, 1998: 183). People generally exhibit a careful approach in choosing their foods. Food choices are not only the product of biological factors such as the rejection of poisonous, dangerous or unhealthy food, but also are clearly influenced by the symbolic importance attached to certain foodstuffs (Fischler, 1988). Food consumption involves often at least some sort of intrinsic motivation, as eating and drinking are sources of pleasure. However, for Hayden the fact that food behaviours are often geographically widespread, persistent over time, pass through generations and expensive in terms of time, resources, and energy demonstrate that they present definite extrinsic motivations as well (Hayden, 2001: 24), such as religious, ideological, or cultural motives.

Food choices structure the identity of a person (Curtin, 1992: 4), an identity which is literally embodied as food and/or beverage is ingested by the individual (Lupton, 1996; Johnson, 2016: 253). This constructs both the person and the food, endowing the individual with the symbolic associations of the food and at the same time reinforcing food as a powerful marker of identity (Ohnuki-Tierney, 1993; Twiss, 2007). Eating a certain food is not just a choice in this case but a preference (Vabø and Hansen, 2014). A large body of literature has been dedicated to define and explore what the notion of ‘preferences’ entails and yet it still “suffers from a remarkable lack of conceptual rigor” (Engelen, 2017: 1). The notion is socially constructed and refers to individuals’ attitudes towards a set of objects (in this case food and practices associated), typically reflected in a judgement and a decision-making process in which subjective and objective criteria, as well as affect and cognitive influences, play an important role (Zajonc and Markus, 1982). Affect and cognition appear as antinomic notions or

at least independent entities, however, as Zajonc points out, while “affect and cognition are under the control of separate and partially independent systems”, they can “influence each other in a variety of ways, and that both constitute independent sources of effects in information processing” (Zajonc, 1980: 151). Food preferences are flexible and can be impacted by environmental factors mentioned above, but they also express ethnic, cultural, religious, household and class identities. By eating the same or different food people can show they belong and are seen as belonging to one group rather than another (Fischler, 1988). At the family nucleus level, food plays a large part in creating and strengthening family bonds, express feelings and affections (Stajcic, 2013; Mann, 2018) as well as defining “roles, rules, and traditions” (Stajcic, 2013: 5) that identify a particular group. However, Mannur elaborates on the role of food “establishing alternative networks of intimacy not circumscribed by lines of blood and filiation” (Mannur, 2010: X) but other communities, and even countries.

Food is a universal language that people from any part of the world understand. Food is shaped, driven and constrained by cultural considerations (Douglas and Isherwood, 1979: 39; Goody, 1982: 6; McCracken, 1988: xi; Lloyd, 2015: 30) to be understood by all. For Douglas, food is indeed a code and “the message it encodes will be found in the pattern of social relations being expressed”. The code has to be understood and recognized by everyone. It uniforms us of “degrees of hierarchy, inclusion and exclusion, boundaries and transactions across the boundaries” (Douglas, 1978: 249; 1997: 36). For Butler, a ‘code is performative: recognizable by others only in its repeated iteration, its re-citation (Butler, 1993: 169). Food consumption must be seen as performative, as it involves people reproducing the same acts, using constitutive conventions that have gained social legitimacy from prior actions. The meaning of food is not only communicated by the food itself but also by the act of eating a certain way, including the associated gestures and instruments.

Food consumption, as we have seen, is constructed in accordance with a broad range of cultural, ideological, and interpersonal factors: status, religion, gender, age, wealth and more. However, food habits (also known as food culture or foodways) - a term employed by Kittler, Sucher, and Nelms (Kittler, Sucher and Nahikian-Nelms, 2012) - are not limited to only the food consumed. Food habits

include how humans use food, including everything from how it is chosen, acquired, and distributed to who prepares, serves, and eats it.
Not knowing how to eat "properly" is universally a sign of outsider status. Food acquisition or production, distribution consumption and discard practices are all intimately intertwined with sociological, ideological, political and economic realities as it involves organisation, division of labour and knowledge (Twiss, 2007; Pollock, 2012; 2015). Eating and drinking are part of the "body techniques" listed by Marcel Mauss in his classification of diverse postures and gestures adopted by people around the world. Variations within body techniques can be observed when linked to different identities, such as sex and age divisions as well as depending on culture, education and upbringing (Mauss, 1979). Humans have also assigned rules and meanings to practices associated with food consumption, such as what time of the day people should eat at and what to eat for specific occasions (Douglas, 1975), who sits where at the dining table, the order in which the food is served and what kind of utensils should be used for each dish (Civitello, 2011).

Sociological and historical scholars have long noted the complex interrelationship between food practices and socio-economic status (Lupton, 1996; Caplan, 1997; Southerton, 2001; Mintz and Du Bois, 2002; Tivadar and Luthar, 2005) and how food might improve people's status or change their identity through eating it (Charles and Kerr, 1988; Murcott, 1988; 2000; Mennell *et al.*, 1993). In the beginning of 19th century, Veblen with 'The Theory of the Leisure Class' (Veblen, 1953) and Georg Simmel with 'The sociology of the meal' first published in German in 1910 (Simmel, 1998) are some of the first scholars to draw attention to the ceremonial use of food and social significance of commensality as well as the 'differentiation of the dietary' (Veblen, 1953). Pierre Bourdieu in "La Distinction: A Social Critique of the Judgement of Taste" (Bourdieu, 1979; 1984) stressed the creation and cultivation of cultural differences from each class and subclass and introduces the term of 'habitus' "which retranslates the necessities and facilities characteristic of that class of (relatively) homogeneous conditions of existence into a particular life-style" (Bourdieu, 1984: 208). Bourdieu, like Elias, argued that specific foods have economic value and consumption practices can be a manifestation of

competitive social display (Elias, 1978; Bourdieu, 1984; Beagan et al., 2015; DeSoucey, 2016)

It is when challenged by or compared to others during food events that a person's identity becomes more apparent. Nowhere is the symbolic meaning of food more evident than at social events. If food consumption is a language and eating specific foods was key to expressing one's identity (real or imaginative), the message needs to be transmitted and received through sociability at food events (Lloyd, 2015: 30). Thus, it was not just diet that helped to mark identity, it was also sociability on occasions where food and beverages were used to establish, reinforce or change relationships (Becuț and Puerto, 2017; Lloyd, 2015: 179). The role of public commensality is multifaceted. Hospitality and commensality provide a platform for communicating messages about social position and personal values and because food events can be used as tools for social inclusion and exclusion (D'Anna, 2012; Lloyd, 2015: 23). For Thorstein Veblen in "The Theory of the Leisure Class", consuming luxuries is a 'canon of reputability' (Veblen, 1953) and for Appadurai in his work on "gastro-politics in Hindu South Asia", luxury is a sign and a social message when he remarks "food in its varied guises, contexts and functions, can signal rank and rivalry, solidarity and community, identity and exclusion, and intimacy or distance" (Appadurai, 1981: 494).

These social and historical studies were increasingly used to model and discuss archaeological cultures. Using the material world they investigate, archaeologists have examined food as a symbolic instrument used in the formulation of membership to specific social groups. The consumption of a particular type of food can bring people together and be a factor in creating bonds and relationships. However, it has been traditionally a treated as a tool in power relations and presented as a dividing agent rather than a unifying one.

2.2.2.2 Food as a tool in identity creation and negotiation in archaeological cultures

Food-related studies in archaeology rarely place emphasis on the individual but on how food consumption practices serve to tie individuals in larger groups through shared understandings of social and cultural norms and conventions

(Wood, 1995), and meals are rituals that signal or reinforce membership and roles in families and communities (VanDerwarker, Scarry and Eastman, 2007: 16).

Non formal food-events are important in establishing and expressing identities (Clark, 1983; Kümin, 2002; Carlin, 2008). When the topic of food and family and household identity in archaeology is touched upon, household social order (e.g. Urem-Kotsou and Kotsakis, 2007; Wright, 2014) and gender and age differentiation are generally the subjects of predilection (e.g. Hastorf, 1991; White, 2005).

However, the majority of archaeological studies are discussing food's socio-economic implications (Bogaard, 2017) in particular status inequality (e.g. van der Veen, 2003; Cuéllar, 2013; Wright, 2014; Fielding-Singh, 2017). A large range of archaeological studies have focused on the use of feasts, in particular by elites, to create and reinforce social distinctions (Goody, 1982; Dietler, 2001).

Feasting has been noted to have "adaptive values" (Hayden, 2001: 24) helping the individual adapt to its environment as it aids survival and reproduction, thus affording greater fitness[2]. Moreover, the elite relied on it not only to forge societal relations but also to negotiate and/or affirm a certain status or position of power (Dietler, 2001: 66). On the one hand, feasts were used as an "intra-elitarian communication medium" (Romano, 2015: 290), helping to produce relations between the highest ranking members of society (Pollock, 2003). Thus, it was a means for political maintenance and integration (Frangipane, 2010; Pollock, 2012). On the other hand, it involved a communal redistribution to appease the lower classes of the population and submit them to the elite, thereby creating economic inequalities, obligation and dependency (Pollock, 2003: 19; Romano, 2015: 290). Thus, "feasts provide an arena for both the highly condensed symbolic representation and the active manipulation of social relations." (Dietler, 2001: 67) Different types of feasts have been identified in order to develop, negotiate, and reinforce relationships within already exclusive circles. These relationships could assume many forms: (1) empowering feasts (generally the best known) (Dietler, 2001: 76–82) turn towards an economic and power gain; (2) patron role feasts, which present an asymmetrical social power dynamic between the participants and include some sort of redistribution

[2] The capacity of an individual to establish itself in competition with the rest of the population. See Darwinian fitness (https://www.britannica.com/science/Darwinian-fitness)

(Dietler, 2001: 82–85); and (3) diacritical feasts involving exclusively members of the same order and characterized by a distinctive cuisine and styles of consumption (Dietler, 2001: 85–88) promoting a display of status and power (Hayden, 2014: 10; O'Connor, 2015: 13). Food was used to display elevated status or to portray powerful individuals in particular ways (Ben-Amos, 2000; 2008) in particular by providing food luxuries (van der Veen, 2003). In his work on "Food and Identity in England 1540-1640", Lloyd comments that when looking at food consumption and social and cultural distinctions, it is important to include two fundamental concepts, necessity and luxury. They help to understand identity construction and image projection (Lloyd, 2015: 23–34). Luxury can have different connotations such as rarity, exotism and/or excess (Lloyd, 2015: 24) and different meanings depend on the different social and cultural groups. Common foods can still symbolize elevated social status if prepared and cooked in special ways, transforming them into luxuries (Lloyd, 2015: 178). Food is commonly used to establish intra-societal cultural strata, asserting our membership in certain groups and distancing ourselves from others (Twiss, 2007). Food consumption is indeed a marker of distinction with food having the "ability to mark the rank of their owner and thus communicate social position" (Weatherill, 1993: 207). For instance, the addition of exotic ingredients or the use of unfamiliar preparation techniques has the potential to bring new economic, social and cultural dimensions to a dish and consequently to the person eating it (Lloyd, 2015: 128, 131). However, the projection of image through sociability at food events, extends beyond the provision of ample and sumptuous food. While seating and serving arrangements reflects the hierarchical order within the communal sphere, etiquette, table manners and demeanour could be used to portray a certain image and identity (Lloyd, 2015: 32–33; Mennell, 1985: 57). Socially relevant distinctions may be communicated by who gets how much or what kind of food, the order in which individuals get served, which containers or utensils people use, or the seating arrangements used while eating (Dietler, 1990). Gestures, position and attitude are indeed important since by occupying a certain space, one signifies a particular social status (Pollock, 2003: 21).

Archaeological studies have mostly focused on competitive and diacritical feasts – marks of social distinctions. Much less attention has been paid to the

composition of community feasts held to mark life cycle events or calendar rituals (e.g. van der Veen, 2003).

Specific food and cuisines may be also used as markers of particular cultures and communities. The exploration of food preferences and ethnic identity has been rarely approached in archaeology (e.g. Jones, 2015). The terms "typical", "authentic", "traditional" or "signature" food often recur in these studies (Hastorf, 2016b; 2016c: 232–237; Amone, 2014) when speaking of ethnic food that is iconic and highly culturally charged. These studies often investigate food preferences in cultural contacts contexts when ethnic dietary practices are identifiable and markers of a difference (e.g. Dietler, 2007; Hawkes, 2001; Jaffe *et al.*, 2018; van der Veen, 2008).

Religious dietary practices (e.g. certain religions abstain, or are forbidden, from consuming certain foods and drinks) cultivate a sense of communal identity and yet the few archaeological studies on food and religion usually focus on religious taboo, restrictions and distinctions (e.g. Twiss, 2012; Borgeaud, 2004; Grottanelli, 2004) as well as the place of food in rituals and differences with quotidian meals (Privat, O'connell and Richards, 2002).

Food-related archaeological studies have demonstrated how social class (in combination with gender, race/ethnicity and age, among other factors) acts as a structural determinant shaping access to food and how food serves as a powerful tool of distinction. This thesis wants to put an emphasis on the power of food in creating and reinforcing relationships of solidarity by investigating subjects rarely explored in archaeology, such as the sensory experience of eating and drinking (**Section 2.3**), in particular those associated with alcoholic beverages (**Section 2.4**).

2.3 Food, Senses and Emotions

As it has been outlined above, the archaeology of food has been primarily focused on perceiving food as an instrument used by people in the past for their subsistence and self-other distinction reasons, often ignoring the fact that eating and drinking are fundamental sensory experiences.

2.3.1 Senses in archaeology

Our senses shape how we experience and interact with the world and thus it should be an important part of archaeological enquiry and interpretation of a site (Kus, 1992; Hurcombe, 2007; Skeates, 2010; Hopwood, 2013; Hamilakis, 2014). Sensory values are entwined with social values and rules and thus strongly conditioned by the society into which humans are socialised (Bourdieu, 1984; Bourke and Hillier, 2002: 5). Sensory experience is material as senses often require materiality in order to be mobilized and yet senses in archaeology is a topic that is still at its beginning (Hurcombe, 2007).

Indeed, despite the fundamental importance of the senses in human experience, archaeologists have, until recently, neglected the abundant sensory dimensions of the material world they investigate. Sensory studies in archaeology have been heavily criticized as biased and highly subjective (Hayden, 2001: 24; Brück, 2005) as well as being too ephemeral to be looked at (Hamilakis, 2011). Yet, at the beginning of the twenty-first century, a growing body of works in archaeology (**Figure 2.2**) and other fields in humanities and social sciences (e.g. Sutton, 2001; Classen, Howes and Synnott, 2003; Howes, 2006; Korsmeyer and Sutton, 2011) have demonstrated the potential of sensory and sensuous approaches to create and enrich narratives about people's lives in the ancient world through the analysis of material culture as well as ancient textual accounts of sensory experience (e.g. Hamilakis, 2002; 2011; Price, 2018).

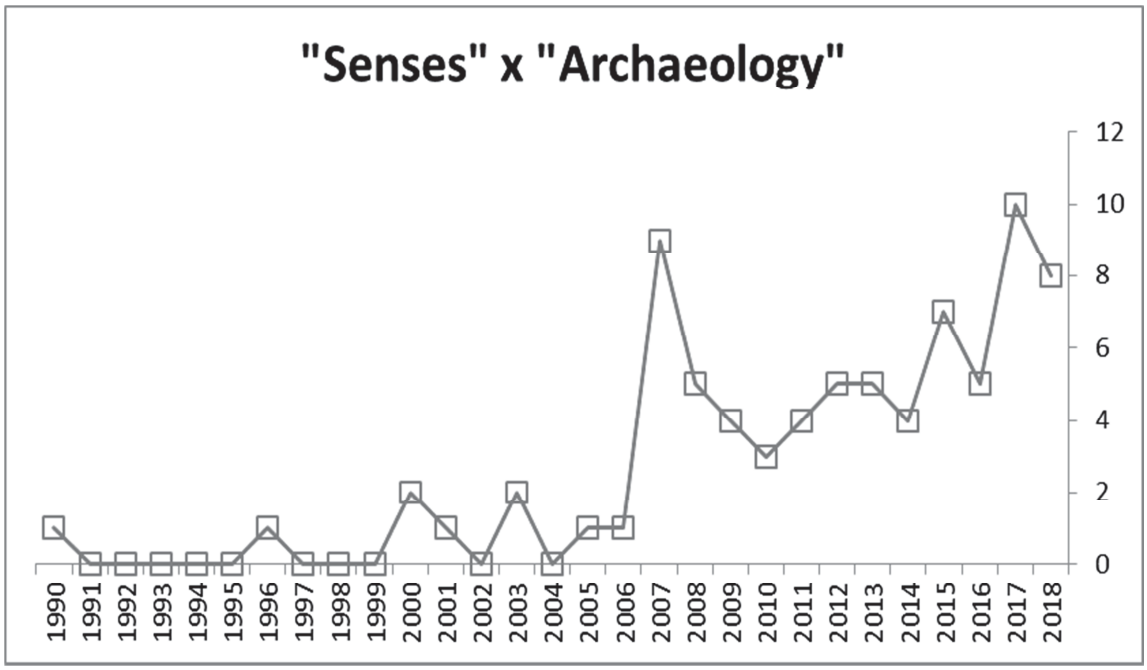

Figure 2.2: Graph presenting the 78 results obtained on the 15/05/19 for the research on Scopus (https://www.scopus.com) of articles between 1990 and 2019 with the query ""archaeology" AND "senses"". The results show an increase of mentions of senses in archaeological studies in the last decade.

Thus, archaeological research, which traditionally has prioritized the sense of sight (e.g. Tilley, 1994; 2004; 2016), gradually has seen the development of new studies on kinaesthesia, i.e. the awareness of the body in space (Molleson, 2007) and the five senses (Seremetakis, 1994; 2004; Sutton, 2005; 2010; 2000; 2001; Cummings, 2002; Hamilakis, 2002; 2014; Keates, 2002; Skeates, 2010; Korsmeyer and Sutton, 2011), in particular olfactory and tactile experience of ritual (e.g. Day, 2013; 2017; Tringham, 2013) and place (e.g. Hamilton *et al.*, 2006). The exploration of senses in food related studies, however, is still as yet in its infancy (**Figure 2.3**).

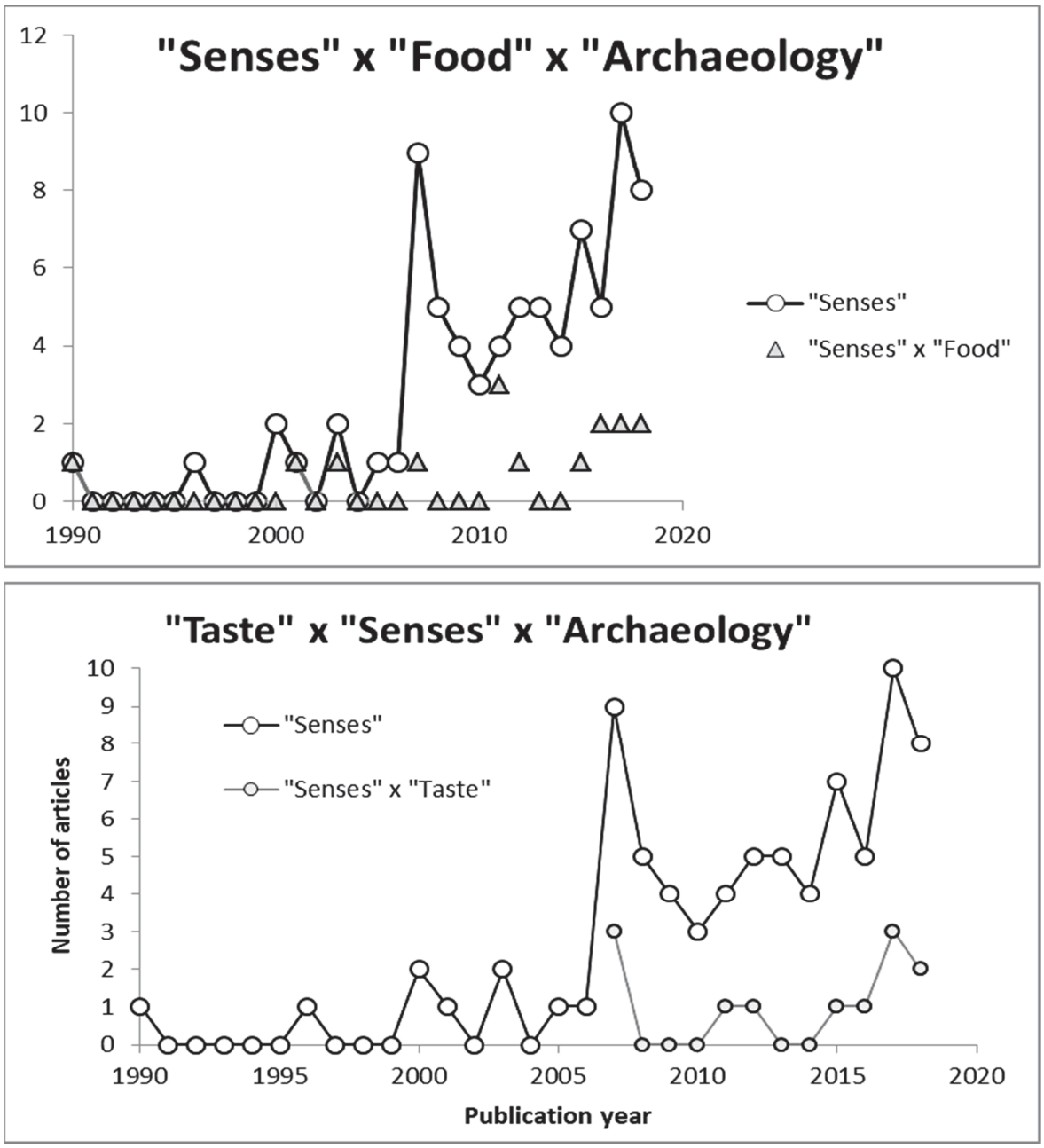

Figure 2.3: Graph presenting the 15 results obtained on the 15/05/19 for the research on Scopus (https://www.scopus.com) of articles between 1990 and 2019 with the query ""food" AND "senses" AND "archaeology"" (above); Graph presenting the 12 results obtained the 15/05/19 for the research on Scopus (https://www.scopus.com) of articles between 1990 and 2019 with the query ""taste" AND "senses" AND "archaeology"" (below). The results show an increase of mentions of food as a sensory experience in archaeological studies in the last decade.

2.3.2 A multi-sensory experience: Beyond taste and smell

Sutton argues that eating "[is] an actual multi-sensory experience" (Sutton, 2010: 211). He has drawn attention to the fact that eating is an activity that engages the five senses. Not only flavour, but also texture, temperature and colour are important criteria of food. Moreover, the material used in food

preparation and consumption practices will also have an impact on the overall sensory experience of food consumption (Brumfiel, 1987; 2005). Furthermore, eating and the experience of food involves not only foodstuffs and the individual body but is also impacted by one's surroundings (e.g. context, place, company). We should not forget that eating is often a socializing event. When thinking about food, the interrelated senses of smell (or 'olfaction') and taste ('gustation') (Ermidoro, 2015: 23) are the first obvious senses that come to mind. However, other senses are going to be stimulated by the properties of the substance ingested and the context and utensils used: 1) the appearance (e.g. colours) using sight; 2) hearing, centrepiece of communication and various social behaviours, 3) touch stimulated by the textures not only of the substance ingested but also of the vessels used. Each sense also influences the others.

Taste and smell are maybe the most intimate of the senses as they are ingested into the human body. Taste and smell are biologically and chemically determined by molecules released by substances (such as food) that stimulate nerve cells in our noses, mouths, and throats, which in turn send messages to our brains. This intimate process enables us to perceive and discriminate a multitude of odours and flavours, both pleasing and possibly harmful as "any new, unknown food is a potential danger" (Fischler, 1988: 278).

Taste is the sensation produced just before ingestion by an individual, when the substance in the mouth reacts chemically with taste receptor cells located on taste buds mostly located on the tongue. Taste is highly subjective. However, taste and smell are also highly cultural and socially conditioned. Anthropologists such as Lévi-Strauss (1965; 1968), Elias (1978) and sociologists such as Bourdieu (1979) and Fischler (1988; 1990) have stressed the two interrelated senses of taste and smell were primary motivators of not only individual but also collective food choices and preferences. As part of the *habitus* defined by Bourdieu, taste for food established personal and collective identity and marked social differences (Bourdieu, 1984; Mennell, Murcott and van Otterloo, 1993: 8–13 and 32). Mennell, discussing taste, has concluded that "likes and dislikes are never socially neutral, but always entangled with people's affiliations to class and other social groups" (Mennell, 1985: 32–33). Douglas also argued that "[…] palate is trained, […] taste and smell are subject to cultural control" (Douglas, 1978: 59) and thus food should be treated as a marker of differences in gender,

class and ethnicity (Douglas, 1975; 1978; 1984; Charles and Kerr, 1988). The taste and smell of the food we chose to take into our bodies, communicates and helps to define our personal, social and cultural identities (Duruz, 2007; Sutton, 2010). Furthermore, taste and smell of food will be connected to different cultural and social values depending on the time, place and context in which they are consumed (e.g. Gell, 1977).

Food also plays a role in the mental, emotional and spiritual well-being of a person. Food stirs the emotions both because of its sensual properties and its social meanings. There is a particularly strong link between the senses of taste and smell and the emotional dimensions of human experience (Proust, 1913; Serres, 1985). The actions of tasting, smelling food during consumption and preparation may evoke particular emotions on both the conscious and unconscious levels linked to memories of past events when that meal was prepared and eaten. It provides multisensorial pleasure that affects our moods and actions and is used as a source of comfort (Sutton, 2001; 2005; Mata-Codesal, 2008; 2010). Taste may trigger nostalgia and memories of people, places and events as illustrated by Proust in The Remembrance of Things Past (Proust, 1913). Gunkel notes how food has the "strange capacity to embody conceptual –even philosophical- frameworks, such as time, nature or home" (Gunkel, 2016: 247). In the same way, odours from food stir up emotions and memories (Seremetakis, 1994; 2004) as they have "the power to evoke vivid, emotionally-charged, memories of past events and scenes" (Tuan, 1974: 10). Smells may also help define the character of different spaces and places (Waskul *et al.*, 2009).

2.3.3 Senses in food-related studies in archaeology

Archaeologists have generally not explored the smell and taste of food from the past (Hayden, 2001: 24; Hopwood, 2013: 237–238). It is only in recent years that a few studies have begun to point out the importance of these senses, touching upon some of the key themes presented above, such as *habitus*, community, memory and social identity in food production and consumption practices.

Several studies in archaeology have mentioned smell and taste as units of pleasure (e.g. Saul *et al.*, 2013) or disgust (e.g. Eerkens, 2007: 91), as well as their source of evocative symbolism and memories, in contexts ranging from

funerary rituals to feasts (e.g. Parker Pearson, 2003: 7) to more mundane meals (e.g. Urem-Kotsou and Kotsakis, 2007). From instance, Parker-Pearson in his introductory paper on food, culture and identity in the Neolithic and Early Bronze Age gives examples of olfactory rituals including incense, decomposing and cremating corpses and food offerings (Parker Pearson, 2003). Urem-Kotsou and Kotsakis in their work on pottery, cuisine and community in households in the Neolithic of northern Greece acknowledge the "strong link between food and emotions, embodiment, subjectivity and memory" and the importance of food and taste to unify and structure communities (Urem-Kotsou and Kotsakis, 2007).

Some scholars have gone beyond the mention of smell and taste to observe how the sensory experience of food preparation and consumption may have evoked emotional responses.

Hopwood, based on evidence of food-preparation practices in particular ceramic vessels used in food production, has taken a look at the sensory experience of the preparation of food at the Halaf period site of Fıstıklı Höyük, Turkey and conclude that "feeling the texture of the raw food itself, stirring it in a pot, smelling it cooking across an open space, tasting it for seasoning and 'doneness', even hearing its sounds as you go about another task" would have sustained the body of the individuals and the unity of the community (Hopwood, 2013: 222).

Regarding consumption, Jones suggests that meadowsweet, a white coloured and sweet smelling plant, may have been used as an agent of memory in the mortuary rituals at the Early Bronze Age site of Whitehorse Hill (Dartmoor) to trigger recollections of the early summer (Jones, 2016: 227).

Moreover, we should not forget that foodstuffs are not the only parameters that will create a heightened sensory experience. In her study of the materiality of Aztec feasting, Brumfiel argues that the use of specially painted vessels as containers for food and drink during ritual events are also of great importance, as they brought a distinctive visuality and symbolic meaning to these ceremonies (Brumfiel, 2005).

Hamilakis has also highlighted the multisensory dimension of food consumption (Hamilakis, 2008; 2011; Hamilakis and Harris, 2011) and the fact that taste, odour, memory and meaning are closely linked (Hamilakis, 2002). For instance, investigating mortuary rituals in the Aegean Bronze Age societies, Hamilakis set the scene by picturing the rituals performed around communal 'tholos' tombs, mixing dead relatives with living descendants. By incorporating food in these

rituals, the settings and the scents of food mixed with those of the decomposing bodies. This would have created an intense and memorable multisensory experience (Hamilakis, 1998). However, Hamilakis also underlines the use of food for political ends and the role of the sensory experience of these communal food events in the creation and maintenance of political agenda and power dynamics, with particular reference to Bronze Age Crete (Hamilakis, 1996; 1998; 2002; 2008; Hamilakis and Sherratt, 2012). These highly sensory- and memory-charged feasting events would have played a distinct role in the creation of "embodied histories" (Hamilakis and Sherratt, 2012).
Another investigation by Hamilakis, this time on archaeological evidence of small-scale feasting event at the site of Nopigeia-Drapanas (Crete), concluded that food production and consumption and the sensory experience created were in this case more inclusive and were not trying to create distinction, based on animal remains and standardized ceramic vessels uncovered on site (Harris and Hamilakis, 2008; Hamilakis and Harris, 2011).

Hamilakis attributes a key role to alcoholic beverages consumption in the sensory experience of such feasts (Hamilakis, 1996; 1999; 2008), which has, however, remained a largely understudied subject in archaeology.

2.4 Alcohol consumption: an understudied subject in archaeology

To date, and despite recognizing the importance of alcohol in everyday meals and more exceptional feasts, few archaeological studies have explored alcoholic beverages (**Figure 2.4**). Moreover, extant research investigates mainly production processes rather than consumption. However, with the development of technologies and chemical analysis previously mentioned, archaeologists are able to uncovered new evidence of alcohol in ancient times.

2.4.1 Archaeological evidence of alcohol

Archaeological studies of alcohol, by and large, base their identification on ethnobotanical remains of the production processes of alcoholic beverages such

as remains of grapes (e.g. Zettler and Miller, 1995) or cereals (e.g. Stika, 2011; Larsson, Svensson and Apel, 2019). The use of starch granules (Samuel, 1996b; McGovern *et al.*, 2017; Wang *et al.*, 2017; Brown, 2018) and phytoliths analysis (Wang *et al.*, 2016; Liu *et al.*, 2018) to identify wine and beer is a growing field of research. Use-wear analyses of the material used in alcohol production (Liu *et al.*, 2018), organic residue analysis and chemical markers have also been employed to identify wine and beer in production and storage vessels (Michel, McGovern and Badler, 1993; McGovern *et al.*, 2005; 2017; McGovern, Mirzoian and Hall, 2009; Barnard *et al.*, 2011; McGovern, Hall and Mirzoian, 2013) as well as consumption vessels (Perruchini *et al.*, 2018).

Recently, the isolation and characterization of yeast cells from ancient production vessels has made headlines by bringing new way to identify the production of beer in the past (Aouizerat *et al.*, 2019).

The application of scientific methods has also brought new insights into production processes and techniques (Samuel, 1996b; Stika, 2011; Wang *et al.*, 2016; Aouizerat *et al.*, 2019) as well as ingredients such as staple (Michel *et al.*, 1993; Samuel, 1996b; Barnard *et al.*, 2011; Brown, 2018) and more rarely adjunct ingredients (McGovern, Mirzoian and Hall, 2009; McGovern, Hall and Mirzoian, 2013).

In contrast, direct archaeological evidence of alcoholic beverages in their consumption context has been relatively sporadic (Perruchini *et al.*, 2018; Otto, 2012). It is primarily found in the form of the vessels used for consumption, but without the ability to pinpoint what beverage was actually consumed. However, the large number of archaeological discoveries of drinking sets, decorated and undecorated, associated with ritualistic and ceremonial contexts attest of the social importance of the act of drinking in the past (Guerra-Doce, 2006; 2015; Rojo-Guerra *et al.*, 2006; Balossi Restelli, 2012; Perruchini *et al.*, 2018).

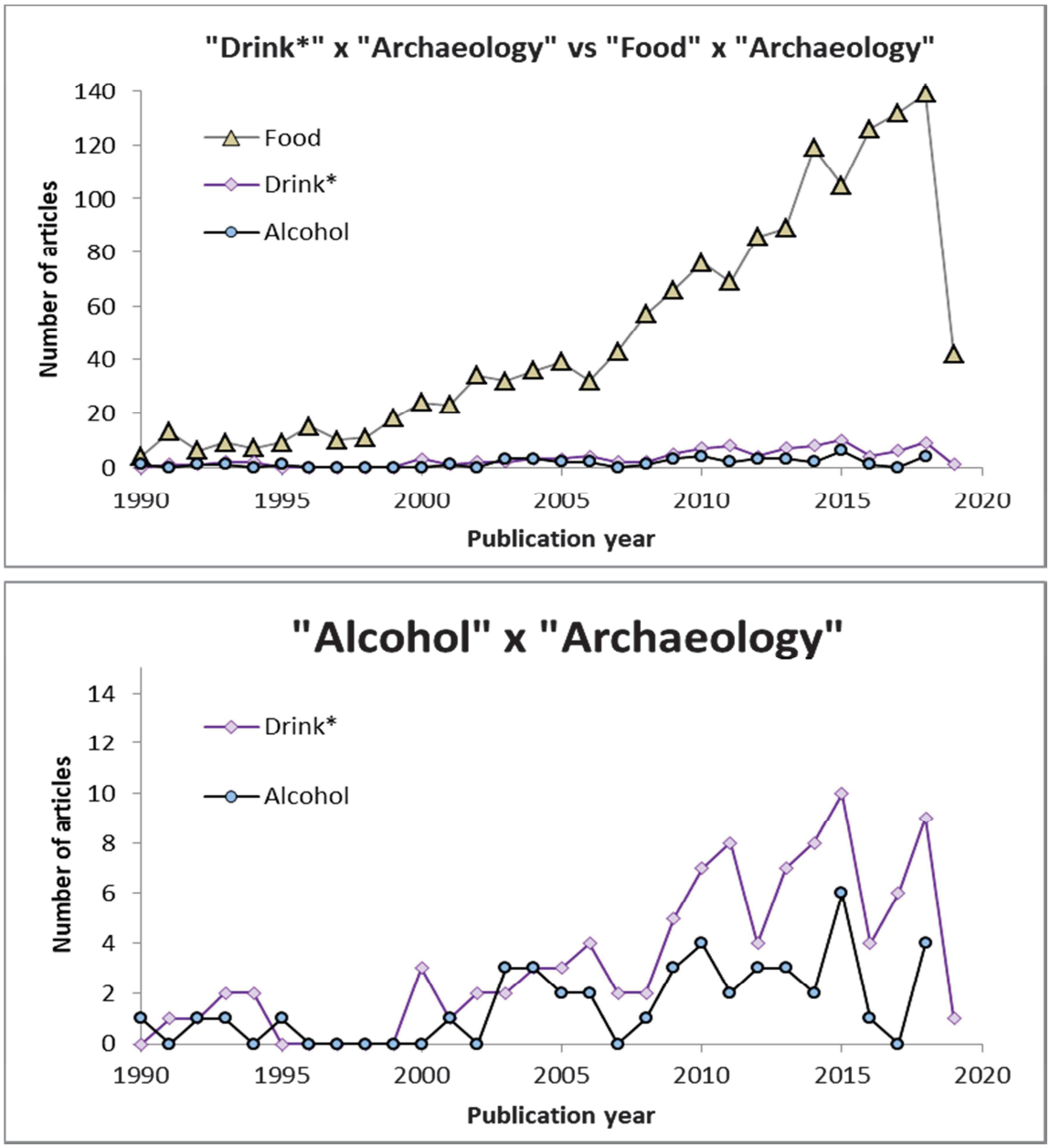

Figure 2.4: Graph comparing the results obtained on the 15/05/19 for the research on Scopus (https://www.scopus.com) of articles between 1990 and 2019 with the query ""Drink" AND "Archaeology"" and ""Food" AND "Archaeology""(above); Graph presenting the results obtained the 15/05/19 for the research on Scopus (https://www.scopus.com) of articles between 1990 and 2019 with the query ""Alcohol" AND "Archaeology"" (below). The results show the rare study of beverages, in particular alcoholic beverages, in archaeology.

2.4.2 Alcohol in the past

The previously mentioned archaeological evidence has proven that alcohol was produced and consumed already in prehistoric times in several parts of the world (Michel, McGovern and Badler, 1993; Barnard *et al.*, 2011; Guerra-Doce, 2015; Wang *et al.*, 2016; Liu *et al.*, 2018). For instance, evidence for beer production

has been recovered from a Natufian burial site at Raqefet Cave, Israel dating back as far back as 11 000 BCE (Liu *et al.*, 2018). The long history of alcoholic beverages attests that inebriation was, and is, a long-established habit, as well as indicates the importance of alcohol in ancient societies.

Alcohol was not only consumed for nutritional reasons or pleasure (e.g. Jennings *et al.*, 2005). It is widely recognized today that alcohol, in particular beer, has played an important part in the development of social complexity in the ancient Near East (Joffe, 1998). It has even been hypothesized that beer was the motivator behind the domestication of cereals (Braidwood *et al.*, 1953; Katz and Voigt, 1986).

First and foremost, alcoholic drinks possess mood-enhancing properties (**Section 2.4.3**) that would have given them a magical aura. Substance made from grapes, cereals and other staple foods are able to alter human consciousness (Sherratt, 1997; Joffe, 1998: 298; Steel, 2004a; 2004b: 283). Furthermore, as it is still the case in some modern societies (Arthur, 2003), alcohol possessed social and economic value (Neumann, 1994; Joffe, 1998). Alcoholic drinks can be produced from the fermentation of a wide variety of fruits, grains, roots, or other natural products. Thus, almost every society has locally available raw materials for making alcohol and everyone in a society generally has access to the means of production, that is, the basic materials and techniques. However, a certain economic wealth as well as knowledge and equipment are necessary to produce large quantities or special types of alcoholic beverages. Thus, the identification of certain type of alcohol may indicate status and cultural differences (e.g. Jennings and Valdez, 2018).

Alcohol was also an integral part of rituals and competitive feasting, as evidenced through texts, iconography and archaeology (Dietler, 1990; 2001; 2006; Michalowski, 1994; Joffe, 1998; Arnold, 1999; Hayden, 2001; Jennings *et al.*, 2005; Twiss, 2008; Sallaberger, 2012). For instance, maize beer (or *chicha*) was (and is still today) a key component of South and Central America feasting events (Jennings and Valdez, 2018; Jennings *et al.*, 2005; Logan *et al.*, 2012). We find the same dominant presence of alcohol at feasts in other past and modern societies around the world (Twiss, 2008). During these feasts, consumption practices (e.g. vessels and gestures) for alcohol also played an important role in marker of social differences (Arnold, 1999; Dietler, 2006).

As a cultural marker of wealth and status, alcohol was also an important item in political agendas (Dietler, 1990; 2006; Joffe, 1998) through its used as tribute, diplomatic gift and "mechanism of labor mobilization" (Dietler, 1990).

While alcohol has been considered as a "social barrier" (Arnold, 1999) in the majority of these studies, alcohol would also have been a powerful unifying agent (Dietler, 1990; 2001) which would have helped with the "forging of alliances" (Steel, 2004: 283) due in part to its consumption settings but also its psychoactive, consciousness-altering and sensuous properties (Jennings *et al.*, 2005; Guerra-Doce, 2015). These properties are rarely explored in archaeology.

2.4.3 Alcohol, senses and sociability

A large body of literature across diverse disciplines addresses alcohol consumption in a context of abuse and misuse (Oscar-Berman and Marinković, 2007), with a substantial body of work detailing the links between 'binge-drinking', crime and violence (e.g. Hollows *et al.*, 2014).
However, while higher doses and "binge-drinking" of alcohol may lead to aggressive and risky behaviours (Murdoch and Ross, 1990; Stappenbeck and Fromme, 2014), hangover, exhaustion, and depression (Tucker *et al.*, 1982; Townshend and Duka, 2005), as well as vomiting and loss of consciousness (Oscar-Berman and Marinković, 2007), the effects of alcohol, in moderation, may bring feelings of relaxation and exuberance. Indeed, alcoholic beverages contain ethanol, a psychoactive drug with relaxant and euphoric effects.

2.4.3.1 Disinhibitory effects

Some evidence suggests that alcohol may have disinhibitory effects on behaviour (Källmén and Gustafson, 1998; Oscar-Berman and Marinković, 2007).
As already mentioned, antisocial impulses and behaviours such as aggression and risk taking are possible consequences of disinhibitory effects. However, other more "social behaviours" may occur, such as playfulness (Varlinskaya *et al.*, 2001), lowered social anxiety and enhanced social confidence. Alcohol-induced disinhibition also has an impact on sexual behaviour and arousal (Wilson and Niaura, 1984; Maisto and Simons, 2016).

2.4.3.2 Impact on senses and emotions

Alcohol consumption has been proven to either enhance or impair physical perception (Caton, Marks and Hetherington, 2005; Ickes and Cadwallader, 2017). For instance, some studies have shown that high alcohol exposure may sensitize the brain's response to the taste of food (Eiler *et al.*, 2015) while, in contrast, alcohol may increase olfactory performance (Endevelt-Shapira *et al.*, 2014). Blurred vision, visuospatial deficit (do Canto-Pereira *et al.*, 2007), balance problems, motor coordination and slow reaction time are other possible consequences of alcohol on perception and senses (Oscar-Berman and Marinković, 2007).

The combination of the underlying factors mentioned (e.g., visuospatial deficits, abnormal processing of social information, poor inhibitory control, etc.) will have an impact on emotional perception and mood. Alcohol consumption may trigger negative emotions, such as aggression and depression (Marmorstein, 2009; Ashton *et al.*, 2017). Ashton and colleagues argue that alcohol consumption has a direct impact on moods (Ashton *et al.*, 2017), with research showing that people often consume alcohol with the specific aim of regulating their emotional experiences, reducing negative and enhance positive emotions (Cooper *et al.*, 1995; Luhtanen and Crocker, 2005; Cox *et al.*, 2006; Aurora and Klanecky, 2016; Sayette, 2017)

Alcohol's relaxant and euphoric effects and its perceived capacity to temporarily reduce negative emotions and enhance social confidence may help increase sociability and levels of social bonding (Michael A. Sayette *et al.*, 2012; Ashton *et al.*, 2017).

To conclude, alcoholic beverages are very particular items in the realm of food. As "social lubricants" (Arnold, 1999), alcoholic beverages are integral to interpersonal relationships, religious and ceremonial practices, and valuable items in creating social division as well as cohesion in modern and ancient societies.

Yet, compared to their storage and production, archaeological research rarely investigates alcoholic beverages consumption. Furthermore, archaeological research has rarely considered the properties of the beverage when identified – its taste, texture, and alcohol content – and its effects on consumers and their

overall sensory experience. This lack of information about the overall physical properties of ingredients in alcoholic beverages and contexts in which they are consumed as well as practices involved in their consumption, present a major challenge when attempting to assess their sensory impact and their consequence on social experience.

Compared to other parts of the world, alcohol in Mesopotamia has been largely studied through the use of textual, iconographic evidence as well as archaeological discoveries. Archaeological research so far has been focused mainly on identifying production of alcohol and what beverage, i.e wine or beer, was prepared. However, adjunct ingredients used in alcohol in Mesopotamia still remain for the most part a mystery. Furthermore, alcohol beverages have rarely been identified archaeologically in a consumption context. Consequently, practices associated with alcohol consumption (contexts, vessels, etc.) are understudied subjects mainly due to the lack of archaeological evidence.

3 “Beer in mind”: Alcoholic beverages in the ancient Near East

‘They placed food in front of him,

They placed beer in front of him;

Enkidu knew nothing about eating bread for food,

And of drinking beer he had not been taught.’

- Epic of Gilgamēs, Tablet 2 -

(George, 2003)

The most striking evidence of the symbolic significance of food and beverages in Mesopotamia can be found in the Epic of Gilgamesh/š, where the act of eating and drinking is presented as synonymous with civilization (Ermidoro, 2015: 11) as highlighted in the passage above. Enkidu – a man created by the goddess Aruru- is living in the wilderness and eating only what nature provides him with, like a wild animal. In Tablet 2, Enkidu is introduced to his first taste of bread and beer. He drinks the beer out of a jug, which is a new experience for him. As Bottéro noted, this poem dating from the Third Dynasty of Ur (ca. 2100 BCE) points out the symbolic gap between those eating and drinking “natural” food and those consuming “artificial” (i.e. processed) food (Bottéro, 2004: 36–38). Drinking was not a simple mechanical activity used to respond to basic needs; drinking had great social and cultural significance in the ancient Near East.

In this chapter, I will focus on the two main types of alcoholic beverage consumed in Mesopotamia and the wider ancient Near East: beer and fruit wines. I will summarize what conclusions have been drawn so far on alcoholic beverages from ancient texts, iconography and archaeological finds, in particular organic residue evidence.

Available written sources provide us with diverse information on the beverages available in the ancient Near East and their social and economic significance. Iconographic sources, in particular cylinder seals, provide insight into beverage consumption in feasting settings, as well as the participants and gestures

involved. By contrast, archaeological finds provide us mainly with evidence for the production and storage of alcoholic drinks.
Taken together, these sources and the studies exploring them also highlight the large knowledge gap that still exists when it comes to the production and consumption of alcohol, including (1) ingredients and additives used; (2) alcohol content; (3) practices and vessels involved in their consumption; and (4) the place of alcohol in social events.
In this chapter I highlight the need to seek new ways of approaching the special artefacts that are alcoholic beverages in order to address these knowledge gaps.

3.1 Beer

In many past, and also in some contemporary, societies, beer constituted an essential nutritional staple (Karp, 1980: 85; Arthur, 2003; Jennings *et al.*, 2005) and a fundamental part of daily life (e.g. in South Africa as presented in Taylor and Duodu, 2019). Beer has found a range of different geographical and historical expressions and variations. The earliest evidence for beer brewing dates back to the Neolithic period and comes from the Chinese site of Jiahu (ca. 7000-6600 BCE). Brewing, thus, forms one of the earliest attested food processing techniques. Chemical analysis revealed that Chinese beer was made from rice (McGovern *et al.*, 2004; 2005), while Peru is known for its corn-based beer or *chicha* (Hayashida, 2008).

Beer was the most important and common beverage in the ancient Near East, so much so that some scholars have argued that it was the appetite for beer, rather than bread, that led to the domestication of cereals in the Neolithic (Braidwood *et al.*, 1953; Katz and Voigt, 1986), prompting associated economic and technological developments such as the production of pottery vessels (McGovern *et al.*, 2004; Hayashida, 2015).
Cereals grains such as barley and emmer wheat constituted not only the staple foundation of daily food in the ancient Near East but were also the base for their most important beverage (Samuel, 1996b; Potts, 1997: 141; Bottéro, 2004: 89; Jennings *et al.*, 2005). Indeed, drinking beer was considered “the custom of the land” in the Epic of Gilgamesh (George, 2003). Whether for its high nutritive value (Bamforth, 2004), its safety over potentially contaminated water sources

(Kaiser, Medicus and Bruene, 2011), or simply the pleasure people derived from it (Geller, 1993), beer has long been recognized as a dietary staple (O’Connor, 2015), an essential component of cult festivals and feasting events (Otto, 2012; Sallaberger, 2012) as well as an important economic product. Thus, beer seems to have seeped into every aspect of life in the ancient Near East, and Mesopotamia more particularly.

Information about beer is provided by four types of sources: textual, iconographic, archaeological and chemical evidence.

Beer has been investigated largely through textual sources (Hartman and Oppenheim, 1950). Beer (Sumerian k a š, Akkadian š i k a r u) is well attested in a variety of cuneiform tablets - some dating back from the beginning of writing itself (ca. 3500 BCE) with the proto-cuneiform sign for beer (k a š) represented by a large straight-spouted vessel filled with water and grain (Bottéro, 2004: 90; Potts, 1997: 141) (**Figure 3.1**). Beer is frequently mentioned in administrative, legal, and literary texts, as well as private letters. Furthermore, its consumption and production are portrayed on a range of media such as seals and ceramic plaques. However, as stated in **Section 2.1.1**, the information these sources give us is partial and limited, making it complex to interpret. By contrast, archaeological and chemical investigation of beer has so far been mostly confined to ceramic containers used in beer production.

Figure 3.1: Clay tablet, record of beer (circled in red) Late Uruk period (3100-3000 BCE) ©Trustees of the British Museum

3.1.1 Evidence for Beer Brewing

A hymn dedicated to Ninkasi (ca. 1800 BCE), the Babylonian goddess of beer and brewing (Jennings et al., 2005), includes rare instructions for beer brewing in Mesopotamia (Civil, 1964; Katz and Voigt, 1986; Hornsey, 2003: 75–113). The text is both incomplete and phrased in often very general terms, which leave much room for speculation on the production sequence and ingredients involved. However, it mentions the use of É-BAPPIR or beer-bread. After the malting of the cereal grains, the malted grains were crushed and used to make dough which was then baked. These malt loaves, or beer-bread, could have ingredients incorporated into them to alter the taste of the beer (Ellison, 1978; 1984; Hornsey, 2003; Zettler and Miller, 1995). Textual evidence indicates that É-BAPPIR was kept in government storehouses and was eaten during food shortages, suggesting that it was considered a foodstuff in its own right. However, it also was mainly a convenient way to store the principal ingredient for making beer (Katz and Maytag, 1991).

In the next step, beer-bread was then crumbled and added to water, heated, and mixed to make the mash (Curtis, 2001: 135–137; Hornsey, 2003). The same practice of using beer-bread is attested in Egypt in inscriptions and iconographic representations, such as in early Dynastic tombs (mastaba) (Samuel, 1996b; Curtis, 2001) as well as archaeological evidence. For instance, cereal-based food and beverages were uncovered at the Predynastic settlement of Hierakonpolis and the New Kingdom (1550-1070 BCE) workmen's villages at Deir el-Medina and Amarna (1350 BCE) (Hornsey, 2003: 52-53; Samuel, 1996b).

Using Scanning Electron Macroscopy on the botanical remains found at Deir el-Medina and Amarna (1350 BCE), Samuel suggested that beer brewing in mid-2nd millennium BCE could have been a two-stage process that did not include the use of cooked bread. The cold mash method would have involved the use of malted and heated cereal grains mixed in a container with water as well as sprouted and unheated grains. The mixture would then have been decanted and fermented with yeast to make beer (Samuel, 1996b). The method proposed by Samuel would appear to represent a change in beer production between the Old/Middle Kingdom and the New Kingdom. Alternatively, the two methods could have been used to create beer with different taste. We know from

epigraphic and textual sources that various types of beer were produced including sweet, dark, iron and garnished beer (McGovern et al., 2009).

Apart from the hymn of Ninkasi, other lexical and administrative texts also contain a wide variety of information related to beer production and storage including production vessel: beer vat, vessel for beer-mash and other brewery vessels (Potts, 1997: 140). However, they do not provide us with any more detailed information about the brewing processes and recipes for different varieties of beer. Changes over time in vocabulary associated with beer brewing in Mesopotamia may indicate changes in production practices. Rosemary Ellison argued that the evolution of the term ‘brewer’ from the third millennium BCE LÚ.ŠIM + GAR/LÚ.BAPPIR, which includes the term ‘beer-bread’, to simply LÚ.ŠIM in the Kassite Period (ca. 1500-1100 BCE), suggests a change in beer brewing technique that no longer involved the use of special bread types in most production contexts (Ellison, 1984).

Archaeological attestations of beer brewing are limited in the ancient Near East and their identification often hinges on the use of cuneiform texts mentioning individuals, ingredients or equipment involved in the brewing process.
Advances in the field of archaeological organic residue analysis over the past three decades have opened up new ways of exploring ancient diet (see **Section 4.2**). So far, contrary to research into ancient wine, no specific biomarker has been conclusively proven to provide the reliable identification of beer in ancient vessels (Guerra-Doce, 2015). Beer has been identified in only three attested instances so far, each of which relies on the presence of either contextual archaeological evidence indicative of beer brewing and storage or macroscopic (visible to the naked eye) residues of the so-called beerstone, a by-product of barley beer making. Beerstone consists of a precipitate, which tends to settle on the surface of processing and storage vessels used in the brewing of beer (Michel, McGovern and Badler, 1993; Otto, 2012).
Beer was identified using chemical methods in a large Late Uruk period handled jar from Godin Tepe (ca. 3500-2900 BCE) (Michel, McGovern and Badler, 1993), a site with strong cultural ties to lowland Mesopotamia that is located in the Zagros Mountains of western Iran (Rothman and Badler, 2011). Organic residue analysis was carried out on a yellowish-brown resinous-looking material that was preserved on the lip of the Godin Tepe jar. A Feigl spot test (Feigl, 1956)

identified the presence of oxalate and likely calcium oxalate, a salt of oxalic acid, principal component of beerstone (Michel, McGovern and Badler, 1993; Hornsey, 2003; Gregg, 2009). The fact that a similar result was obtained from the analysis of pure calcium oxalate and residues from Egyptian vessels "clearly intended for beer" has been seen as evidence that the Godin vessel was indeed used for the processing or storage of beer (Hornsey, 2003: 92).

An Early Dynastic III (ca. 2600–2350 BCE) building at Tell al-Hiba, ancient Lagash, yielded an assemblage consisting of vats with perforated bases, hearths and ovens. The structure's interpretation as a brewery, however, rests on the presence of an administrative text listing quantities of beer, as well as mentioning the terms É-BAPPIR and brewery (É-LUNGA) (Hansen, 1980-1983).

The early 15th century BCE "Tablet Building" at Tell Hadidi on the Syrian Euphrates, yielded several rooms in which a series of 1) storage jars and vats, 2) cups, mugs, pitchers and 3) small bowls/platters, as a strainer and vessels with perforated bases were found (Dornemann, 1977; 1981). The latter were identified by Marie Henriette Gates as beer vats on the basis of cuneiform lexical texts, which refer to such vessels as DUGNÍG.DÚR.BÙR or *namzitu* (Gates, 1988). Alongside these vessels, other finds would also seem consistent with beer production such as carbonized grains, grind stones and an oven in the courtyard. The identification of the "Tablet Building" as a brewery received further corroboration from a series of sealed cuneiform tablets that indicate that Yaya, the owner of the building, was a large-scale brewer. Further circumstantial evidence of potential brewing activities come from the Late Bronze Age site of Kuşaklı in central Anatolia, where a monumental structure, Building C (ca. 1450-1380 BCE), contained an assemblage of bowls, medium-sized jars, straws and strainers, interpreted as belonging to a brewery (Müller-Karpe, 1999; 2006).

Chemical evidence for beer was also found in a series of household contexts at the 13th century BCE site of Tell Bazi on the Syrian Euphrates (Otto, 2012). Of the 50 or so houses excavated at Tall Bazi, many contained material assemblages indicative of beer brewing such as mills and large vats, alongside bronze filter tips to which drinking straws could be attached. Like at Godin Tepe, organic residue analysis at Bazi also focused on the macroscopic remnants of beerstone and the presence of oxalate.

Finally, chemical identification of beer at Gordion, the capital of the Iron Age kingdom of Phrygia in central Anatolia also rests on the presence of oxalate

(Mcgovern *et al.*, 1999). There, beer was identified as one component of a mixed alcoholic drink which also included grape wine and possibly honey mead and was served at the funeral feast of a Phrygian king in the great tumulus, or Midas' tomb (ca. 700 BCE). However, Nelson notes the difficulty in distinguishing which of these ingredients were meant to ferment from those simply added to flavour the beer (Nelson, 2005:2). Even more difficult to determine is during which step those ingredients have been added: during the brewing process or at the time of drinking.

3.1.2 Beer production

Cuneiform texts recording beer production activities and the distribution of beer have been recovered (Civil, 1964). The information they provide, however, is largely restricted to lists of required raw materials, the amounts of beer produced, and associated economic transactions (e.g. delivery of cereal grains, selling of beer), with few insights on the brewing processes itself.
Although there is no consensus on the details of the brewing process in Mesopotamia, a tentative operational chain can be reconstructed when considering modern brewing processes in concert with ancient texts, iconography and ancient organic residues of beer brewing in vessels that have survived through times.

3.1.2.1 Beer brewing technique(s)

Beer brewing involved a three-step process: malting, mashing and open-air fermentation. Fermentation occurs when a cellular organism, usually yeast (first natural and later cultivated by ancient brewers), converts sugars contained in malted grain and releases ethyl alcohol and carbon dioxide gas (CO_2) as by-products (Alba-Lois and Segal-Kischinevzky, 2010). Additional ingredients (fruits, honey, etc.) were eventually added to beer not only as a sweetener or flavouring but also to facilitate the fermentation process (Jennings *et al.*, 2005).
Unlike fruits, which already contain the necessary sugars for fermentation, cereals must be converted into soluble sugars, through the action of enzymes. There have been two main ways of doing so: masticating the cereal grains (e.g. Maize chicha), or by malting (Hornsey, 2003; Jennings *et al.*, 2005), meaning

transforming the raw grain into malt. Malting is a complicated and long process that requires considerable skill in creating adequate conditions for malting to occur (i.e. stable and controlled moisture and heat). The cereal grains have to be soaked in water for several days to germinate (Ellison, 1978). Germinated – i.e. malted – grains, are dried and stripped of their rootlets, which is a long process. They are then crushed or ground to facilitate the extraction of the sugars from the malted grains (saccharification) during the next and essential step: mashing.

During mashing, the now crushed malted grains or grain starches are put in heating water for a period of time and converted to fermentable sugars by the grain enzymes. For this part, temperature is of critical importance: if the water is too hot, the starch grains will be killed; too cool a temperature and the enzymes will not work optimally. While temperature can be controlled easily in modern times, this was not the case in the ancient world. While saccharification could be signaled by the darkening of the mash, it would have required a certain technical knowledge and experience to complete this step (Jennings *et al.*, 2005).

As previously mentioned in **section 3.1.1**, an experiment conducted at the archaeological site of Tell Bazi, Syria, has also shown that beer can be produced through a cold-mashing process (without heating but still performed under the hot climate typical of the Middle East) (Zarnkow, Otto and Berthold, 2011; Otto, 2012).

The resulting liquid containing the sugars is called wort. The wort, to be fermented by the yeast to produce alcohol, is boiled to kill any still-active enzymes. Ancient Mesopotamian brewers either relied on open air fermentation and natural environmental yeasts and perhaps, later, cultivated them by reusing the ceramic vessels used for fermentation from previous brewings (Kahn, 2012: 197).

Today, brewers would add hops, a cone-shaped flower of a special vine, for flavour and preservation. However, hops were not known to the brewers in the ancient Near East. There is as yet no reliable evidence for ingredients used as sources of fermentable sugars and flavouring (Jennings *et al.*, 2005).

3.1.2.2 Ingredients

Cereals

Cereals were the main food staples and the basis for the production of several common derivatives, mainly bread and beer. Ancient beer was made with all kinds of cereals and other starchy plants. In Mesopotamia and the wider Near East, beer was made primarily from barley (*Hordeum vulgare*), but also from emmer wheat (*Triticum dococcum*), both domesticated cereals. Although wheats are superior to most other cereals (e.g. maize, rice or barley) in term of nutritive value, judging by the cuneiform evidence, barley was "the most important cereal crop in southern Mesopotamia" and was preferred over wheat probably due to the fact that barley was suited to an intensive agricultural regime and more resistant to the harsh environment (Potts, 1997: 59–60; Zohary and Hopf, 2000: 69; Pollock, 2012). Barley withstands drier conditions, poorer soils and salinity (Mitchell, 1959; Zohary and Hopf, 2000: 59). Remains, in the form of charred kernels and/or spikelets and carbonized grains of wheat and barley dating to as early as ca. 8500-7500 BCE, have been recovered in Upper Mesopotamia at Tell Mureybit in Syria (Van Zeist and Casparie, 1968). Along with wheat, barley continued to be the principal crops used in food and beer production in the following periods and well into the Iron Age (Hald and Charles, 2008; Hald, 2010).

Additives

We know from mid-3rd millennium BCE administrative records from the Mesopotamian city of Lagash, as well as a first millennium lexical list ḪAR-ra = ḫubullu (called also the "Great Encyclopedia" by Bottéro, 2004: 92), that a wide variety of beers existed at the time. It mentioned golden beer, sweet dark beer, red beer, cloudy beer, alongside differences in beer quality (Michel, 2012). However, those texts do not provide any information on the ingredients or processes that may have been used to produce these different types of beer.

Herbs and spices were used in medicinal, magical and culinary contexts and could have been used as additives in beer brewing.

They included plant seeds, petals, roots, resins, twigs and barks in different forms (fresh, dried, pulverized form). Generally found under the generic term

mun-gazi in administrative texts, previous ethnobotanical studies - although scarce - have allowed us to identify some of the herbs used in Mesopotamian cuisine, including coriander, cress seed, cumin, fennel, and mint (Potts, 1997: 65–66; Bottéro, 2004: 69). Mustard or radish seeds also have been attested in the temple oval at Khafajah dating to ca. 3000 BCE (Potts, 1997: 68).

Oils contained in plants were also used in ancient cuisine, as an edible additive to food and as an important cooking and baking ingredient (Potts, 1997: 66). Sesame (*Sesamum indicum*) was an important oil plant in the ancient Near East. It has been suggested that it was introduced to Mesopotamia from the Indus Valley around 2000-2500 BCE (Fuller, 2003). The use of this oil plant in Mesopotamia is well attested in texts; however, archaeological evidence of sesame has yet to be discovered (Bedigian and Harlan, 1986; Bedigian, 2004; 2010: 2–6). The majority of these items could have been domesticated and grown locally (Zohary and Hopf, 2000), though some may also have been imported. Circulation of goods, in particular foreign items, is difficult to identify archeologically since goods could have been moved over long distances through many different routes and mechanisms (Crawford, 1973; 2013: 447; Algaze, 2001). However, we have evidence, albeit minimal, of more exotic spices reaching the ancient Near East.

Historical sources suggest that spices were some of the most highly-valued products traded in multiple and competing long distance networks that connected Asia with the Middle East and Europe. The earliest secure textual mentions of spices - cinnamon and cassia - date to the 5th century BCE and can be found in Herodotus (Hdt. 3.111) (Gilboa and Namdar, 2015). By the Hellenistic and Roman periods, the Asian spice trade was well established and attested not only in texts but also in the archaeological record. However, spices in Mesopotamia prior to these periods have been theorized based on strong textual and archaeological evidence.

In their work on the South Asian trade with the Western regions in the Late Bronze Age - Early Iron Age, Gilboa and Namdar investigated the trade in spices from South Asia to the West, particularly at its beginnings. One main route linking South Asia to the West ran through the Mesopotamian river system (Potts, 1995: 1453–1459), and spices were probably marketed farther west to Cyprus (Poth and Sauer, 2000: 2–3; Gilboa and Namdar, 2015). However, organic residue analyses performed on Early Iron Age (11th–late 10th century BCE) Phoenician clay

flasks recovered from three sites (both ritual and domestic settings) in Israel (**Figure 3.2**) provide evidence that this trade could have taken place much earlier than the previously stated Hellenistic and Roman periods. Indeed, the residue analysis of one of these flasks presented possible chemical evidence of cinnamon (Namdar *et al.*, 2013). Evidence of nutmeg were recorded in 1913 when excavators of Dayr al-Bahrī in Egypt (ca. 1550–1298 BCE) suggested an archaeobotanical identification of nutmeg. However, the specimen in question is now lost and the find impossible to confirm (Naville, 1913; Amigues, 2005). An uncertain chemical identification of nutmeg in an incense chalice from the first millennium BCE site at Yavneh, Israel, has also recently been put forward through the identification of two compounds: myristic acid (C14:0) and isopropyl myristate (Namdar *et al.*, 2010; D. Namdar, Amrani and Kletter, 2015).

Another evidence of the consumption of spice during this period is presented in Radner's study on Simurrean and Hašimur grindstones mentions in written documents of the early 2nd millennium BCE and 1st millennium BCE. Radner identifies these instruments, often associated with mentions of spices, as specialised spice mills (Radner, 2014). The names of the grindstones may refer to two localities in the Zagros, Hašimur and Simurrum, located in the vicinity of the Diyala River (Radner, 2014: 578).

Between 721 and 710 BCE, Babylonia was ruled by the King Merodach-baladan II, who cultivated in his royal gardens different species of plants (Potts, 1997: 66; McIntosh, 2005: 122). In texts from the 1st millennium BCE we can find precise instructions concerning the cultivation of a long list of plants including spices and herbs such as cardamom, saffron, coriander, garlic, thyme and turmeric. A document from the great library in Nineveh, established by King Ashurbanipal of Assyria (668–633 BC), records a long list of aromatic plants, among them thyme, sesame, cardamom, saffron, poppy, garlic, cumin, anise and coriander (Rosengarten, 1969). Gilboa and Namdar add that since the flasks showing evidence of cinnamon and nutmeg in Israel extend over circa 150 years, an export of some regularity likely existed, at least during the period in question. Their study also demonstrates that spices, and particularly cinnamon, were rather widespread in the southern Levant, and probably also other parts of the ancient Near East in the early Iron Age (Gilboa and Namdar, 2015).

Figure 3.2: Example of flask discovered at Tell Qasile (Israel) (Namdar et al., 2013)

For Gilboa and Namdar, it is clear that imported commodities such as spices were considered luxuries due to their exotic origins (Gilboa and Namdar, 2015) and thus were often restricted to special events used as gifts, tributes and offerings.

So far, none of these ingredients have been identified securely as an element of beer production. However, the range of additives available to brewers at different periods has implications for the overall sensorial experience of drinking, since herbs and spices are potent sensory agents. I will return to this pint in **Chapter 6**. For now, however, let’s turn to the second most important alcoholic beverage in the ancient Near East: wine.

3.2 Wine

While beer is often described as “common”, grape wine appear to have been consumed in more special events and tend to be “used in feasts that signalled social differences” (Jennings *et al.*, 2011:285).

However, it is important to acknowledge the fact that wines are fermented alcoholic beverages which could be made from a variety of fruits and additional flavouring ingredients, such as herbs and spices. I will

briefly mention date wine, but will focus on grape wine under the general term of "wine".

3.2.1 Date wine in the ancient Near East

Date palm (*Phoenix dactylifera L.*), a fruit suited to the climate of Mesopotamia, flourished in the region (Broshi, 2007: 55). Compared to other fruit trees, the date palm, like barley, can grow in warm and dry climates and withstand considerable salinity. Date cultivation was therefore particularly suited to semi-arid and arid environments such as the Mesopotamian alluvium (Zohary and Hopf, 2000, 165-166). Date palm was thus well established and had been domesticated by the 4th millennium BCE, according to written documentation and archaeobotanical evidence (Hodges, 1992: 114–117; Broshi, 2007; Tengberg, 2012). It was, for instance, found among other fruits deposited in one of the graves in the "Royal Cemetery" at Ur (Potts, 1997: 70, 2002: 196–197; Zohary and Hopf, 2000: 169). Date palms are also depicted on cylinder seals and other iconographic material (Ellison, 1981: 36; Potts, 1997: 69; Zohary and Hopf, 2000: 170).

We know that dates were eaten fresh or dried (Potts, 1997, 69). However, rich in sugar (Nemet-Nejat, 1998: 159) and, known to help in the fermentation process, date palm was also used in the production of both wine and vinegar (Miller and Wetterstrom, 2000: 1128; Hornsey, 2003: 6–7). The oldest evidence of date wine comes from ca. 3000–2000 BCE (Hodges, 1992: 114–117; Murray, 2000b; 2000a). Date wine is mentioned in a cuneiform tablet from Umma dating to the 1st year of Ibi-Sin (Ur III period, ca. 2112-2004 BCE), recording accounts such as "13 ka and 49 ka of date-wine on the 21st day" (Bedale, 1915, Tablet 48). It has also been documented in a piece of literature relating the education of a scribe, which has been dated to around 2000 BCE (Kramer, 1949).

However, it is believed to have consumed by the people in Mesopotamia long before that, contemporaneously to barley beer (see **section 3.1**) (Oppenheim, 1967: 42–44; Ellison, 1978: 329; Stol, 1994; Broshi, 2007: 55).

Ancient Mesopotamian texts do not provide us with an actual recipe for brewing date wine. However, a recipe was recorded by the pharmacologist Dioscorides in the 1st century BCE. According to Dioscorides, the production of date wine was

not a very complex process and was much simpler than that required for cereal beers (Hodges, 1992: 114–117; Broshi, 2007: 55–59). Dates and water were put into a container and left to ferment for ten days. The date mash was then strained and the beverage was ready to be consumed and sometimes flavoured with herbs or other additives (Hodges, 1992: 114–117).

3.2.2 Grape wine in the ancient Near East

Grape wine appears later than beer in textual sources. Vine, grape, grape juice and wine were designated by a single term in Sumerian (geštin) and Akkadian (karânu) making the translation of these texts difficult. The earliest unequivocal documented mention of wine can be dated from the middle of the third millennium BCE. A royal inscription of the King of Lagaš, Urukagina (2351-2342 BCE) states that he built "the beer cellar, where they brought him wine from the Mountain, in great urns" (Ellison, 1978: 228; Bottéro, 2004: 94).

Archaeological evidence points to much earlier viticulture which tends to prove that wine was produced and consumed in the ancient Near East much earlier than suggested by written sources.

3.2.2.1 Wine production sites and circulation

The climate and temperatures of Mesopotamia were not vastly different than the ones is in the region today. Most of the region is considered arid or semi-arid and thus not favourable for grapevines. Unlike date palms, *Vitis vinifera sylvestris* grapevines were unlikely to have grown naturally in the arid climate of southern Mesopotamia. They are more inclined to occur in cooler climates at higher altitutes within the vicinity of springs and streams (Zohary and Hopf, 2000: 152). Grapevines could have grown at higher elevations (Ellison, 1978: 227) such as the upland regions of the Northern Zagros Mountains, the Taurus Mountains of eastern Turkey and the Caucasus Mountains.

It is thus no coincidence that the majority of the sites where wine production has been identified are located in these three regions (Michel, McGovern and Badler, 1993; McGovern, 1997; 2007; 2009; Zettler and Miller, 1995, Table 10.1; McGovern *et al.*, 2017).

So far, the earliest evidence of wine production comes from sites in the Caucasus Mountain and Armenian Highlands. Ancient jars of ca. 6000 BCE have been found at Shulaveris Gora in south eastern Georgia, with red residue coating their inner surfaces as well as possible "domesticated" grape pips (*V. vinifera vinifera*). Thus the site has yielded what may well be the oldest wine production site (McGovern, 2003; McGovern *et al.*, 2017).

However, the first clear evidence for viticulture comes from the highlands northwest Iran. Residues have been found in jars of ca. 5400 BCE in the Neolithic settlement of Hajji Firuz Tepe at an elevation of 1,300–1,350 metres near the Gadar River that flows through it toward the east to eventually end in marshes bordering Lake Urmia (Michel, McGovern and Badler, 1993; McGovern, Fleming and Katz, 1996; McGovern, 2007; 2009). Chemical analyses of two Hajji Firuz jars showed the presence of characteristic triterpenoid compounds indicating that terebinth tree resin, with known antioxidant and antimicrobial proprieties had been added to grape wine. By mixing a tree resin with wine, it could have given medical properties to the beverage in question but also would have helped conserve the wine for a longer period of time (McGovern, 2009).

Similar red residues were discovered on two Late Chalcolithic (radiocarbon dated around 4000 BCE) potsherds found in the cave complex Areni-1 in present-day southern Armenia (Barnard *et al.*, 2011). Residue analyses performed on the sherds indicates the presence of grape products. In the cave, the archaeologists also discovered what has been interpreted as a grape pressing installation complete with fermentation vats and storage jars (Barnard *et al.*, 2011). All over the cave archaeologists found also grape seeds, stems and skins of desiccated vines confirmed to be the domesticated variety *V. vinifera vinifera* (Myles *et al.*, 2011).

Other evidence has been uncovered from 4th millennium sites. Grapes, usually identified as of the wild subspecies, have been recovered from several late 4th millennium BCE sites, such as Kurucutepe in south-eastern Turkey (Zettler and Miller, 1995). At Godin Tepe, situated in the valley of Kangavarin in the central Zagros, forty-three tablets have been recovered and dated to the Late Uruk period (ca. 3500-3100 BCE). One showed the cuneiform sign for a pottery vessel in the shape of a jar, with a narrow mouth and pointed base that could be related to the consumption of a specific beverage, such as wine (McGovern, 2009: 62). From the same period, jars have also been recovered at the site

(McGovern, 2009: 61-66). In one of the rooms, very large jars up to 60L in volume, thus impossible to transport when full, have been discovered. Across the courtyard, on the other side of the room, a very large funnel was excavated. Consequently, it has been suggested wine was produced directly on site (McGovern, 2009: 65) but no hard evidence (e.g. grape pips) has been uncovered (Michel, McGovern and Badler, 1993). If we accept the hypothesis of a winemaking facility, Godin Tepe could have been a wine production centre supplying the emergent city-states of lowland Mesopotamia, since the site is located along a historically important trade route passing through the Zagros Mountains (McGovern, 2009: 66).

In the Southern part of the Zagros Mountains, the Proto-Elamite (ca. 3300-2800 BCE) cities of Susa, Tepe Malyan and Shiraz are thought to have planted domesticated grapevines to produce wine on a large scale (McGovern, 2007: 164; Badler, 2008). We know from cylinder seals and iconographic evidence that wine was important in the Elamite culture (McGovern, 2007: 165-6). However, concrete evidence of a wine industry in this region is still elusive, though the region’s environment is amenable to viticulture. At Susa, located along the Karun River, organic residue analysis was performed on jars discovered there. The results showed that they had originally contained wine, with an unidentified tree resin additive. Tepe Malyan has been identified as the mountain capital city of Anshan. The site is located several hundred kilometres northwest of Shiraz. It has provided crucial evidence for domesticated grapevine (McGovern, 2007: 165). Excavations of the protohistoric site by the University of Pennsylvania Museum yielded numerous grape pips and even grapevine wood (Zettler and Miller, 1995).

By the Old Babylonian period (2000-1600 BCE), the presence of wine production and consumption is clearly attested, especially at the city of Mari on the Syrian Euphrates. Wine was traded using overland but also waterway (sea and rivers) routes. From the production sites, trading routes could have then passed by “supplier cities” before the wine was exported to major cities.
Possible sites of wine production and “supplier cities” are cited in the Mari archives (Powell, 1996; Chambon, 2011). For instance, Eluhut cannot be located with much precision, but must be sought in the mountainous area of the Ṭûr 'Abdîn, possibly near modern Mardin (Chambon, 2011). Another example is the

city of Ursu or Ursum, often appearing in the texts with Hassum, Carchemish and Yamhad (Ellison, 1978: 228). A texts relates the delivery of wine by boat passing through Ursu and Carchemish located in the basin of the Euphrates to Mari (Barjamovic, 2011: 199–200). The supply of Mari, under the reign of King Zimrî-Lîm (1775 to 1761 BCE), comes essentially from two cities located in the north-west of actual Syria: Carchemish and Aleppo (Ellison, 1978: 229) which benefited from a favourable geographical situation near the wine-growing regions of Anatolia. We could refer ourselves to the letters dated from 1750 BCE between a certain Bêlânu who was in charge of buying wine for the King Zimrî-Lîm, and a certain Ahûni a merchant (Chambon, 2011; Leemans, 1960; Oppenheim, 1967). We learn in particular that the wine was transported to Sippar and Mari generally by boat, and that the price of wine climbed sharply throughout its transport: the wine, but also the transport jars, the boats and their equipages and other intermediaries were included in the cost of the jar of wine (Chambon, 2011). We also learn through these letters that wine was present in the framework of diplomatic exchanges and used as a form of tax to the Kings (Ellison, 1978: 228). "Sâmum wine" particularly appreciated by King Mari Zimrî-Lîm - as evidenced by several cuneiform letters - is thought to originate in Zalmaqum where the city of Samum would be located. Mari's archives also occasionally mention other places such as Apisal or South Sinjar as a wine producing region (Chambon, 2011). The Mari archives mention also a local wine production at Hišamta supplying the palace and in particular Mari's queen, Šibtu (ca. 1775– 1761 BCE) (Chambon, 2011). Local wine production is also mentioned in texts of deliveries of wine from an estate at Terqa to the palace cellar at Mari (Ellison, 1978: 230).

Chemical findings as well as remains of grape seeds were recovered from inside amphorae on board of the ca. 14th cent. BCE Uluburun shipwreck excavated in the southern coast of Turkey (McGovern and Hall, 2016). Due to its characteristics (made of cedar of Lebanon) and content, the ship has been identified as a Canaanite merchant boat hailing from the eastern Mediterranean littoral (Katz, 2008; Pulack, 1998; Zangani, 2016; McGovern and Hall, 2016). The Uluburun shipwreck represents the trade in the ancient Near East during the second half of the 2nd millennium BCE (Katz, 2008) and attests of the importance of wine trade (McGovern and Hall, 2016).

The evidence for wine during the Neo-Assyrian period (911-609 BCE) and onwards suggests that wine was still clearly appreciated. The "Garden party" dated to Assurbanipal's reign (668-627 BCE) presents iconographic scenes depicting males and females seated under grape vines, drinking what is most likely wine from cups (McGovern, 2003: 199). We also know from texts that grapevines were brought to the royal garden of Assurbanipal (Albenda, 1974). Wine was also consumed during the Neo-Babylonian period (626-539 BCE) in southern Mesopotamia. A stele from the reign of Nabonidus shows the importance of wine in cults (Bayliss, 1973: 124), and a *kudurru* from the same period indicates that wine was imported to Babylonia after a drought that may have destroyed the local vines (Ellison, 1978: 233).

Looking at the evidence of viticulture in the ancient Near East, wine would have been produced first in the highlands in locations where the environment is favourable to grape vines' growth. Probably due to the upper classes and royalty demand in the late 4th millennium BCE, wine was traded and later on grapevines were transplanted closer to the major urban centres which made local winemaking possible (McGovern *et al.*, 1997). For instance, McGovern notes that Susa's geographic location between the lowlands and the uplands made it ideal to exploit resources there but also to distribute products in the lowland regions (McGovern, 2007: 164).

A similar process can be seen in Egypt. Wild grapes never grew in ancient Egypt and yet a thriving royal winemaking industry had been established in the Nile Delta by at least Dynasty 3 (ca. 2700 BCE, i.e. the beginning of the Old Kingdom period). Transplantation of the domesticated grapevine probably was preceded by trade, which would have created a market for the commodity. For instance, large quantity of jars have been discovered in the tombs of the Kings of the First Dynasty at Abydos alongside remains of domesticated grape pips and sliced figs (*Ficus carioca* or *F. sycomorus L.*). Chemical analysis of the clay of the pottery vessels revealed that the vessels were coming from the region of Palestine where archaeobotanical evidence establishes the domestication of grapevine in the Chalcolithic period and presumably a large scale production of wine by at least the Early Bronze Age (McGovern, 1997).

3.2.2.2 Wine types and ingredients

Several varieties of wine have been documented as being produced and consumed for specific occasions and by specific consumers. The epigraphic documentation in Mesopotamia, which spans three millennia, records about ten different types of wine, depending on the origin (vintages) and quality of the product (Powell, 1996). For example, in the administrative texts from Mari, six categories of wine are listed in a very specific order, according to their quality: *sîmum, du-ga, tardênum, Marrum, Hallum* and *tursummu*m. *Sîmum* has been interpreted as a sweet wine, a kind of liquor of superior quality. It is followed by *du-ga* and *tardenum*, designating wines of good quality. *Marrum* and *hallum* used to describe wines bitter and sour. Finally, the wine qualified *tursummu*, at the end of the list, corresponds to the poorest quality and has been interpreted as wine that has not yet fermented (Chambon, 2011).

Different varieties of wine are also listed in lexical lists of the Neo-Assyrian period, including wine of different origins, and also strong wine, sweet wine and what has been interpreted as vinegar (Ellison, 1978: 231).

Wine could also be flavoured in different ways by adding oil, honey, and tree resins (terebinth, pine, cedar, myrrh, etc.) (McGovern, 2009: 95; Chambon, 2011; Koh, Yasur-Landau and Cline, 2014). The aim of this practice was, aside from the pleasure of taste, a better preservation of the wine. Three categories of fragrant oil - cypress, myrtle and juniper - are mentioned in particular in the archives from Mari and associated with wines of good quality (Chambon, 2011). Besides the antimicrobial properties of many of these additives, some also possess astringent, diuretic, sedative, and stimulant properties (Koh, Yasur-Landau and Cline, 2014: 7–8). These same ingredients were archaeologically identified in jars discovered in the remains of a palatial storage complex uncovered at the site of Tel Kabri (ca. 1900–1600 BCE), Israel, contemporary site to the archives of Mari (Koh, Yasur-Landau and Cline, 2014). Organic residue analysis indicates that the Kabri palatial wine cellar included resinated red wine flavoured with honey, storax resin, terebinth resin, cyprus, cedar oil, juniper and perhaps even mint, myrtle (*Myrtus communis*) and possibly resinated white wine. During this period, the site was the center of a major Canaanite polity (Koh, Yasur-Landau and Cline, 2014).

In Egypt, we also have evidence of flavouring ingredients in wine involved in royal burial practices (McGovern, 1997; Guasch-Jané *et al.*, 2006; McGovern, Mirzoian and Hall, 2009). At Abydos, previously mentioned, the presence of the remains of figs could be evidence that fruits, otherwise unattested in ancient Near Eastern and Egyptian wine, could have been added to wine as a sweetening agent or for special flavouring. Chemical analyses of ancient organics absorbed into pottery jars have also revealed the presence of herbs and tree resins mixed in wine (McGovern, Mirzoian and Hall, 2009).

From the earliest Neolithic, the ancient world was thoroughly steeped in alcohol with textual and archaeological evidence attest of the production of different types of beer and wine and their prominent role in the social, political, economic, and ritual spheres. In the following section, I will examine the broader context of consumption, that is, the places, events, and occasions where beer and wine were consumed, as well as people and practices involved in the consumption of these symbolically loaded liquid items.

3.3 Spheres of consumption: where, by whom and how?

The choice of beverages and complementing them with additional flavour has important socio-economic and cultural implications since some of them could have been reserved for certain categories of people and specific contexts of consumption.

3.3.1 Where and by whom?

3.3.1.1 Beer

Beer was a fundamental part of everyday life as well as integral to ritual practices and the expression of social identity and intergroup relations (Dietler and Hayden, 2001).

Looking at beer's popularity solely through a functionalist perspective, beer was recognized for its nutritious quality (Hornsey, 2003: 83–84) and as such it was part of the common diet.

Beer as ration

For Ellison, evidence for the diet of "ordinary" members of society can be found in food ration lists (Ellison, 1981; 1983). They attest that cereal products, barley, bread and beer, were handed out as rations to workforces (Neumann, 1994; Joffe, 1998; Pollock, 2012) in several important cities (Nippur, Tell Asmar, Lagaš, Ur, Mari, etc.) from the third to the mid-second millennium (Ellison, 1981: 37).

Archaeological evidence of redistribution of liquid and semi-liquid rations such as beer have been proposed at Arslantepe phase VI corresponding to the last few centuries of the 4th millennium (Balossi Restelli, 2010; 2011; D'Anna, 2010: 171-174; 2012; D'Anna and Guarino, 2010; 2012) based on the discovery of large ceramic bowls. The crude, ubiquitous and mass-produced Uruk-period "bevel-rim bowls" (**Figure 3.3**) have been traditionally interpreted as rations containers and possibly beer-drinking vessels (Nissen, 1970; Potts, 1989; Pollock, 2013: 161). However, several scholars have noted "the practical difficulties" of drinking from them (Goulder, 2010).

Figure 3.3: Examples of bevelled-rim bowls (from Sanjurjo-Sánchez et al., 2018)

Beer seems to have been provided for workers, the amount depending on one's social status. Each ration issued was intended specifically for one person since their amount varied according to gender, age and status (Ellison, 1981: 37-39).

In ration lists from Lagaš in the Early Dynastic period, labourers (men and women) of different professions received bread, beer-bread, beer, fish, fruits (e.g. dates and apples) and dairy products (ghee and cheese) (Ellison, 1981: 42). At Ebla, ration texts dating around ca. 2500 BCE and the destruction of the city ca. 2250 BCE record information on the management of food supplies for the royal household and indicate that the king and the personnel of the palace administration received amounts of bread and beer contrary to the female personnel who received only barley (Neumann, 1994: 330).

In the later Ur III period, beer is mentioned sporadically in ration texts and usually allotted to specific people working for the palace as rewards for having accomplished special tasks. For instance, at Umma as well as Lagaš and Girsu, beer rations were issued to soldiers, generals, messengers, singers, riders, and other persons with unknown function (Neumann, 1994: 329; Ellison, 1981: 42). According to a Sargonic court proceeding, the official who was responsible for judicial inquiry received beer as part of the fees for his services (Neumann, 1994: 229). Beer was occasionally allotted to personnel working periodically for temples (Neumann, 1994: 328) as was the case at the temple of Enlil at Nippur (McCown, Haines and Hansen, 1967: 47–148; Potts, 2012: 230).

Ellison points out the difficulty of interpreting this type of text and the information they provide, as rations may not have been the only source of food consumed by the working population (Ellison, 1981: 38). For Potts, since only a limited range of foodstuffs was mentioned in the ration texts, it was impossible rations would have provided the basic nutritional requirements “unless the ration-receiving population was perpetually in state of malnutrition” (Potts, 1997: 57). Another possibility brought by Ellison is that the rations were not consumed at all but were used to purchase other commodities and necessities (Ellison, 1981: 38). Consequently, beer also affected ancient economies and social organisation, as it represented a means of compensation and possibly a form of currency (Neumann, 1994). Neumann (1994: 228) argues that the fact that beer allotments are mentioned so seldom during the Ur III period could be

explained by the fact that beer was also produced privately in common households.

Beer in the common households

Beer seems to have seeped into the daily life of the Mesopotamian population. It was used medicinally and often prescribed to treat various illnesses. Babylonian medical texts prescribed plant products - or most specifically parts of the plant such as leaves, blossoms, seeds, or roots prepared in various ways (e.g. crushed, dried, etc.) - mixed with an appropriate carrier: beside water and milk, alcoholic beverages like beer and wine occur frequently in medical prescriptions (Biggs, 2005; Scurlock, 2014).

People consumed beer in private households (Michalowski, 1994), as seen at Tall Bazi (Northern Syria) in the Mittani kingdom dated around the 13th-14th century BCE where evidence of private production and consumption of beer was discovered (Otto, 2012; 2015). It is important to point out that differences in the features of the domestic area (size, organization, equipment, etc.) had probably existed within the various regions in Mesopotamia depending on the status and wealth of those living inside (Otto, 2012). Yet, the material associated with the preparation and consumption of food uncovered archaeologically gives us an idea of everyday life at Tall Bazi.

Corresponding quite well to the image represented in the (supposedly) 2nd millennium BCE proverb: '*The house where beer is never lacking: she is there! The house rich in soup: that is her place! The house where there is bread in abundance: she is the one who cooks it!*' (Bottéro, 2004: 77), the normal daily diet seems to consist mainly of barley products, primarily bread and beer.

Botanical remains consist nearly exclusively of barley (Otto, 2012: 183). Ovens, used to bake bread, were discovered in almost every one of the houses (Otto, 2012: 181). Residue analysis of several ceramic vessels proves that brewing beer in ancient households was an important activity at Tall Bazi (Zarnkow, Otto and Berthold, 2011).

Beer was also popular for its recreational use. Beer was consumed simply for enjoyment as well as intoxication as evidenced by Mesopotamian proverbs such as "*Pleasure - it is beer. Discomfort - it is an expedition!*" (Gordon, 1959: 264,

2.123) or the passage of the “Hymn to Ninkasi” (ca. 1800 BCE), the Sumerian goddess of brewing, in which it is said that beer was drunk "*in a blissful mood, […] with joy in the heart and a happy liver*” (Jennings *et al.*, 2005: 275). In addition, Damerow recognized that beer was consumed in contexts not too dissimilar to today (Damerow, 2012) and was also consumed in public spaces, including taverns (Neumann, 1994).

Texts from late 3rd-millennium BCE show the importance given to construction and design of brewing establishments not only in major urban centres such as Girsu or Umma but also for small-scale settlements such as Garšana (Allred, 2006; 2011).

Iconographic representations suggest that men and women seemed to have communally and equally consumed beer. A lapis lazuli cylinder seal from the tomb of Queen Pu-abi's in the Royal Cemetery at Ur (Early Dynastic III period, ca. 2600 – 2500 BCE) (Woolley, 1934: 102, pl. 200), depicts a banquet scene in two registers (**Figure 3.4**).

Figure 3.4: Early Dynastic III cylinder seal and impression from Ur, showing persons drinking from a communal pot (upper row), and drinking from personal cups (bottom row) ©Trustees of the British Museum

The upper register shows a male and female participant seated together, likely drinking beer. Later on, a series of Old Babylonian (ca. 1800 BCE) erotic terracotta plaques, depict couples during sexual intercourses, drinking what may be assumed to be beer (Michalowski, 1994; Bahrani, 2001).

Ancient texts also attest that brewing was largely a female activity. The ancient Laws of Hammurabi, compiled and codified during the reign of King Hammurabi, the 6th ruler of the 1st Dynasty of Babylon (ca. 1800 BCE), suggest that drinking establishments were sometimes run by women (Trümpelmann, 1981; Neumann, 1994; Roth, 1997; Dixon, 2006). Indeed, while men participated actively in beer production and distribution, women also played a major social and economic role in ancient beer production (Hartman and Oppenheim, 1950). Women involved in the activity of bread-making, the brewing of beer and the profession of tavern-keepers, appear to be a common occurrence (Hartman and Oppenheim, 1950; Michalowski, 1994; Stol, 1995: 137; Roth, 1997; Dixon, 2006; Lion and Michel, 2016). In the Code of Hammurabi, the gender of the brewer is always feminine but the relation of women with beer brewing most probably existed prior to the Old Babylonian period. Indeed the activity of brewing beer was the only profession in Mesopotamia that was under the protection of a female deity: Ninkasi the goddess of beer and brewing; and also by Siris, who watched over those involved in beer production (Hartman and Oppenheim, 1950; Dixon, 2006; Lion, 2013). Even in mythical texts, Siduri, the erudite woman in the Epic of Gilgamesh, was a tavern-keeper. However, by the end of Hammurabi's Dynasty, women in charge of brew-houses ceased to be a common occurrence, in textual sources at least (Hartmann and Oppenheim, 1950; Dixon, 2006).

Beer and the elite

Beer as a beverage was popular not only with the common people, but also with the elite classes, especially royalty.

Beer was consumed by royalty and high dignitaries privately in their home and palace and also part of festivities and banquets. The Sumerian term for banquet (KAŠ –DE –A) literally means ‘pouring of beer’ which identifies the activity of drinking as the main purpose of such banquets (Michalowski, 1994: 29; Nowicki, 2014: 215). In the Old Babylonian Mari texts, the logogram for banquet, KI.KAS + NINDA, literally means "place of beer and bread" (Hornsey, 2003: 108).

Beer was consumed when kings visited other cities and high elites. For instance, beer is mentioned in the “silver ring” texts from Ur III PuzriS-Dagan recording a ceremony during which rings were given to high-rankings men and women as a means of payment (Michalowski, 1978). In the royal hymn A of the King Sulgi, the

king describes a feast in Nippur where he and his brother drank beer in the palace (Neumann, 1994). In the year 879 BCE, the Assyrian king Ashurnasirpal II (884 to 859 BCE) organized a festival and a great feast to celebrate the completion of his new city, Kalhu, and the inauguration of his grand new palace. He claims to have invited the whole country to attend including dignitaries. His Banquet Stele carved on one of the wall of his palace records the details of the celebration. Alongside a great variety of meats and spices, jars of beer and "fine beer" were served as well as wine (Grayson, 1991: 292–293). Feasts and banquets were thus an important tool to assert power and create actual kinship (Hayden, 2014: 340). These feasts include also a religious aspect: an invitation to the gods (Marti, 2011: 510).

Evidence discovered in the Pre-Pottery Neolithic site of Gobekli Tepe (Turkey) indicate that beer production and consumption were already part of cultic rituals and would have been an important factor in feasts (Dietrich *et al.*, 2012). In following periods, evidence shows that beer was consumed during public festivals (Otto, 2012: 187–189; Pollock, 2012) and was even part of the offerings during private celebrations like weddings, funerals and other death rituals. For instance, 3rd millennium BCE documents from the Sargonic period mention beer as a part of the *tirhatum*, the bridal gift, probably consumed during the banquet (Neumann, 1994). Beer was also part of the offerings taking place in the regular cult of the dead (Cohen, 2005) and was often mentioned as part of the "menu of the gods" (Nowicki, 2014; Michalowski, 1994).
While beer was drunk by every member of the society, it is possible that different kinds and qualities of beer were consumed not only depending on context but also linked to social status. Beers defined by additional adjectives are exclusively listed in palace archives. At Mari, for instance, the king quenched his thirst during his daily meals drinking *alappânu* beer, possibly a local beer variety (Bottéro, 2004: 92).

Certain types of beer may also have been produced for particular contexts such as rituals or feasts. However, as previously established, the available sources provide only very limited information on these variety beers and what processes or flavouring ingredients were involved in their production.

3.3.1.2 Wine

For McGovern, “wine belonged to a different social order in lowland Mesopotamia”, and only royalty could afford it (McGovern, 2009: 97). However Bottéro argues that even if “wine became important everywhere in the land” of Mesopotamia, it never dethroned beer (Bottéro, 2004: 96) that had been divinized (under the traits of Goddess Ninkasi) long before wine (Bottéro, 1995: 21–34, 2004).
Besides an economic value, it also had a certain cultural importance. Like beer, wine and grapes were assigned a tutelary deity: the Goddess Geshtin or Ama-Geshtin (Geshtinanna or Ama-Geshtinna) (McGovern, 2003).

Scholars generally agree that grape wine was an elite product. However, Chambon (2011) argues that different consumers were expected to drink different qualities of wine. While wines of good quality were reserved for royalty and elites, cheaper wine may have been consumed by soldiers, for instance in the Neo-Assyrian period (Ellison, 1978: 229). Bottéro also postulates that depending on the location and period, wine in regions amenable to viticulture would have been much more socially accessible product (Bottéro, 1995: 22).
Administrative documents found in the city of Mari dated to the first half of the 2nd millennium BCE) indicate that wine – most probably wine of good quality - was consumed by kings and queens. Indeed, we know that Mari's queen, Šibtu, had her own winery in this region that delivered wine directly to Mari's palace for her personal consumption. Women - or at least elite women - were not excluded from consuming wine (Chambon, 2011). Archaeologically, evidence of the importance of wine in the palace are the previously mentioned remains of the palatial storage complex uncovered at the site of Tel Kabri, Israel (ca. 1900–1600 BCE) (Koh, Yasur-Landau and Cline, 2014). Archaeologists here recovered the remains of approximately 40 restorable large, mostly handle-less, storage jars, as well as a few smaller vessels, all of which were found covered by a thick collapse of mudbricks from either the walls or the ceiling of the room. The large total volume of the stored wine – up to 2,000 liters – and the context of this storeroom, next to a ceremonial room within the palace in which banquets might have been held, contribute to a greater understanding of Canaanite court

ceremony and economy and the importance of wine for the private consumption of the ruler and his household (Koh, Yasur-Landau and Cline, 2014).

Wine was also consumed during feasts and banquets held to commemorate the visit of distinguished guests at the palace such as ambassadors or other sovereigns (Chambon, 2011: 502). In a text that describes the building of Nimrud, Ashurnasirpal states: '*I pressed wine and gave the best to Assur my lord, and the temples of my land*' (Grayson, 1991: 252).
Wine thus was used as offering to gods. This is also attested in the so-called 'Nimrud Wine Lists', a collection of wine ration texts. Before listing ambassadors of other kingdoms as recipients of wine rations, the first entry records wine rations for 'the regular offering' for the gods and for ceremonial purposes and additional amounts are listed 'for libations'(Kinnier Wilson, 1972: 112–113).
Wine was indeed present during nuptial festivities (Chambon, 2011) and wine was also used for libations during sacrifices and festivals such as the New Year Akitu-festival from Middle Assyrian Aššur (Scurlock, 2006) or the *zukru* festival at the Late Bronze Age Emar (Salaberger, 2012). Wine was also part of funerary offerings intended for the afterlife (McIntosh, 2005: 226–227).
The type of beverage and context of consumption have the potential to help identify social and cultural groups. However, it is important to acknowledge that the vessels and the performative gestures of serving and drinking are also the expression of cultural and social distinctions.

3.3.2 Drinking practices and spheres of consumption

Our knowledge of the vessels and gestures involved in drinking is limited. It derives mostly from iconographic sources and, in less detailed form, from archaeological inference and texts (Potts, 1997). Feasting is a popular motif in Mesopotamian art and a frequent topic in texts (Dietler, 2001; Schmandt-Besserat, 2001: 392–394 and 396–397; Bray, 2003: 1; Pollock, 2003: 22–24; Hayden and Villeneuve, 2011: 434; Romano, 2015: 290). Beverages and drinking practices are central themes in these depictions, with food being rarely depicted. In fact, in most iconographic representation of feasts, only occasionally does food emerge (except from the depiction of bread and food being transported to the feast); the main (and often the only) motif being

depicted, however, is drinking. For Pollock, it “suggests that drinking and the dispensing of liquids may have held a greater symbolic and/or ritual importance than eating” (Pollock, 2003: 24-25). Yet, the specific beverage depicted in those drinking scenes often cannot be identified conclusively.
However, changes and continuities in beer and wine consumption practices through times may be explored.

3.3.2.1 Ubaid period (ca. 6500 and 3800 BCE)

In the Ubaid period - characterised by village-based settlements and increasing social stratification (Balossi Restelli, 2011) - food and drink production and consumption seemed to have taken place primarily in large domestic spaces as illustrated by the number of ceramic vessels discovered (Helwing, 2003; Pollock, 2013: 154). These vessels - shallow bowls, goblets and cups - vary in size and present painted decorations that suggest “intra- and inter-household differentiation in domestic commensal practices” (Pollock, 2013: 155-156). In the course of the Ubaid period, decorations on vessels became simpler and in the terminal Ubaid phase, painting on vessels disappeared completely and the diversity of shapes and sizes decreased (Pollock, 2013: 156). The decrease in variation does not represent equality as differentiation could have been expressed by the usages and gestures involved in handling these vessels (Pollock, 2013: 156-157). Moreover, consumption could range from individual consumption in small containers to communal consumption from larger vessels. Seals from the Ubaid period depict drinking scenes and the consumption of what has been interpreted as beer from large communal piriform jars that sat on the ground using long tubes. A seal impression from Tepe Gawra (ca. 4000 BCE), for instance, shows human figures drinking from an enormous jar with bent straws (Rothman, 2002) (**Figure 3.5**). These straws enabled people to share beer but also to reach the beer that lay beneath the impurities on the beverage's surface (Wright, 2010: 224, note 51), like it is still the case today for instance in South Africa (Karp, 1980). However, the limited evidence does not allow us to determine if other beverages were also consumed from shared vessels and if beer was consumed in other ways. What we do know is that beer continued to be shared from communal vessels in the following periods.

Figure 3.5: Drawing of a seal impression found at the site of Tepe Gawra in northern Iraq dating around 4000 B.C.E. (after Tobler, 1950, Pl. CLXIII: 91)

3.3.2.2 Uruk period (ca. 4000–3100 BCE)

During the Uruk period - characterised by a shift from small agricultural villages to larger urban centers with a full-time bureaucracy, military, and stratified society, including a ruling class - the increase in the number of vessel forms and in particular spouted jars and flasks indicates increased use of beverages made and stored in closed vessels (Delougaz, 1952: 125–137). Moreover, as seen above, beer was also associated with labour’s compensation, and Uruk beveled-rim bowls, as some have suggested, may have served as ration containers for cereal derivatives such as cereal grains and beer (Joffe, 1998; Pollock, 2013: 161).

3.3.2.3 Early Dynastic period (ca. 2900–2350 BCE)

During the Early Dynastic period - characterized by the existence of multiple competitive city-states and the pronunciation of social stratification – we witness the increasing variety of ceramic vessels.

The Early Dynastic period ceramic assemblage appears to be dominated by individualised drinking vessels (Pollock, 2013: 161). This includes especially the

so-called footed goblets and small jars such as those excavated at Tell Abu Salabikh (Postgate and Moorey, 1976; Martin, Moon and Postgate, 1985: pl. XXVIc; Moon, 1987) (**Figure 3.6**).

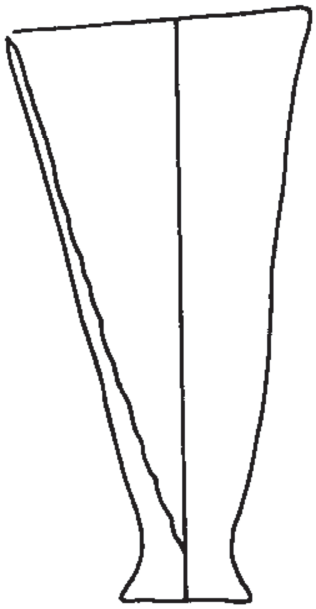

Figure 3.6: Example of footed goblet discovered at Abu Salabikh (Early Dynastic period) (from Moon, 1987)

However, contemporary depictions still show the previously mentioned use of shared beer consumption vessels. A lapis lazuli cylinder seal from the tomb of Queen Pu-abi in the Royal Cemetery at Ur (Early Dynastic III period, ca. 2600 – 2500 BCE), depicts a banquet scene in two registers (Woolley 1934: 102, pl. 200). The upper register shows a male and female participant seated on either side of a wide-mouthed jar drinking from long straws or tubes (**Figure 3.4**). A couple seated behind them and several more in the second register are drinking their beverages from cups, balanced on their palm or fingertips, a way of handling the vessels that would certainly have required knowledge of particular etiquette and skill (Pollock, 2003). Roughly contemporary limestone plaques from Tell Khafajah in the Lower Diyala region, depict feasting events and similarly show a variety of drinking practices (Frankfort, 1939: 185 and 18, Pl. 105 and 107, 185 and 18). In one of them, a large jar with a narrow neck is transported to the feast taking place in the upper register (Frankfort, 1939: 185, Pl. 105) (**Figure 3.7**). Here, three seated figures drink from small, rounded

bowls balanced on their finger tips or grasping the long stems of pedestal cups. However, it is impossible to determine what beverage(s) was (were) consumed (Breniquet, 2009). Cylinder seals from the same site also depict the consumption of what is most likely beer in large jars through long straws (Frankfort, 1955) (**Figure 3.8**).

The observed differences in consumption equipment – bowls and cups versus large jars and straws – have thus usually been interpreted as indicating the consumption of different beverages, with bowls/cups commonly associated with wine (Stronach, 1995).

Metal vessels, as textual evidence attests to, were the preferred drinking equipment of the high elite (CDLI no.P431882), though only few have survived in the archaeological record. The Royal Cemetery at Ur has yielded a significant array of drinking equipment made from gold and silver as well as semi-precious or special stones (e.g. lapis lazuli, marble, obsidian, etc.) (Weber and Zettler, 1998 : 138-139; Potts, 1997 : 148; Moorey, 1980 : 182). They take the form of cups, pitchers, and strainers as well as a drinking tube in gold and lapis lazuli (Moorey, 1980: 182; Potts, 1997: 148).

Figure 3.7: Stone plaque with a banquet scene (top register) showing seated individuals drinking a beverage from cups (Khafajeh, Iraq, Early Dynastic period - ca. 2600-2350 BCE). (Oriental Institute of the University of Chicago)

Figure 3.8: Cylinder seal (left) and modern rolling (right) showing the consumption of beer through long, reed straws. (Khafajeh, Iraq, Early Dynastic period - ca. 2600-2350 BCE) (Oriental Institute of the University of Chicago)

3.3.2.4 Old Babylonian period (ca. 2000-1600 BCE)

The same drinking practices are attested in the Old Babylonian period (ca. 1800 BCE). A series of erotic terracotta plaques depict copulating couples with the woman bending over to drink what could have been beer from a large jar through a straw (Bahrani, 2001) (**Figures 3.9** and **3.10**).

Figure 3.9: Old Babylonian Fired clay plaque showing a woman drinking through a straw from a jar resting on the ground ©Trustees of the British Museum

Figure 3.10: An Old Babylonian clay plaque depicting a couple having sex (photo credit: The Israel Museum)

The dichotomy between bowls and cups versus large jars and straws that have usually been interpreted as indicating the consumption of different beverages, with individualised cups commonly associated with wine (Stronach, 1995) is challenged here. However, other scholars have suggested that jars, bowls and cups may have been used for the consumption of beer in the 3rd millennium BCE (Ellison, 1978). Wine and beer seemed to have been consumed in both as proved by two monumental cylinders containing the myth of "The building of Ningirsu's temple and commissioned by King Gudea of Lagash (ruling around 2200- 2100 BCE) (CDLI no.P431881 and P431882). While the first cylinder relates the different phases of construction of the temple of Ningirsu, the second describes the enthronement of the divine couple king and queen of Lagash and finally the ceremony of the sacred marriage. In this second cylinder, beer and wine are mentioned as being part of the ceremony alongside other delicacies such as syrup, butter oil, wine, sour milk, fig-cakes, cheese, dates and grapes. In the text, it is said that gold bowls were filled with honey and wine. However, it is

also said that "*beer was poured into bowls and wine into jars*" (CDLI no. P431882).

Ellison proposed that different drinking equipment may indicate differences in beer brewing techniques. Straws depicted as protruding from the beer jars, were used to filter out thick and cloudy beer full of pieces of beer bread and herbs and other impurities (Ellison, 1978). Archaeologically attested are also metal strainers that would have been placed at the tip of the straws to filter the beer. The use of cups, according to Ellison, suggests a brewing or preparation technique that produced less kräusen or wort and fewer unpleasant impurities (Ellison, 1978).

3.3.2.5 Kassite period and following periods

Following the Old Babylonian period, drinking scenes become rare in the iconographic repertoire of Mesopotamia. Kassite-period (ca. 1500-1100 BCE) cylinder seals, stele, wall reliefs and moulded brick façades do not depict banquet or other scenes involving the consumption of food and drink. We thus have to refer ourselves to the archaeological material.

Metal strainers that could have been fitted at the end of these tubes or straws have been discovered at Tell Bazi (14^{th}/13^{th} centuries BCE) and are associated with individualised cups (Otto, 2012). Beside the discovery of beer brewing vessels (*namzitu*, large beer vat, storage jar), small ring-based pots with varying body types have been unearthed. In several instances, they also presented decorations, similar to the 'Habur ware' previously described, with red to brown painted horizontal or spiral bands. One of these painted examples was associated with a bronze filter tip from a drinking straw used for drinking beer (**Figure 3.11**). The presence of oxalate residue identified in one of these vessels using a Feigl spot test indicates that beer was consumed from individualised vessels through straws at Tell Bazi (Otto, 2014) (Results not published).

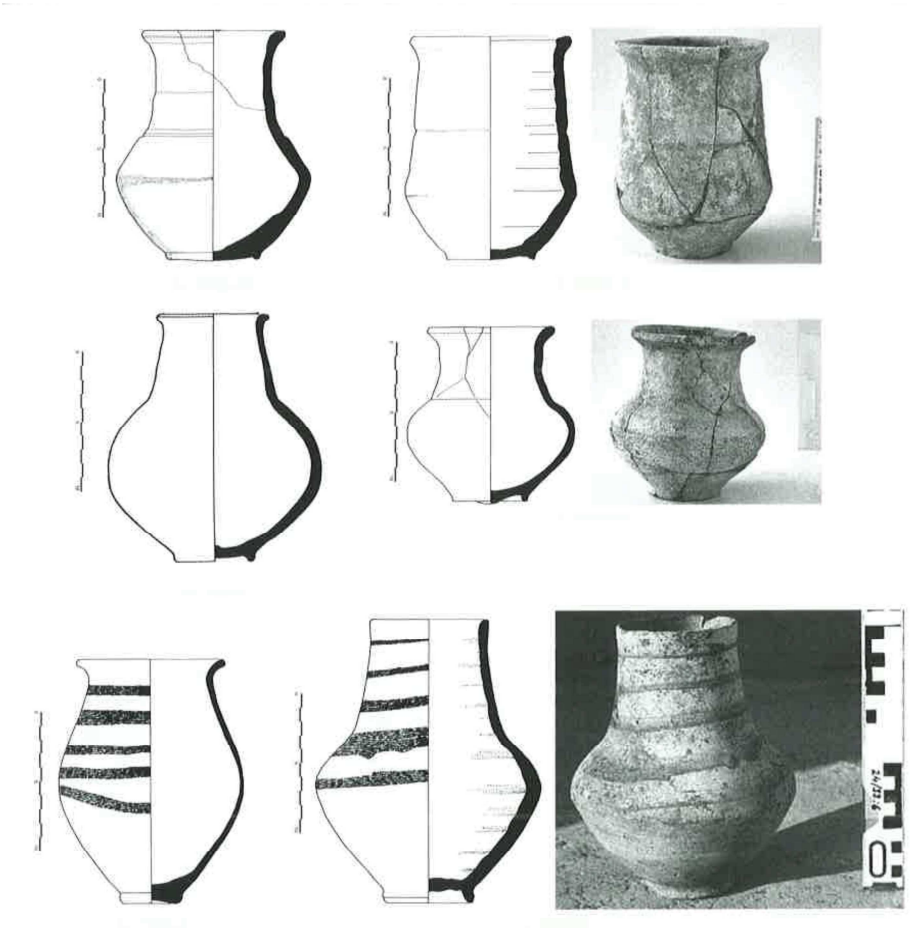

Figure 3.11: Small ring-based pots found at Tell Bazi (from Otto et al., 2014)

At Tell Khaiber, a site located in southern Mesopotamia and occupied during the second millennium BCE, small cups and bowls indicative of individual consumption dominate the ceramic repertoire (Calderbank, 2018).

A drastic reduction in the ceramic repertoire of settlements associated with Kassite-Babylonian ceramic traditions (Armstrong and Gasche, 2014; Armstrong, 2017), which includes the disappearance of large jars of the type depicted on earlier beer-drinking scenes, would suggest a shift in consumption practices, at least as far as the use of ceramic vessels is concerned.

Later on, Neo-Assyrian banquet scenes usually represent characters holding a cup in one hand usually with a wide-mouth such as the one depicted in the Garden party of Ashurbanipal. The flat-based bowl with what seems to be gadroon on its body held by Ashurbanipal has been often interpreted as containing wine. This type of wide-mouth bowls has been discovered during the excavations at Nimrud and included examples made of precious metal (gold, bronze and silver) (Curtis, 2008). Ellison notes that archaeological discoveries

include footed goblets and beakers, which could have been used to drink wine. For instance, ceramic palace ware beakers were discovered at Neo-Assyrian Nineveh, but they may have also been used for drinking beer. In any case, the quantity of liquid which could be held by these vessels would have varied greatly (Ellison, 1978: 232-233).

To conclude, examining the information collected about wine and beer consumption through time, one key observation emerges. While information on instruments and processes involved in alcoholic beverages production has been easily explored, our knowledge of flavouring ingredients and consumption practices, in particular gestures and vessels involved in drinking and serving, is still limited. And yet, practices involved in beverage service and consumption can provide important information on ancient societies’ organisation and cultural traditions.

The act of drinking is primarily a social act. Indeed drinking occurs almost exclusively in the context of social interaction. It means also that the choice of beverages and drinking behaviour are often governed by cultural rules and expectations.

Very little work has been realized so far on these issues and what could they mean in term of expression of identities and social relationships. New investigations are thus crucial.

In contrast to traditional archaeological method, extant textual and iconographic sources, organic residue analysis has the potential to identify confidently contents of ancient vessels, unravel ingredients involved in beverage preparation, but also shed light on consumption settings and practices with the identification of specific vessels involved in the production, service and consumption of particular beverage items.

This is the main aim of this thesis. As presented in the following chapters, organic residue analysis was carried out on ceramic vessels uncovered at the Late Bronze Age site of Khani Masi, located in the Upper Diyala Region of Iraq, in order to investigate their contents and reflect on the social and sensual experience of drinking in the Late Bronze Age.

4 Accessing senses through archaeological data: Case study and Methodology

Reflecting on drinking as a sensory experience can be facilitated and improved by the use of archaeometry. This project goes beyond what we know so far from texts, iconography and the macroscopic archaeological record to access the invisible: absorbed residue inside ceramic vessels. Through the chemical characterization of vessel contents arises the possibility to measure, analyse and interpret the characteristics of the beverages that were consumed in the past and to advance, on a firm empirical basis, hypotheses of how and where they were consumed and perceived by the five senses.

It is what I wished to explore in my case study: ceramic drinking vessels from the Late Bronze Age site of Khani Masi. Yet, no material analysis can ever be divorced from its historical and archaeological context. With the aim of discussing the sensorial experience of drinking, it is imperative to know the contexts in which beverages were consumed.

This chapter will, firstly, provide a brief summary of the site of Khani Masi (**Section 4.1**), its environmental features that likely would have influenced consumption (**Section 4.1.3**) as well as the ceramic assemblage discovered at Khani Masi (**Section 4.1.4**), before moving on to a discussion of the theory and practice of organic residue analysis (ORA) in archaeology (**Section 4.2**). One section will be particularly devoted to analysing the limitations of previous approaches in ORA, thus drawing attention to lacunae, which this thesis intends to find a solution to (**Section 4.2.2.3**).

4.1. Khani Masi site

Ceramic vessels from the Late Bronze Age site of Khani Masi form the central case study of this thesis. Khani Masi consists of a large monumental complex located in the Upper Diyala plains of northeast Iraq.

Khani Masi was first recorded in 2013 by the Sirwan Regional Project (SRP) (**Figure 4.1**), an international collaboration directed by Dr. Claudia Glatz (University of Glasgow, UK), Prof. Jesse Casana (Dartmouth College, USA) in

collaboration with the Garmian Directorate of Antiquities (Glatz and Casana, 2016; Casana and Glatz, 2017; Glatz *et al.*, 2019).

Khani Masi presents an ideal case study for the investigation of alcohol consumption and its social implications.

First, the site yielded an abundance of ceramic vessels, in particular drinking vessels (Perruchini *et al.*, 2018; Glatz *et al.*, 2019). And while those ceramic types, such as the iconic Kassite goblets, have been thoroughly typologically studied (e.g. Armstrong and Gasche, 2014), their purpose(s) and functions were so far unknown.

Furthermore, Khani Masi yielded evidence for a range of ritual practices as well as likely feasting, which were critical contexts for the expression and negotiation of identity(ies), including through the consumption of food and drink (Glatz e*t al.*, 2019).

Finally, Khani Masi material culture and monumental architecture identifies it as an important regional centre in the Kassite period (ca. 1595–1155 BCE), a period as yet shrouded in mystery. The Kassite period represents a long and rich part of ancient Babylonia history. And yet, texts and iconography from this period have been largely discovered in the southern part of the Kassite kingdom (e.g. Nippur and Ur) and dated to the second half of the Kassite period (Brinkman, 1976). Furthermore, the subjects presented in these texts are very limited with little socio-economic and diplomatic information, legal administration documents as well as building activities. Other subjects related to identities such as everyday lives as well as cultural and religious aspects are absent from the repertoire of textual sources from this period (Brinkman, 1976; Evans, 2008: 201).

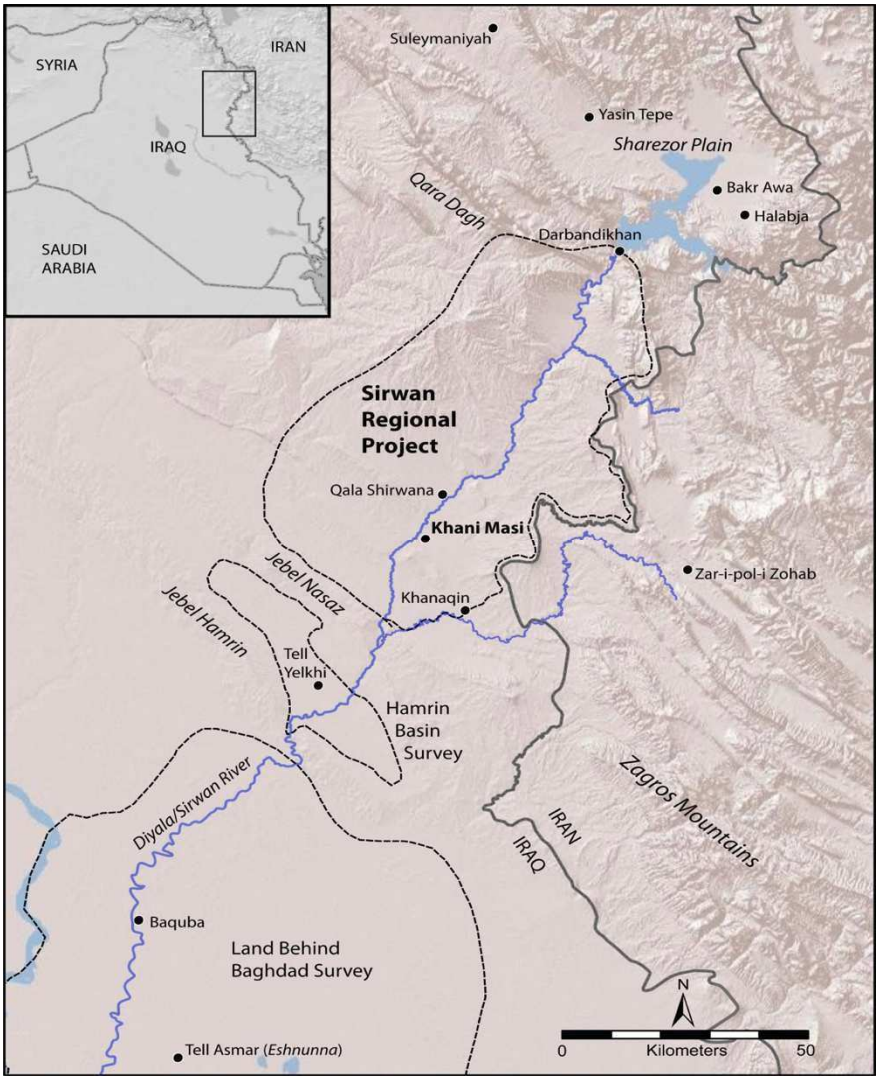

Figure 4.1: Map of the actual scope of action of the Sirwan Regional Project (adapted from Glatz and Casana, 2016)

Archaeologically, the evidence is also very scarce and only a few sites dated from the Kassite period have been excavated so far, mainly concentrated in southern Mesopotamia, for instance Nippur (Zettler, 1993) or Ur (Clayden, 2014), and only hardly any beyond this area (e.g. Boehmer and Dämmer, 1985). Excavations at Khani Masi provide new insights so far lacking on cultural aspects and social organisation in the Kassite period.

4.1.1 Outline of the Khani Masi site

Khani Masi consists of a low mound measuring 3-4m above the plain level whose main phases of occupation date to the later part of the second millennium BCE (Glatz *et al.*, 2019).

Magnetic gradiometer surveys in 2014 and 2017 demonstrated the presence of a series of large-scale, and in some cases monumental, structures at the site (**Figure 4.2**). The largest building complex identified during the magnetic gradiometer survey is located at the south-eastern end of the site and measures approximately 80x90m (Glatz and Casana, 2016). To the north and north-east of this building complex, are located a series of other sizable structures (**Figure 4.2**).

An on-going program of large-scale excavations was initiated in summer of 2016. The primary aims of these excavations were to expose some of the large-scale architectural features identified by the magnetic gradiometer survey and to reconstruct on the basis of detailed material analyses, the site's settlement history, function and cultural milieu (Glatz *et al.*, 2019).

Several trenches were investigated at SRP 46 and other component mounds of the Khani Masi cluster (**Figure 4.2.a**). For the purpose of this thesis, I will focus on the three trenches which yielded the ceramic material here analysed: trenches Y88/Y89 opened to explore the monumental complex, trench V85 that revealed a domestic building superseded by an industrial area, and trench L80 in the north-western part of the site, another industrial area (**Figure 4.2.a**). Trench K136D explored the neighbouring component mound of SRP 94, a rather substantial late third to early second millennium BCE settlement, from which a cup was also analysed for comparative purpose.

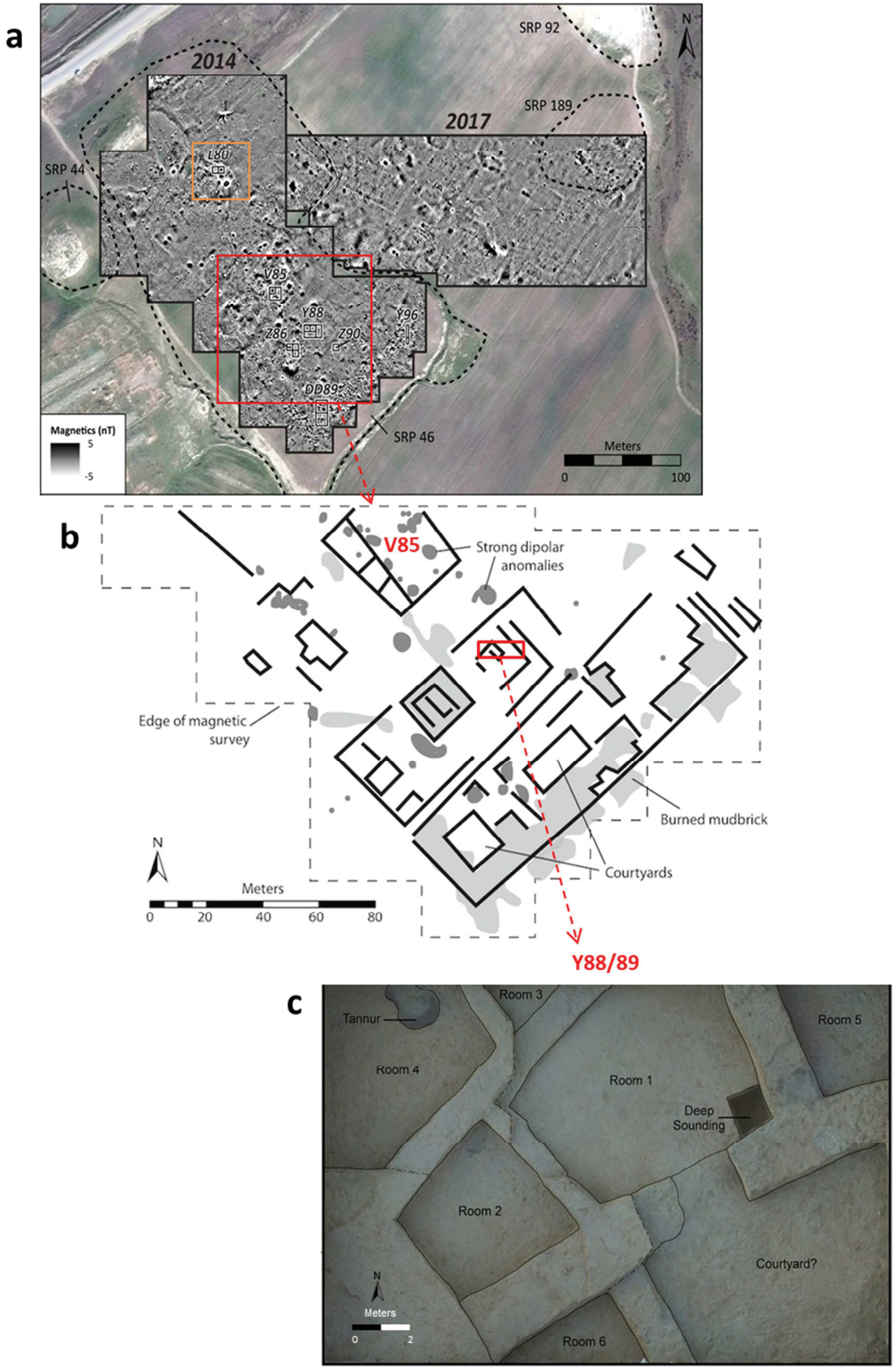

Figure 4.2: a. Results of magnetic gradiometry survey at SRP 46 with the location of the trenches (adapted from Glatz *et al.*, 2019); b. Interpretative plan of SRP 46 with trenches names mentioned in this thesis (adapted from Glatz and Casana, 2016, Fig.8); c. Annotated orthophoto of the second building phase of the building in Y88/89 (from Glatz *et al.*,2019)

4.1.2.1 Monumental Complex: trenches Y88/Y89

The majority of the material analysed in this thesis derives from trenches Y88/Y89, which exposed a cluster of four trapezoidal rooms and possible courtyard area in the north-western part of the monumental complex (30x40m) (**Figures 4.2.b and 4.2.c**). The structure, alongside others to the north, was built using unbaked mudbrick and mudbrick packing on what appears to be virgin soil (**Figure 4.2.b**) (Glatz *et al.*, 2019). An external wall, which separates the suite of rooms from the internal courtyard, measures ca. 1.2m in width (**Figure 4.2.c**), while smaller, internal walls have a width of ca. 40cm. The largest, central Room 1 measures ca. 4x6m and was exposed almost in its entirety. It is flanked by a smaller room (Room 5) to the east and three excavated rooms (Rooms 2-4) to the west as well as a possible courtyard identified to the south (**Figure 4.2.c**) (Glatz *et al.*, 2019).

A total of three building phases are attested, separated by destruction events (Glatz *et al.*, 2019). Much of the data for this study derives from the third and final phase of occupation of the monumental complex and from subsequent ritual activities (Glatz *et al.*, 2019).
The third phase of rebuilding includes the widening of the southern entrance to Room 1 and a possible cutting of an entrance passage between Rooms 1 and 2. The remnants of a curved baked brick-lined drainage were exposed in the south-western part of Room 1 (**Figure 4.2.c**). Floor surfaces in Room 1 and Room 5 and the collapse layer just above were littered with the material paraphernalia of commensal consumption (Glatz *et al.*, 2019): large quantities of small drinking vessels, larger footed goblets and other consumption-related vessels (**see Figure 4.3**) that were analysed as part of my corpus (Perruchini *et al.*, 2018). Evidence of food preparation activities were found to the west and north-west, with Rooms 2, 3 and 4 (**Figure 4.2.c**) yielding cooking installations and faunal remains (Glatz et al., 2019). A charcoal sample from Room 1 dates the material sealed under the collapse layer to between 1415 to 1290 cal. BCE (Glatz *et al.*, 2019).
Dug into the final collapse layer of the central Room 1 (**Figure 4.2.c**) were at least three separate instances of cult-related depositions (Glatz *et al.*, 2019; Perruchini *et al.*, 2018). One was a neo-natal or small infant jar burial dug along the northern wall of Room 1, the other two appear to be ritual offerings not

directly associated with burials (Glatz *et al.*, 2019) (**Figure 4.2.c**). Offering 1 consisted of two very similar drinking goblets with globular bodies, flaring rims and narrow bases (Armstrong and Gasche, 2014: Group 195), a faience bucket with loop handle (Clayden, 1998: Type II) and a gold earring (Glatz *et al.*, 2019). Also found nearby was the better part of a beer brewing vat (Glatz *et al.*, 2019), a large open-mouthed vessel with perforated base known as DUGNÍG.DÚR.BÙR or *namzitu* in cuneiform sources (Gates, 1988). Offering 2 consisted of a simple straight sided bowl in which were stacked a somewhat larger drinking goblet with straight neck (Armstrong and Gasche, 2014: Group 205), and a faience bucket with simple rim (Clayden, 1998: Type I) (Glatz *et al.*, 2019; Perruchini *et al.*, 2018). Part of these two cult offering sets was analysed as well as other ceramic vessels discovered near the burial and the *namzitu* (see **Chapter 5** and Perruchini *et al.*, 2018).

4.1.2.2 Trenches V85 and L80

The magnetic gradiometer survey indicated the presence of another large (ca.30x40m) trapezoidal structure to the northwest of Y88/89, consisting again of a large courtyard with a series of rooms along its western side and several large magnetic anomalies within the structure (**Figure 4.2b**). Trench V85 (10x10m) was opened in the middle of this structure. In first phase of activity in the building, the excavation at V85 revealed an intramural infant pit burial radiocarbon dated between 1505 and 1416 cal. BCE which provides a broad *terminus post quem* for the construction of the first phase of this structure (Glatz *et al.*, 2019). The structure and surrounding areas were subsequently re-used for industrial activities, as attested by several ovens and two large domed kilns being constructed on top of the wall-stumps of the earlier house (Glatz *et al.*, 2019). Pottery vessels from these two phases were analysed using ORA (see **Section 5.1**).

Another industrial area in the north-western part of the site was investigated in trench L80 (**Figure 4.2a**). In the east part of the trench excavations revealed another large kiln with large amount of ceramics, lithics, bones, as well as fragmentary metal. Tannurs and a food preparation area were also identified. A role in food preparation is further supported by the presence of cooking wares to the north of the installation as well as a stone grinder found sitting on the floor surface directly west of the southern installation (Glatz *et al.*, 2019). In the

south-west corner of the trench, a concentration of features also suggests a function in food preparation (e.g. oven) (Glatz *et al.*, 2019). In a final phase, we can see the disuse of the industrial installations and a phase of ritual deposition. In the centre of the western half of Trench L80 was found deliberately covered by the bricks and brick fragments a large cylindrical ceramic object, most likely a stand with fenestrations at the top and with a prominent decorative relief showing three Mischwesen so far never encountered in the literature (Glatz *et al.*, 2019). A footed cup from this phase has been analysed using ORA (see **Section 5.1**).

4.1.3 The archaeobotanical record

The archaeobotanical record from SRP 46 currently includes a predominance of barley (*Hordeum sativum*), as well as emmer (*Triticum dicoccum*), einkorn (*Triticum monococcum*) and bread wheat (*Triticum aestivum*) (Glatz *et al.*, 2019). This is broadly in line with the usual flora mentioned in textual evidence (Zeder, 1991; 2011; Potts, 1997: 86) as well as the archaeobotanical records from other archaeological sites excavated in the Upper Diyala region (Zeder, 1991; Zohary and Hopf, 2000) (**Section 3.1.2**).

4.1.4 The ceramic assemblage

The ceramic assemblage recovered at Khani Masi is characteristic of the Late Bronze Age Babylonian tradition (**Figure 4.3**) (Armstrong, 2017; Armstrong and Gasche, 2014). The ceramic assemblage of the Kassite period consists of: 1) small and large bowls with straight or wavy sides, 2) footed cups that still resemble their predecessors in the Late Old Babylonian period but are characterized by their bases, 3) goblets which are the most characteristic and recognizable vessels of the Kassite period, 4) small jars and finally 5) large vessels such as storage jars and *namzitu* (Armstrong, 2017: 421). Studies by Armstrong (2017) and Armstrong and Gasche (2014) are registering the homogeneity and small size of the ceramic assemblage during the Kassite period in the centre of the Kassite Babylonian kingdom as well as peripheral regions (Armstrong, 2017: 421). Nevertheless, Glatz and Casana noted that, despite being typical of the Kassite period, there is more variation amongst individual

formal types at Khani Masi than is often given credit in Kassite assemblages, which are conventionally presented as highly standardized (Glatz and Casana, 2016).

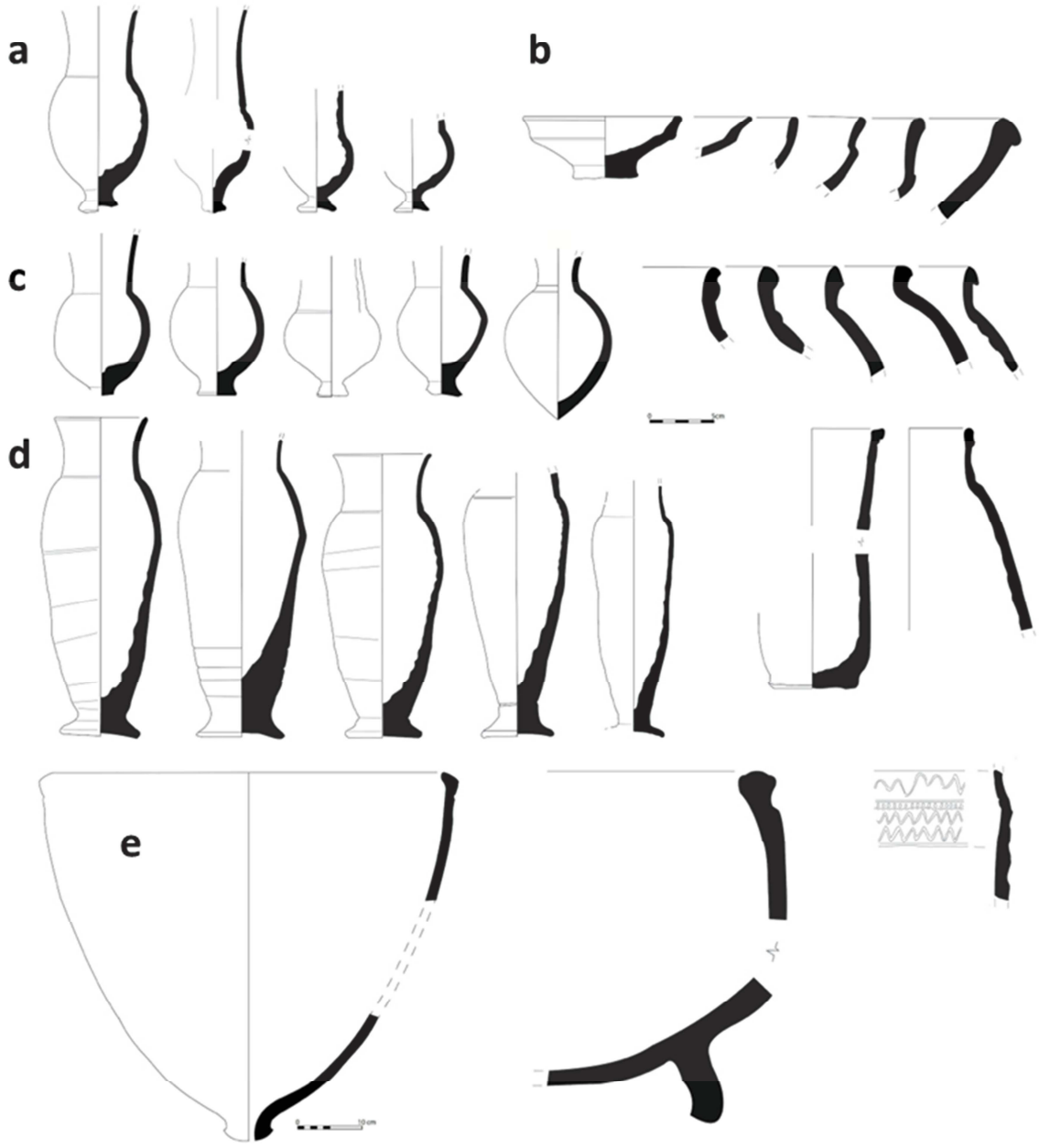

Figure 4.3: The Late Bronze Age pottery assemblage from Khani Masi (from Glatz *et al.*, 2019)

The most common vessel shapes in the assemblage are goblets and cups, such as those found in large amounts in Y88/89. Goblets (**Figure 4.3.d**) are present in a range of sizes, from impractically tall, steep-sided shapes, to squatter, more

rounded vessels (Glatz *et al.*, 2019). Cups (**Figure 4.3.a and c**) generally have a rounded body shape, but base and neck shapes show a good degree of diversity (Glatz *et al.*, 2019). Bowls (**Figure 4.3.b**) are common in two main shapes: straight-sided and wavy-sided (Glatz *et al.*, 2019). Large vats have also been discovered such as large open-mouthed vessel with perforated base known as *namzitu* (**Figure 4.3.e**), often associated with the filtering of contents during beer brewing (Zarnkow *et al.*, 2011; Glatz *et al.*, 2019; Perruchini *et al.*, 2018) and flat base cylindrical vessels, often identified as "grain measures" (Glatz *et al.*, 2019).

Each characteristic element of the ceramic assemblage discovered at Khani Masi was investigated through ORA. ORA in archaeology has made great strides since its introduction in the 1970s, with the discipline encompassing today a vast range of archaeological materials and the identification of diverse natural and processed sources. ORA has not only been applied to freshly excavated artefacts, but also to museum objects (Koh and Birney, 2019) opening up a new world of possibilities for archaeological research. The synopsis of the Book "Organic Contents of Ancient Vessels: Materials Analysis and Archaeological Investigation" by Biers and McGovern states that the papers presented in the volume "clearly demonstrate the importance of investigating organic residues to elucidate crucial aspects of ancient life such as agriculture, trade, ritual practice. Much of the information presented here could only have been derived using scientific techniques of analysis" (Biers and McGovern, 1990). However, while it seems that ORA is today an established discipline, several questions and challenges in this research field still remain unresolved. The following section will explain the motives for applying ORA to archaeological material as well as highlight the strengths and limitations of this approach. It will focus mainly on reviewing method and techniques development in residue analysis in archaeological pottery and how this thesis contributes to this field of research.

4.2 Organic residue analysis in archaeology

ORA has been extensively applied to archaeological studies first and foremost to determine the original contents of vessels (e.g. Condamin *et al.*, 1976; Charters *et al.*, 1993b, 1995; Evershed, 1993; Heron and Evershed, 1993; Evershed *et al.*,

2003; Malainey, 2007; Dunne *et al.*, 2012; Cramp *et al.*, 2014; Colonese *et al.*, 2017; Nieuwenhuyse *et al.*, 2015; Roffet-Salque *et al.*, 2017; Evershed, Heron and Goad, 1991; Copley *et al.*, 2001a; Baeten *et al.*, 2013). Analysing the content of vessels enables researchers to address specific archaeological questions: it can inform us about vessel use (e.g. Charters *et al.*, 1993b, 1995; Evershed *et al.*, 2003; Oudemans, 2007; Namdar *et al.*, 2009; Nieuwenhuyse *et al.*, 2015), craft production (e.g. Charters *et al.*, 1993a), support or challenge theories regarding ancient economies (e.g. Dudd and Evershed, 1998; Copley *et al.*, 2001b; 2003; 2005; Craig *et al.*, 2007) as well as revealing insight into ancient diet and cuisine (e.g. Mukherjee, Gibson and Evershed, 2008; Craig *et al.*, 2011; Colonese *et al.*, 2017), long-distance trade (e.g. Namdar *et al.*, 2009; 2013; Namdar, Amrani and Kletter, 2015) and even traditions/cultural practices (e.g. Namdar, Neumann and Weiner, 2010; Namdar, Amrani and Kletter, 2015). Finally, another successful application of ORA is in detecting key technological developments in human history such as the shift to agriculture (e.g. Debono Spiteri, 2012; Debono Spiteri *et al.*, 2016), such as the detection of dairy fats which certifies the practice of pastoralism (e.g. Dudd and Evershed, 1998; Craig, 2002; Copley *et al.*, 2003; Evershed *et al.*, 2008; Dunne *et al.*, 2012; Cramp *et al.*, 2014; Debono Spiteri *et al.*, 2016).

Organic residue analysis in archaeology is employed today on a vast range of porous artefact types and has allowed the identification of diverse natural sources. To name a few: residues left on lithic tools during use (e.g. Buonasera, 2005; 2007; Monnier *et al.*, 2013), residues left in plaster and other archaeological floors by human activities (e.g. Binford, 1967; Barba, 2007; Pecci, 2013; Pecci *et al.*, 2013; Pecci, Barba and Ortiz, 2017), substances such as organic colourants on textiles used in mummification (e.g. Brettell *et al.*, 2015), metal (e.g. Evershed *et al.*, 2004) and glass vessels (e.g. Ribechini *et al.*, 2008). However, ORA has been applied most extensively to ceramic artefacts, in particular unglazed pottery vessels (Heron and Evershed, 1993; Colombini *et al.*, 2005; Correa-Ascencio and Evershed, 2014; Cramp *et al.*, 2014). More recently, successful results have also been obtained from glazed ceramic sherds (Pecci *et al.*, 2016).

4.2.1 The principle of ORA

During processing, use or storage in ceramic vessels, remains from foodstuffs (e.g. waxes, oils, fats or beverages) as well as other natural products (e.g. pitches, tars or resins) can adhere to the interior or exterior surface of a vessel as visible residue or become absorbed, trapped and preserved into the pores of the vessel's clay wall. Visible organic residues, which appear as encrusted deposits, are not common in pottery assemblages because they are prone to post-burial and post-excavation deterioration and contamination. Consequently they are not the preferred choice for ORA (Steele, 2013; Roffet-Salque *et al.*, 2017). Instead, the majority of analyses now target amorphous, invisible and absorbed organic residues preserved in unglazed ceramic vessels (Pecci *et al.*, 2016). This way, they remain locked away from degradation by microbes and are difficult to extract using natural means.

Organic residues are carbon-based substances made up of biomolecules (also called organic compounds or biomarkers) and derived from living things. In an archaeological context, it is usually associated with, and the consequence of past human activities. Like any other archaeological artefact, absorbed residues in vessels are susceptible to degradation and transformation. Organic residues can be affected by high temperatures (Lejay *et al.*, 2016; Evershed *et al.*, 1991; Evershed *et al.*, 1995), exposure to light, water logging (unless anoxic), microbial growth over time, and finally modern contamination from excavation and post-excavation processes (Steele, 2013; Perruchini *et al.*, 2018). This is why it is imperative to have knowledge of the transformation of organic material through time and the sources and events that could cause those transformations. The residues that are left behind certainly degrade over time, but they still contain certain compounds that are characteristic of what substance was once there. Through the use of different methods and techniques (**Section 4.1.3**), ORA aims to identify lipid molecules that are characteristic of certain plants, animals, etc. and ultimately to determine the vessel's original content(s). These may have been consumed, stored or processed in the vessels analysed, representing either a single use or an accumulation of events over a vessel's lifetime (Roffet-Salque *et al.*, 2017).

4.2.2 The development of methods and instruments

4.2.3.1 Common sample preparation protocol

ORA follows four major steps: sampling, sample preparation, analysis of archaeological residues, and interpretation of the results using background research (ancient records, archaeological remains, comparison with a reference chromatogram of modern food items, etc.). Below these four steps commonly employed in ORA are detailed.

Sampling

Pieces of pottery are cleaned with a modelling drill fitted with an abrasive bit to remove ca 1mm of the sherds outer surface and thus supposedly modern contaminants coming from the excavation. As I experienced first-hand this line of reasoning is not entirely true (**Section 4.2.3**) as lipids from the soil could have already migrated inside the buried pottery sherd even if previous studies suggest that this type of contamination is negligible (Heron, Evershed and Goad, 1991).The cleaned sherd is then crushed into powder with a pestle and mortar preferably in agate, which is resistant to scratching and abrasion by hard minerals, such as, quartz. This provides a smooth surface for cleaning with organic solvents between samples and prevention of cross-contamination between samples. The amount of powdered material required for analysis is usually about 1-2g, but larger (100g; Condamin et *al.*, 1976) and smaller (0.1g; Stern *et al.*, 2000) sample sizes have also been used depending on the type (piece of pottery, soils, etc.), organic content concentration, and amount of sample available for analysis.

Extraction

Several methods for sample preparation have been developed over the last few decades. The first step is the extraction of lipids from the ceramic matrices. The traditional methodology still largely employed today involves the use of organic solvent mixtures to extract lipids from powdered sherds (Evershed *et al.*, 1991), generally a mixture of chloroform or dichloromethane and methanol that dissolve and extract the lipids from the matrix (Debono Spiteri, 2012: 63). The product obtained is called total lipid extract (TLE).

Several lipid extraction techniques are available, including soxhlet (Condamin *et al.*, 1976), sonication and saponification (e.g. Mukherjee *et al.*, 2008), accelerated solvent extraction (ASE) (**Figure 4.7**) (Richter *et al.*, 1996; Hughen, Eglinton and Xu, 2004; Jansen *et al.*, 2006), and 'microwave accelerated reaction system' (Gregg, 2009; Gregg and Slater, 2010).

It is also possible to use other protocols (Spiteri, Heron and Craig, 2011) and even combine different techniques in order to recover specific compounds. For example, a two-step extraction protocol was used in the work of Garnier and Valamoti (2016) and Correa-Ascencio and Evershed (2014). This protocol involves direct hydrolysis and methylation of the sample and, according to the article, enables a higher recovery of lipids from archaeological sherds to be achieved (Correa-Ascencio and Evershed, 2014). However, this protocol leads to the loss of important compositional information such as the distribution of triacylglycerols (TAGs) and/or wax esters, which required re-examination using solvent extraction (Correa-Ascencio and Evershed, 2014). This method has not been used widely, as research has generally been carried out using the established methods described previously.

Derivatization

Derivatization of carbon compounds involves the alteration or replacement of reactive groups of atoms within a molecule to increase the molecule's volatility during instrumental analysis, thereby improving its detectability (Pollard *et al.*, 2007). Total lipid extracts before analysis are usually derivatized with BSTFA (bis-trimethylsilyl-trifluoroacetamide) to improve Gas chromatography peak resolution and ensure that all compounds, regardless of functional group reactivity, make it to the detector. Hydroxy compounds (mono- and di-acylglycerols, hydroxyl carboxylic acids) are trimethysilylated, carboxylic acids (fatty acids, dicarboxylic acids, hydroxyl fatty acids) are methylated, and monounsaturated fatty acids are converted to methyl ester-dimethyl disulfide derivatives. However, although samples can be derivatized to produce volatile components suitable for analysis by Gas chromatography, not all compounds are appropriate for this kind of analysis (Debono Spiteri, 2012, 64). For instance, polar compounds or compounds with high molecular weight (Stashenko and Martínez, 2014: 2).

4.2.3.2 Analysis and interpretation

Since its beginning, lipid analysis in archaeology has advanced dramatically not only in term of its range of applications, but also in terms of the techniques and instruments used. The development of methods and analytical techniques has been driven largely by the challenge and need to recover and identify different compounds to characterise varied organic substances. New developments in the field of ORA have allowed the identification of an increasing range of organic substances identified in pottery vessels, including plant waxes, beeswax, animal adipose fats, dairy fats, plant oils, marine oils, bitumen, conifer resin/tar, birch bark tar and Boswellia resin (frankincense) (Evershed, 2008; McGovern and Hall, 2016; Roffet-Salque *et al.*, 2017). We can also add alcoholic beverages to the list (e.g. Biers and McGovern, 1990; Pecci *et al.*, 2013; Koh, Yasur-Landau and Cline, 2014).

The early techniques used (and still used today) to analyse food and beverage residues were infrared spectroscopy (e.g. Shillito *et al.*, 2009), raman spectroscopy (e.g. Bordes *et al.*, 2018), and nuclear magnetic resonance (NMR) (e.g. Ghisalberti and Godfrey, 1998). More recent techniques include Liquid chromatography (LC) and Gas chromatography (GC) with various detectors, such as, Flame Ionising Detector (FID), Mass Spectrometer (MS), and Isotope Ratio Mass Spectrometer (IRMS).

This section will focus primarily on the analytical instrumentation techniques that are most often used to analyse lipids and employed in the current study: Gas chromatography flame ionisation detector (GC-FID) and Gas chromatography-mass spectrometry (GC-MS).

While in the 1990s, IR-spectrometry or UV-spectroscopy was primarily used to identify the chemical function of a molecule, these two methods did not permit total, sure and definitive identification. Many analysts have shown that these methods have often been over-interpreted and underlined the need for more rigorous analysis and ORA protocol (Boulton and Heron, 2000; McGovern and Hall, 2016). Over the last twenty years, instrumental analyses using Gas chromatography coupled with mass spectrometry (GC-MS) have progressively become the standard methodology used. The high sensitivities of instrumental methods such as Gas chromatography coupled to a flame ionization detector (GC-FID) and Gas chromatography mass spectrometry (GC-MS) allow compounds

to be separated, detected and identified even in when only small amounts of TLE are recovered from pottery.

GC-FID: principles

Once the extraction procedure and the derivatization have been carried out, the sample solution dissolved in an organic solvent solution is injected into the GC inlet where it is vaporized as it is injected into a carrier gas (such as hydrogen or most commonly helium). This is known as the mobile phase. The carrier gas then passes the components of the vaporized solution into a long, coiled, silica-lined, narrow-diameter, glass column inside a temperature-controlled oven where organic compounds 'stick' in what is known as the stationary phase: the compounds are separated by virtue of their differences in volatility and relative interaction with the polymer coating of the column. Temperatures are programmed to rise in the oven at controlled rates, and compounds are released, or eluted, into the carrier gas again as temperatures rise and their volatility increases. The retention times, elution orders, and relative abundances of the different molecules in the sample are then measured and recorded as they are released and combusted in a device known as a flame ionization detector (FID), a scientific instrument that measures the concentration of organic species in a gas stream (Gregg, 2009: 45). Components with lower molecular weights and polarities elute before those with higher weights and polarities that are retained in the column for longer periods (Pollard *et al.*, 2007). The graphic representation produced is called a chromatogram, showing the separation of components (represented by a peak) their retention times, elution orders, and relative abundances within the mixture of interest (**Figure 4.4**).

GC-MS : principles

In lieu of the flame ionization detector (FID), a mass spectrometer (MS) is often coupled to the output port of a GC in order to obtain structural information on individual molecules. This allows the sharper identification of components in complex samples. Indeed, because different compounds often share many molecular components that vary only to a small degree, mass spectrometry can provide corroboration of the identification of compounds and increased efficiency and reliability in the identification of complex mixtures.

As the compounds exit the end of the GC column, they move into the mass spectrometer (MS). Here, at the end of the column, compounds undergo ionisation: the MS generates a shower of high-energy electrons that removes an electron from each molecule and creates a stream of charged particles that is subsequently bent by a powerful magnetic or electrical field. A molecule with one electron missing is called the molecular ion and is represented by M+ (a radical cation). The positive molecular ions in the stream of charged particles are separated from one another on the basis of their atomic masses (Pollard *et al.*, 2007). When the resulting peak from this ion is seen in a mass spectrum (**Figure 4.4**), it gives the mass-to-charge (m/z) ratio of the fragment. The signature of fragments is unique for each compound, so the spectrum of fragments can be statistically matched to those of known organic and inorganic compounds through an attached computer database such as the mass spectral NIST (National Institute of Standards and Technology) spectra library (e.g. Baeten *et al.*, 2013; Dunne *et al.*, 2016). Spectra libraries assist analysts in their compound identification by providing over 100 000 reference mass spectra for GC-MS and LC-MS/MS.

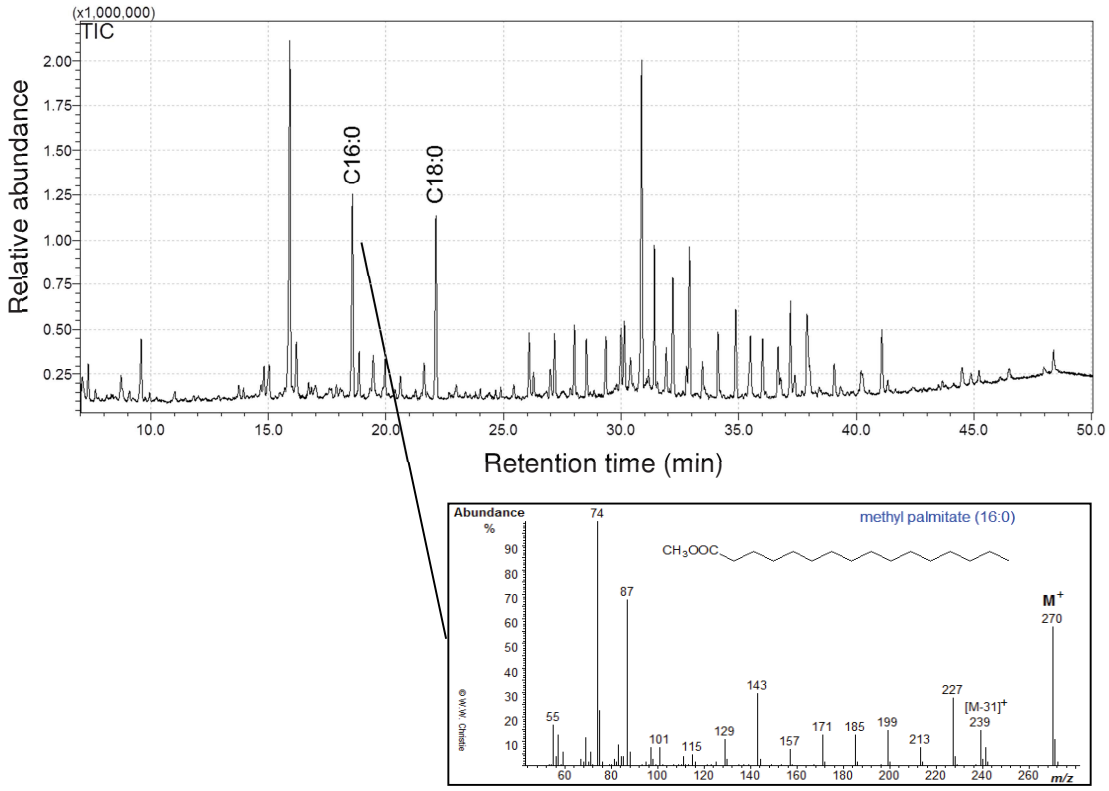

Figure 4.4: Example of a chromatogram obtained after injection and analysis by GC-MS and mass spectrum of the compound $C_{16:0}$ saturated fatty acid (palmitic acid).

Higher sensitivity can be achieved using selected ion monitoring (SIM) mode instead of full scan mode in particular for quantitative analysis (e.g. Baeten *et al.*, 2013; Burger *et al.*, 2016). In order to quantify compounds, analysts used either external or internal standards. An internal standard (IS) in analytical chemistry is a chemical substance (one compound or a mix of compounds) with a known concentration that is added in a constant amount to samples, blanks and other control samples. An external standard is like the internal standard (known concentration), but is not added to the unknown sample. Rather it is run alone, as a sample, and usually at different concentrations, and is used to generate a standard curve by plotting the absolute analyte response against the analyte concentration. Again, the peak areas are related to the known amounts of the external standard run. External standards do not correct for losses that may occur during preparation of the sample, such as extraction, centrifugation, evaporation, as well as injection-to-injection variation. This is why it is less precise and less used than internal standards.

The identification of particular compounds has led to some impressive residue origin identifications, based in part on the presence of unusual fatty acids that are restricted to limited biological sources (e.g. Copley *et al.*, 2005) or on unusually high abundances of certain compounds (e.g. Copley et *al.*, 2001a; 2001b). Other examples include the identification of specific biomarkers present in epicuticular waxes of *Brassica sp.* (Evershed, Heron and Goad, 1991; Baeten *et al.*, 2013), ω-(-o- alkylphenyl) alkanoic acids, isoprenoid fatty acids and dihydroxy acids in marine and freshwater organisms (e.g. Craig *et al.*, 2007). However, compounds might be present in a multitude of different food items, thus it can be difficult sometimes to pinpoint their origins.

4.2.3 An established discipline?

Since the beginning of analysis of organic residues preserved in archaeological material in 1970s (Condamin *et al.*, 1976), this interdisciplinary field of study has progressed and is today a discipline carried out by many private and public laboratories. With an increasing number of new methods and instruments at our disposition, archaeologists today consider ORA amongst the many scientific tools available to them. This discipline has become increasingly important to our

understanding of ancient diet, trade and technology. It has particularly progressed in the field of ceramic analysis.

Organic residue analysis generates today a great enthusiasm in archaeology as it opens up a series of questions that may be difficult to approach using traditional archaeological methods. For instance, ceramic material in itself cannot give us details on its content, consumption contexts and practices. While texts and iconography, if accessible, can provide general information on diet, organic residue analysis has the capacity to bring answers to these site-specific research questions. However, while today ORA has become an established discipline, archaeologists interested in incorporating it into their research programs should familiarize themselves with a basic understanding of the costs and timelines involved and the possibilities and limitations of ORA, particularly residue degradation and contamination.

It is crucial for scholars in this field to share their experience (in the form of papers, talks, workshops, etc.) and the "do's and don'ts" in organic residue analysis for the development of the discipline. Even with the development of "good practices" recommendations in the ORA field (e.g. Historic England's "Organic Residue Analysis and archaeology: a Guidance for good practice" published online in 2017[3]), scholars do not often caution the readers against generalised interpretations and false positives.

The importance of the sampling methods and/or strategies, which can have large implications on the preservation and contamination of organic residues, is often understated in publications. In addition, due to the lack of communication and methodologies published, the various instruments used to perform the analyses are often seen by archaeologist as infallible and the data believed to be easily interpretable. While residue analysis has become a valuable source of information in recent decades, there are still elements about which we know very little, like the mechanisms at work during the formation of residues, as well as the multiple possible reasons behind their degradation and contamination (**Figure 4.5**).

3 https://historicengland.org.uk/images-books/publications/organic-residue-analysis-and-archaeology/

A move toward open access to methodologies and good practices is urgently needed to make ORA a technique that more and more archaeological projects would have the opportunity to employ.

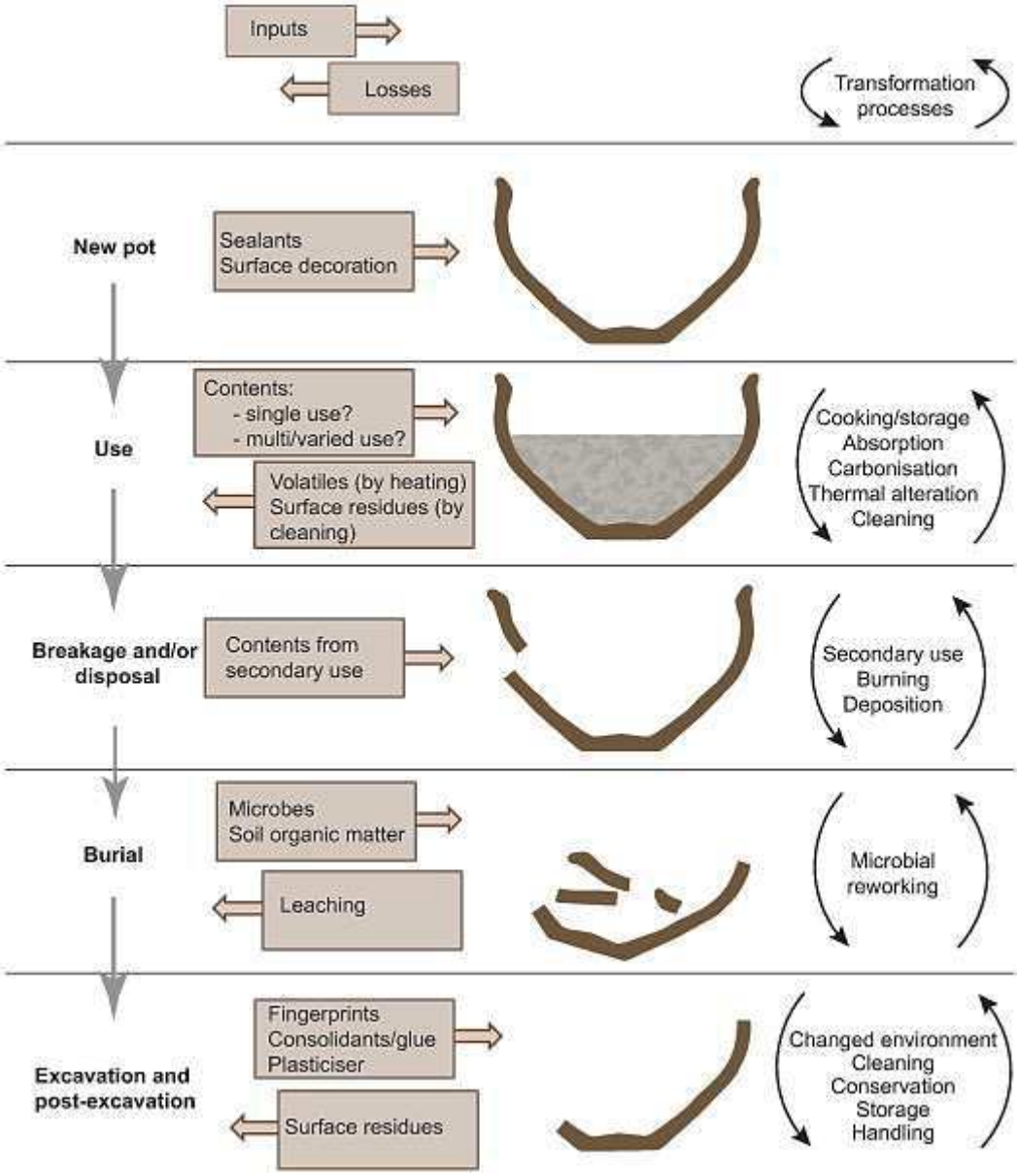

Figure 4.5: Main inputs, losses and transformation processes affecting the survival and composition of visible and absorbed organic residues in archaeological ceramics (from Roffet-Salque et al., 2017)

This section highlights the principal challenges that scholars have to face when implementing ORA to their projects, challenges that offer opportunities for future research.

(1) It is often difficult to appraise how organic residues have been altered (contaminated or degraded) by the archaeological context before analysis. For instance, the soils that ORA samples are found in have variability in their chemistry that will affect the preservation and degradation of samples. Acidic soils often result in the exceptionally poor survival of organic materials (Roffet-Salque *et al.*, 2017). Other factors such as local temperature and humidity, that will have direct consequences on soil water content and texture, may also play a part in the destruction or survival of organic residues (Steele, 2013). Thus, while residues in ceramics are trapped within the pores of the clay walls, and therefore are provided with at least some protection, degradation, dissolution and contamination certainly occur. Studies have been carried out to investigate the degradation patterns of organic residues extracted from archaeological artefacts (e.g. Evershed *et al.*, 1991; Stern *et al.*, 2000; Evershed, 2008; Romanus, 2008). However, little work has been done investigating the effect of different ceramic fabrics (coarseness, degree of firing, etc.) on the formation and preservation of residues (Steele, 2013).

(2) Consequently, not all residues will survive or will only survive partially during their burial time. Thus, caution should also be exercised in interpreting the absence of specific biomarkers. Certain compounds are indeed more prone to fast decay (Debono Spiteri, 2012: 70; Steele, 2013). Lipids such as fatty acids or waxes are the most commonly occurring materials in archaeological residues as they are relatively insoluble in water and resistant to degradation. In contrast, water-soluble compounds such as sugars and alcohols either leave no trace or disappear very rapidly in the burial environment. Wine residues have been identified with a certain degree of success on exceptionally well-preserved material based on the presence of tartaric acid, a rarely found water-soluble biomarker. This is why, today, studies focus on identifying alternative minor components consistent with wine that might survive over centuries or millenia.

(3) Another challenge is that the residue analysed often consists of a mixture of compounds of different origins. Indeed, ceramic vessels could have been reused for different purposes and could have held different commodities (Charters *et al.*, 1995; Evershed *et al.*, 1995; Baeten *et al.*, 2013). Furthermore, activities such as post-firing treatments or cooking events could hinder the identification of the vessel's content (Heron and Evershed, 1993).

(4) Finally, certain compounds can be found ubiquitously in nature and thus can have various possible source origins. This issue is particularly problematic when faced with sample contamination coming from the burial environment (e.g. Condamin *et al.*, 1976) and modern contamination during and after the exhumation of the ceramic vessel (**Figure 4.5**). Archaeologists when collecting and sampling ceramic vessels for ORA during excavation multiply the contamination factors already introduced during their burial time by them and putting them in contact with skin, plastic, dust, etc.

(5) One of the most challenging questions facing organic residue researchers at the present time is discerning lipids from the past from modern contamination. While certain modern contaminants are not found in nature and thus can be excluded easily from consideration, other compounds can be found both in food from the past as well as in modern contaminants since many of the compounds identified through ORA are ubiquitous in nature, including in the oils that our bodies produce.

Early works in ORA revealed the presence of compounds likely originating from human-derived lipids (Steele, 2013; Roffet-Salque *et al.*, 2017). For example, fatty acids, found in animal fats, are also shed from the surface of human skin and will be deposited on any handled artefact. Human skin lipids and other animal fats also contain the sterol cholesterol, used as an indicator of animal origin in degraded fats, which can sometimes be deposited on surfaces by contact with hands. Skin also excretes the compound squalene which degrades rapidly and it is usually considered contamination, even though it has multiple possible origins. Squalene is also present in olive and other plants, sometimes in large abundances, and is not always present in skin. Skin lipids in fact appear to be very variable and skin may also carry compounds from food, cosmetics (e.g. sunscreen), topical medicines (i.e. insect repellent) and any other handled materials.

Other modern contaminants are phthalate plasticizers introduced through contact with plastic, most likely from plastic storage materials. They are easily identified, as they are very distinctive and have no ancient equivalent (Pollard *et al.*, 2007). However, plastics contain a wide range of other compounds which have the potential to migrate into material stored in close proximity. For instance, plastics can exude fatty acids, which are biomarker compounds of

degraded fats. So, while insect repellents and phthalate plasticizers are easily identifiable as modern contaminants and excluded from consideration, other modern compounds might have been present in the ancient world as well. Consequently, handling the ceramic samples with bare hands and storing them in plastic bags should be avoided to prevent contamination (Heron and Evershed, 1993; Perruchini *et al.*, 2018).

Despite this known pathway of contamination, there have been no published studies designed to measure how much material might be absorbed by ceramics during handling, washing and storage. In this thesis, I address this knowledge gap by analysing a set of control samples and comparative data; First, soil samples were analysed to help assess possible contamination from the burial environment to determine and quantify exactly how much soil contamination has contributed to our organic residues (Steele, 2013; Stern *et al.*, 2000). Second, outer and inner sherd surfaces (1-2mm) were removed before crushing into powder the potentially contaminated sherd to minimize the potential for and identify modern contaminants discussed above. Third, background levels of many contaminants are present in dust and air and may be a source of contamination in the laboratory. The preparation and analysis of method blanks can identify and quantify contamination introduced in the laboratory. Finally, comparative data (other ORA studies, zooarchaeological and ethnobotanical remains) as well as information found in texts and iconography were implemented to help identify compounds and interpret the results. As mentioned above, one of the world's largest and most widely used databases for the identification of compounds is the National Institute of Standards and Technology or NIST mass spectra library. However, this library was created largely for the pharmaceuticals and biotechnology fields and it could happen that compound peaks do not yield an acceptable mass spectrum match with any of the reference spectra from the NIST spectra library. In addition, it is not advisable to identify compounds based purely on spectrum matches with the NIST library, doing so will often lead to false identification. It is therefore important to look at compound distribution, the retention time index and the fragmentation pattern of the mass spectra for confirmation as well as to identify archaeologically relevant compounds from compounds that are most likely coming from modern contamination. Even cases in which the chemical compound is successfully identified, a definite association between a particular

compound (or co-occurrence of compounds) and a specific source is very rare without comparative data (Koh, Yasur-Landau and Cline, 2014).

4.3 An improved ORA protocol

At the beginning of my PhD, I was confronted with the exact challenges presented above. In seeking to characterize organic material from the archaeological site, I was faced with the problem of trying to identify traces of significant compounds in the face of contamination and destruction of information coming from the burial environment, the sampling process and sample preparation in the laboratory.

Organic residues recovered from archaeological and conservation contexts represent an accumulation of materials by original deposition and post-depositional processes. However, the organic material of interest can be obscured by contaminants from the environment as well as field and laboratory materials. Contamination in ORA must be taken seriously, since any recovered residue can become masked by contaminant peaks, which may co-elute with GC and GC-MS peaks of interest, hindering identification.

Hence, another significant part of my PhD work was dedicated to the elaboration of an ORA protocol aiming to assess and reduce contamination and requiring the presence of the analyst from beginning to end, from the excavation site to the laboratory. With this objective in mind, I have mapped my research methodology with a graphic organizer to help me explore the possible issues and how I could plan to investigate different solutions to obtain the best results (**Figure 4.6**).

The principal questions I wished to resolve were:
- At the sampling stage: Which type(s) of vessels are more suitable and relevant for organic residue analysis (e.g. surface/buried pottery vessels)? How do we assess the contamination coming from the burial environment? How do we assess and reduce contamination coming from the sampling process (modern contamination)?
- At the sample preparation stage: Which sample preparation method should be adopted in the hope of recovering a large range of compounds, including compound markers of alcoholic beverages?

- At the analysis stage: What oven temperature program was most appropriate for analysis?

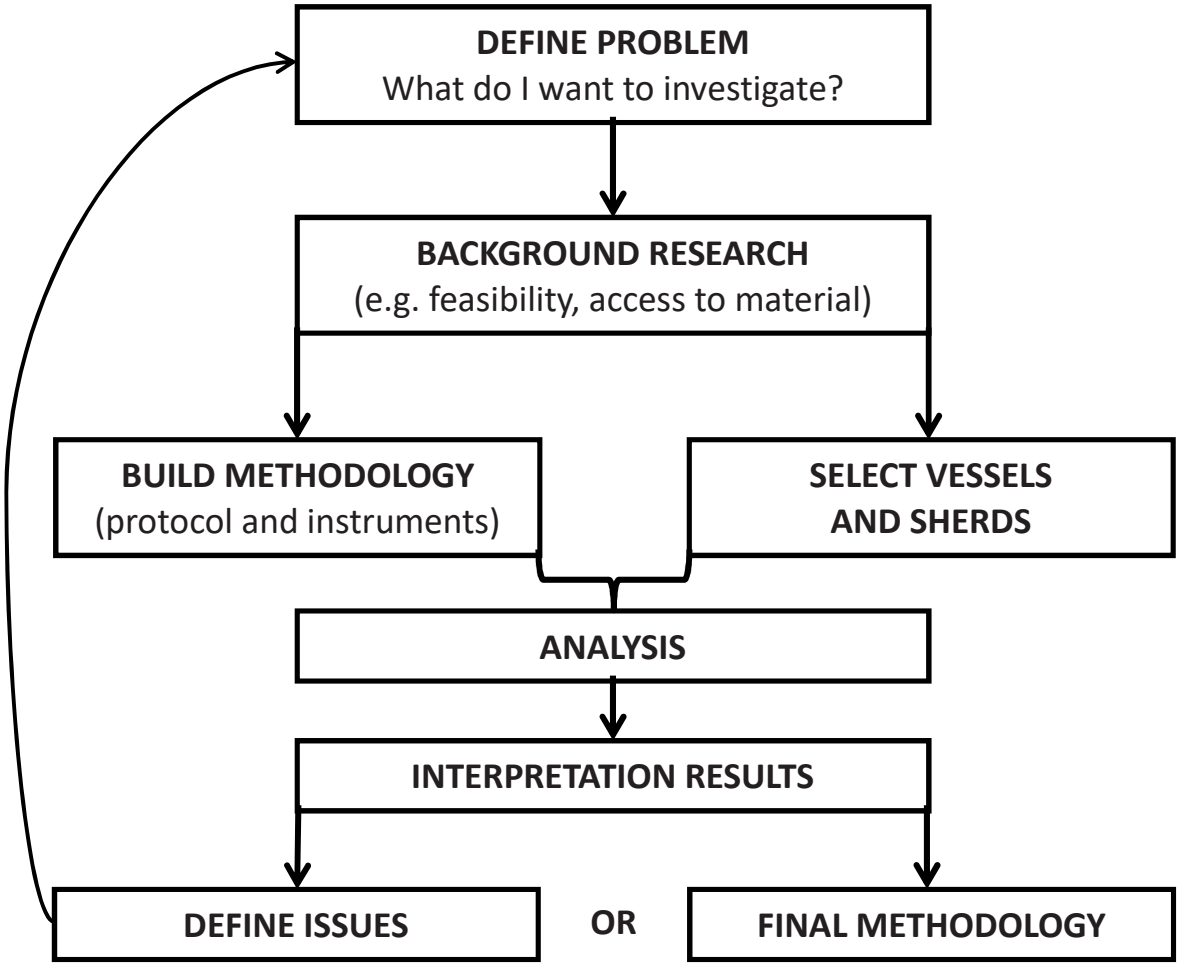

Figure 4.6: Graphic organizer of the research methodology used in the present thesis

4.3.1 Sampling strategy: trials and errors

4.3.1.1 Pilot study

For my pilot analysis, ceramic sherds from different archaeological sites in the Upper Diyala Region - including Khani Masi - had been collected by the SRP team during a previous season and stored at the University of Glasgow for ORA.
The vessels came from surface survey collection, touched without gloves, washed, and put together in plastic bags for transportation. Soil samples were

not available but in certain cases, soil still present inside the vessels was collected and put in vials (combusted beforehand in an oven at 450°C for 8-hours).

Each vessel was recorded before being sampled with gloves and tweezers cleaned beforehand with dichloromethane: DCM[4]. The sample part(s) were also recorded and listed with a description in the BECS laboratory[5] Logbook. On a sheet of aluminium foil, sherd surfaces were cleaned with a drill (1-2 mm removed) and finally the sherd was crushed into powder using an agate mortar and pestle (previously cleaned with isopropanol or acetone used as cleaning solvents because they dissolve a wide range of non-polar compounds - especially oils - and also evaporate quickly). The resulting powder was transferred into 60 ml glass vials (combusted beforehand in an oven at 450°C for 8-hours).

From the pilot analysis, I sometimes found lipid recovery to be very low (see **Appendix B, Figures 1-11**). Furthermore the compounds with the highest relative abundance were plasticizers (e.g. phthalates) coming from the plastic bags used for storage and insect repellents (DEET) (**Appendix B, Figures 1-11 and Table 1 at http://dx.doi.org/10.5525/gla.researchdata.875**). These compounds have no ancient equivalent and could be easily excluded from consideration. However, these peaks could mask peaks of archaeologically interesting compounds. In addition, other compounds might have been present in the ancient world and distinguishing the modern from the archaeological can become very challenging. For example the compound benzophenone (**Appendix B, Figures 2 and 11 and Table 1 at http://dx.doi.org/10.5525/gla.researchdata.875**) is consistent with grape juice and wine, but can also be found in sunscreen and other cosmetic products making it difficult to identify if this compound is archaeologically significant or another product of modern contamination.

In some cases, only modern contaminants were recovered with no traces of other compounds (**Appendix B, Figures 6 and 7**), which probably did not survive the washing process.

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4 Dichloromethane, or methylene chloride, is an organic compound able to dissolve a wide range of organic compounds and that evaporates quickly

5 BECS lab: Biomarkers for Environmental and Climate Science research group laboratory based at the University of Glasgow and led by Prof. Jaime Toney.

This pilot study demonstrates that the fieldwork protocols commonly used in archaeology introduce analytically significant contaminants into ORA samples. Projects using ORA are advised to acknowledge all potential sources of methodological contamination. These include materials for general use but also materials that have been manufactured and marketed specifically for ORA. This is not only true in the field, but also in the laboratory. It is imperative to engage in rigorous control of instruments and methodologies to assess methodological contaminants independently and to include primary control data in final project publications.

4.3.1.2 A new sampling strategy

Following the pilot study, one of the objectives of my PhD was to elaborate and test a new sampling methodology for ORA performed directly on site. This sampling methodology was created in order to avoid and control any possible contamination of archaeological samples during the excavation and post-excavation processes (e.g. handling, recording, storage and transportation) while also facilitating the exportation of samples and the recording of the ceramic material (Perruchini *et al.*, 2018).
Instead of sampling the archaeological material after reception at the laboratory, the idea was to sample the vessels directly on site, crush them into powder and put them into 40 ml combusted glass vials (450°C for 8-hours) for exportation, ready to be analysed at the BECS laboratory, upon my return.

It is important to note that the sampling protocol was developed gradually and was the result of a collaborative effort between the members of Sirwan Regional Project. This type of communication is essential when selecting material for ORA, because our sampling techniques and analyses are destructive. Which vessels were suitable for organic residue analysis (based on the type of vessel, context of discovery, etc.) and which vessels were kept intact to construct a typology was a thoroughly discussed topic before any decisions were made. Furthermore, if a vessel was selected for ORA, it was important to sample it critically. While the base of drinking vessels is more likely to have been in contact with ancient substances, fats at the base of a cooking vessel can be degraded by direct contact with a source of heat. It is thus more suitable to sample the body or the rim (Charters *et al.*, 1993b: 216).

All the tools and material used for sampling were either cleaned before each use with acetone (forceps, mortar and pestle, drill), or combusted in an oven (450°C for 8 hours) (aluminium foil, glass vials).

The protocol consists of four steps:

1. After taking a picture of the vessel in situ, part(s) of the vessel was selected for sampling. Sherd(s) of ca. 5 cm diameter were sampled for each vessel. The pottery sherds were never manipulated with bare hands: we used cleaned forceps and combusted aluminium foil and in one case cotton gloves. The pottery sherds were not washed nor put into contact with water. The sherds were recorded (pictures, entry in the database, etc.). The sherds were then wrapped into combusted aluminium foil. The sherds were never put into contact with plastic bags.
2. Samples of soil around and/or inside the vessel were also collected. They can be used as a control, since they provide a picture of potential contamination from the burial environment (e.g. leaching from decaying plant matter). The soil samples were processed using the same methodology employed for the samples extracted from the sherds (see below).
3. At the BECS laboratory, the sherd samples kept for comparison were handled carefully using cleaned forceps and combusted aluminium foil. After recording (BECS label and pictures), both inner and outer surfaces of the sherds were drilled using a cordless Dremel 8200 with an abrasive point as a cleaned grinding tool to remove parts of the exogenous contamination. The resulting powders were kept for ORA. By comparing the inner and outer surfaces no information was lost. Furthermore, samples drilled from both sides of a pottery sherd can provide an assessment of any contamination present, as residues of archaeological interest will be present usually on only one surface of a sherd (most often the interior), while contamination will accumulate on both surfaces.
4. The now “cleaned” fragment was crushed into powder using a cleaned agate mortar and pestle and put into combusted 40 ml glass vials. The powder was weighted before lipid extraction.

4.3.2 Sample preparation

4.3.2.1 Lipid extraction

Lipids were extracted using a Dionex Accelerated Solvent Extractor (ASE 350) in a mixture of DCM and methanol (9:1 v/v DCM:MeOH) (**Figure 4.7**). The ASE 350 can run 24 samples in 10 ml cells. On average, a 10 ml cell can hold 3 g of sample. This instrument enables better and more consistent extractions of the total lipid extract (TLE) of samples in less time and effort than manual techniques, such as ultrasonication.

Figure 4.7: Dionex Accelerated Solvent Extractor (ASE) 350 at the BECS laboratory

A rinse with DCM was programed between each extraction of samples to avoid possible cross-contamination. Each extraction process takes around 60 minutes and includes: **(1)** loading the cell, **(2)** filling the cell, **(3)** heating the cell, **(4)** static extraction. Pressure is 1500 psi is applied via nitrogen gas to the sample extraction cell to maintain the heated solvent in a liquid state during the extraction. **(5)** The extract is flushed with fresh solvent from the sample cell into a standard collection bottle. This process is repeated three times. Then, **(6)**

the solvent is purged from the system and **(7)** the cell is unloaded. The 60 ml glass vials containing the extracted TLEs and the solvents were left to evaporate under a fume hood for around 3 days until only the TLEs were left.

Blanks were also extracted from combusted sand, to assess possible contamination coming from the machine and dust in the laboratory. Phthalates can also be found and are probably from the sample preparation or analysis and are modern materials unrelated to any archaeological residues.

4.3.2.2 Transfers and recording of TLEs mass

After evaporation of the solvents, the remaining TLEs were rinsed three times with about 0.5ml of DCM (using combusted Pasteur pipettes) and transferred into 8 ml vials (pre-combusted and pre-weighted). The solvent in the 8 ml glass vials containing the TLEs was left to evaporate (around 3 days). The 8 ml vials containing the TLEs were then weighted again to record the mass of TLE for each sample.
The 8 ml vials containing the TLEs were then rinsed with 150 µl DCM and transferred into a 2 ml vial with insert (that can only contain 200 µl of sample) and left to evaporate under a gentle stream of nitrogen (around 2 days).

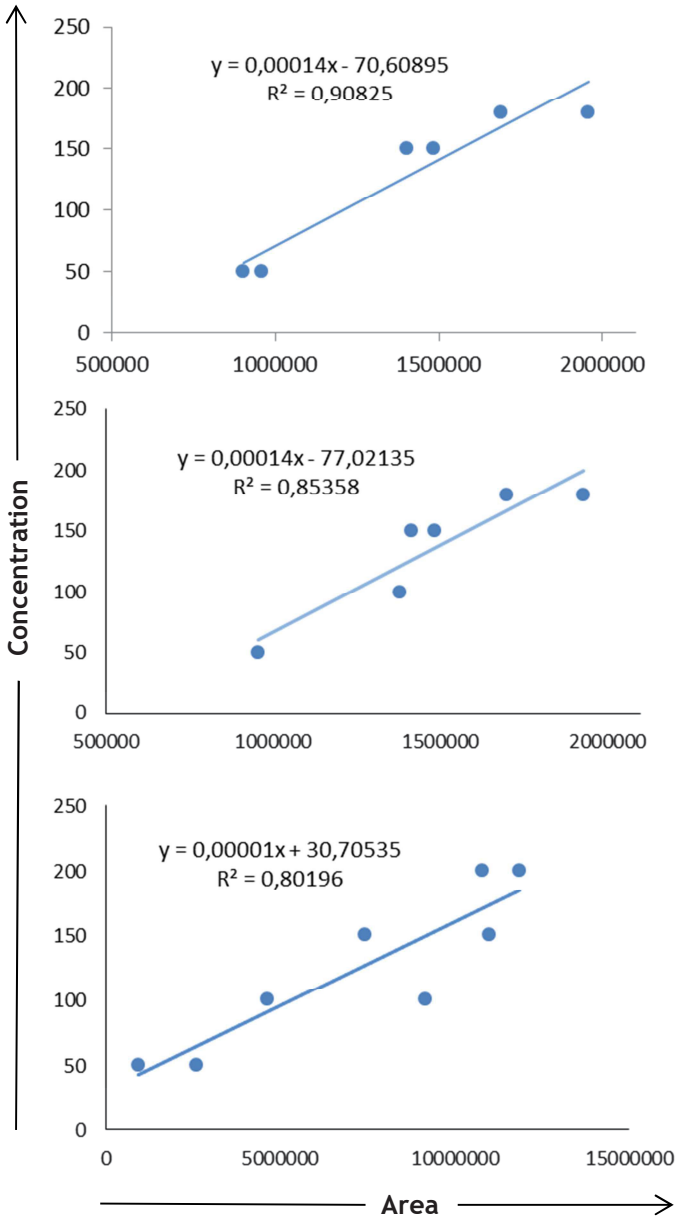
4.3.2.3 Derivatization

The last step was the derivatization of the resulting fraction. Derivatization temporarily chemically modifies compounds to transform them into trimethylsilyl (TMS) ethers that have properties suitable for analysis using Gas Chromatography (increased volatility, detectability and stability). The samples were then transferred into 2 ml vials and derivatised by heating at 80°C for two hours with the addition of 50 µl of the reagent N,O-bis(trimethylsilyl)trifluoroacetamide, with 1% trimethylsilyl chloride and 10 µl of pyridine added as basic catalyst (Perruchini *et al*. 2018).

4.3.2.3 Standards and compounds quantification

To quantify compounds, I used both external and internal standards.

For the first samples collected in 2016, external mix-alkanes standards with known concentration (10 µg), were used because we did not know what types of compounds we would find in our samples. For the second batch of samples collected in 2017, I created and used internal standards. A constant amount (100 µl) of a solution of C_{22} n-alkane with a known concentration in hexane was added to the samples before analysis for quantification. I used the alkane C_{22} because it was not present in our first samples. However, after analysis, I discovered that several samples most likely contained the alkane C_{22} originally. Fortunately, the same solution of C_{22} n-alkane in hexane was used as well as an external standard, which run at different concentrations and allowed me to create calibration curves (**Figure 4.8**).



C22 n-alkane external standard 1	
Concentration	Area C22 n-alkane
50	902436
50	956935
150	1402667
150	1482054
180	1691020
180	1957671

C22 n-alkane external standard 2	
Concentration	Area C22 n-alkane
50	956935
100	1379880
150	1412534
150	1482054
180	1926820
180	1699485

C22 n-alkane external standard 3	
Concentration	Area C22 n-alkane
100	9148219
100	4630889
150	11005203
150	7440539
200	11870253
200	10779439
50	2589379
50	924860

Figure 4.8: Calibration curves (x= area, y= concentration) and Tables for the three C_{22} n-alkane external standards used in the quantification in 10 of my samples.

4.4 Analysis

Finally, after dilution in DCM, the samples are run on the GC-FID and the GC-MS. Before running any samples on the GC-MS, I selected several samples with different quantities of TLE (high, medium, low quantities) to run on the GC-FID. Running samples on the GC-FID enabled me to check (and correct if needed) the samples' concentration. If the sample presents a chromatogram with low Intensity peaks, it needs to be concentrated. On the other hand, if the sample presents a chromatogram with high intensity, it is important to dilute the sample in order to avoid damaging analytical instruments as sensitive as the GC-MS.
TLE samples presenting a high quantity of co-eluting compounds, were further separated into acid (TAF – Total acid fraction) and neutral (TNF – Total neutral fraction) fractions before analysis (**Figure 4.9**).

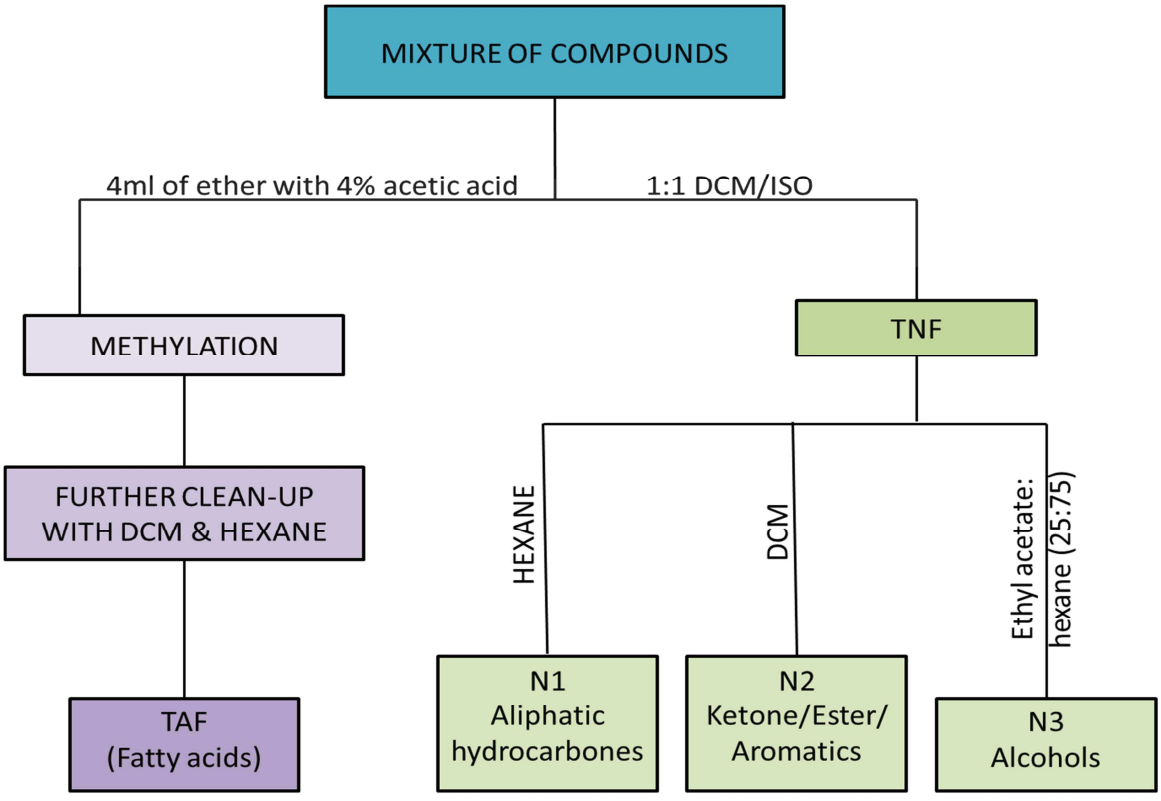


Figure 4.9: Flowchart presenting each steps of the acid/neutral separation process used for this study.

4.4.1 2016-2017 Analyses

At the beginning of my PhD, the samples collected in 2016 were run on two Shimadzu machines: Shimadzu GC-FID 2010s and Shimadzu GC-MS-QP2010 Plus.
For both the GC-FID and MS, the 10 µl syringe for the injection was rinsed three times with the rinse solution (trimethylpentane) before each run. A BECS standard mix as an external standard as well as a hexane were run several times at the beginning of the run as well as between every four/five samples. Of the sample solution, 1 µl was injected for analysis.

4.4.1.1 GC-FID : Shimadzu GC-FID 2010s

After several tests, the following analytical features were applied:

GC Capillary Column: SGE BP-1 (New 330) (length of 60 m, inner diameter 0.25 mm, thickness 0.25 µm, max temperature 350°C)
Carrier Gas: Hydrogen (Pressure 190.7 kPa)
Injection mode: Splitless with an injection temperature of 350°C
Analysis time: 63 min
Column Oven Temperature program:
The GC oven temperature was held at 60°C for 2 min, then increased 30°C/min up to 120°C, then increased 5°C/min up to 340°C held isothermally for 15 min.

4.4.4.2 GC-MS: Shimadzu GC-MS-QP2010 Plus

After several tests, the following analytical features were applied:

GC Capillary Column: SGE BP-1 (New 330) (length of 60 m, inner diameter 0.25 mm, thickness 0.25 µm, max temperature 340°C)
Detector: Quadrupole mass spectrometer and ion-trap mass
Carrier Gas: Helium (Pressure 306.5 kPa)
Injection mode: Splitless with an injection temperature of 350°C
Analysis time: 63 min (starting at 7 min)
Column Oven Temperature program:
The GC oven temperature was held at 60°C for 2 min, then increased 30°C/min up to 120°C, then increased 5°C/min up to 340°C held isothermally for 15 min.

To obtain a better chromatographic separation and resolution, a slow temperature ramp was used. The mass range was scanned in the range of 50-800 m/z.

4.4.2 2017-2018 Analyses

In the course of 2017, new analytical instruments were acquired: a GC Agilent 7890B and a GC-MS Agilent 5977a MSD.
For both the GC-FID and MS, the 10 µl syringe for the injection was rinsed three times with the rinse solution (trimethylpentane), then three times with methanol before each run. A C_{22} alkane in hexane solution with different concentrations as well as several hexane blanks were run at the beginning of the run as well as between every four/five samples. Of the sample solution, 1 µl was injected for analysis.

4.4.2.1 GC-FID: GC Agilent 7890B

After several tests, the following analytical features were applied:

GC Capillary Column: Restek Rtx-1 (length of 60 m, inner diameter 0.25 mm, thickness 0.25 µm, max temperature 345°C)
Carrier Gas: Alternate Carrier Gas Hydrogen / Helium
Injection mode: Splitless with an injection temperature of 320°C
Analysis time: 63 min
Column Oven Temperature program:
The GC oven temperature was held at 60°C for 2 min, then increased 30°C/min up to 120°C, then increased 5°C/min up to 330°C held isothermally for 15 min.

4.4.2.2 GC MS: Agilent 5977a MSD

After several tests, the following analytical features were applied:

GC Capillary Column: Restek Rtx-1 (length of 60 m, inner diameter 0.25 mm, thickness 0.25 µm, max temperature 345°C)
Carrier Gas: Alternate Carrier Gas Hydrogen / Helium
Injection mode: Splitless with an injection temperature of 350°C
Analysis time: 63 min

Column Oven Temperature program:
The GC oven temperature was held at 60°C for 2 min, then increased 30°C/min up to 120°C, then increased 5°C/min up to 340°C held isothermally for 15 min.

4.4.3 Interpretation

Results obtained for the archaeological samples were compared to the associated control samples (inner and outer surfaces, soil samples and blanks). This method allows us not only to easily identify contamination but identify archaeologically significant compounds as well. This compound can be therefore characterized using the NIST spectra library integrated in the MassHunter software as well as through the use of comparative data compiled from the literature and the creation of reference material of authentic food and beverages items (**Appendix E, Figures 265-275**).

To conclude, this thesis makes two key methodological contributions to this field of research. The first is a novel, field-based sampling strategy that successfully minimises sample contamination from excavation and post-excavation handling and enables a straight-forward distinction to be made between archaeologically significant chemical compounds and others likely presenting contamination. Secondly, by analysing authentic material of food and beverages used in ancient times based on textual, iconographic evidence as well as faunal and ethnobotanical remains, I present a more grounded interpretation of my ORA results (see **Chapter 5** and Perruchini et al., 2018).

5 Investigating beverage consumption at Khani Masi

The site of Khani Masi is an ideal site to explore beverage consumption practices. The ceramic assemblage discovered in the rooms excavated inside the monumental compound and adjacent areas contained vast quantities of ceramic vessels of different forms and sizes, dominated by drinking vessels (e.g. goblets and cups).

Following the new and improved ORA protocol described in **Section 4.2**, I analysed these vessels with the aim of confidently identifying their contents.

In this chapter, I first give a short description of the material analysed (**Section 5.1**), not only the vessel forms and ceramic ware types, but also the context of their discovery.

In a second section, I present the results of ORA (**Section 5.2**). Due to the above sampling regime, organic residues were well-preserved in the majority of the samples with only trace amounts of modern contamination such as phthalates and phenols (**Sections 5.2.1 and 5.2.2**). Comparisons were made with soil residues and residues extracted from outer and inner vessel surfaces to ensure that identified compounds are of archaeological significance and not the results of contamination.

The final section of this chapter is the interpretation of the data (**Section 5.3**) and identification of the content of the vessels. This interpretation is not only based on the presence of characteristic chemical compounds and the analysis of comparative samples, such as reference samples of modern food. It also relies on textual, iconographic and archaeological evidence of food and beverages in the Near East reviewed in **Chapter 3**.

5.1 Ceramic assemblage analysed

At Khani Masi, a large quantity of varyingly sized ceramic vessels was recovered during the two excavation seasons, with large concentrations in trench V85 and inside several rooms of the monumental building (trenches Y88 and Y89). Shapes represented include goblets, bowls, cups, *namzitu*/brewing vats and other larger vessels as well as so-called faïence buckets, which are not made of clay but from

quartz-derived vitreous material (**Figure 5.1**). I have grouped these vessels into three functional categories: drinking vessels (cups and goblets), larger vessels (for storage and production), and a last and somewhat broad 'other' category for the other types of small vessels such as bowls and faïence buckets. The majority of these vessels were used in daily and more exceptional production and consumption context, including ritual occasions.

For clarity, I cannot detail in this thesis the total ceramic vessels assemblage distribution at Khani Masi. However, of the vessels collected at the site we can note that, in comparison to the number of goblets and cups (drinking vessels), few bowls and almost no cooking wares were collected. This distribution is reflected in the material analysed in this study (**Figure 5.2**). The high percentage of drinking vessels of different forms and sizes shows the importance of drinking activities in the monumental complex and point to short-term storage and frequent consumption.

Figure 5.1: Two offering set assemblages from trench Y88 (from Perruchini *et al.*, 2018)

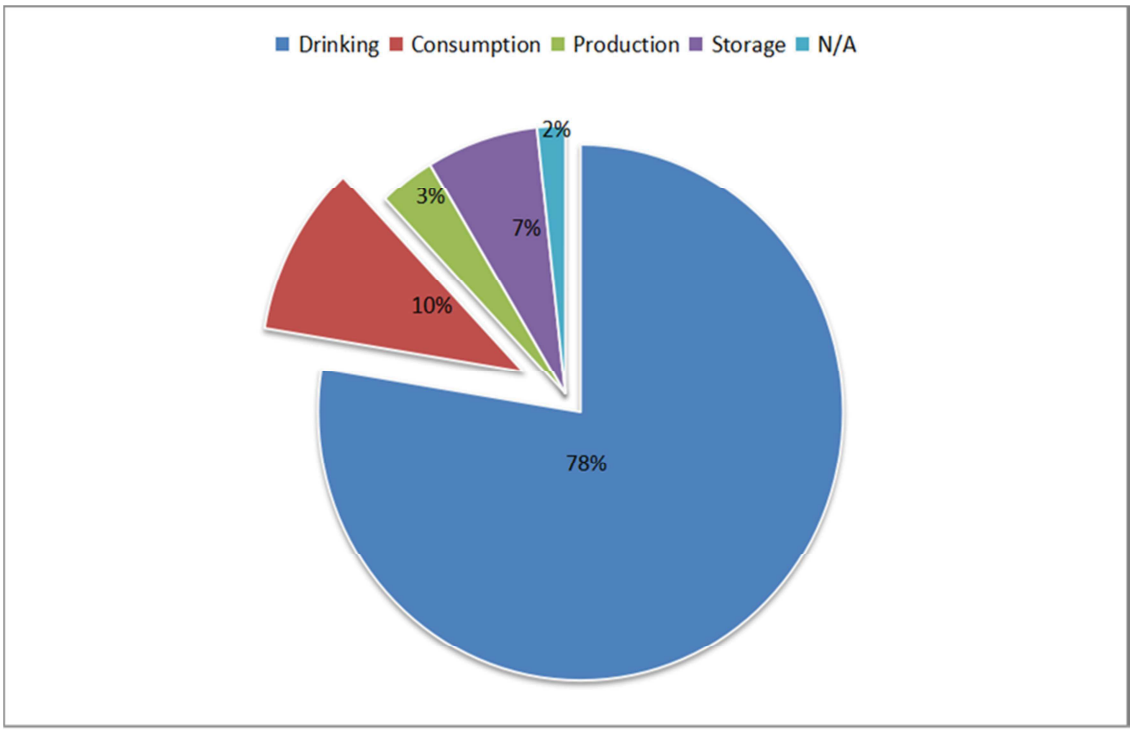


Figure 5.2: Material analysed in this study and their vessel type functions

5.1.1 Drinking vessels

5.1.1.1 Kassite Goblets

Goblets present one of the most prominent ceramic types found at SRP 46. For the purpose of this study, **20 goblets** were collected and analysed. These steep-sided vessels are representatives of the iconic solid-footed or 'Kassite' goblet typical for late second millennium BCE sites in central and southern Mesopotamia (Amstrong and Gasche, 2014). While the largest Kassite goblet found at SRP 46 (ca. 40 cm high) is able to contain 500-600ml of liquid (equivalent to a bottle of wine), the most common goblet (ca. 20-25 cm) is able to hold the equivalent of a pint of beer (**Figure 5.3**) (Perruchini *et al.*, 2018). Discovered at other Babylonian sites (Armstrong, 2017), these vessels have been traditionally treated as a material trait of Kassite imperialism. In reality, their function(s) as well as social and political significance remain entirely unknown as studies of these vessels to date have focused solely on their manufacture, typological development and geographical distribution (van As and Jacobs, 1987; Clayden, 1998; Armstrong and Gasche, 2014; Armstrong, 2017). However, we can hypothesise that these goblets were probably used for consumption rather than

serving or storage of liquid, as on-site experiments showed that they were not very easy to pour from, as it resulted in a lot of spillage (Perruchini *et al.*, 2018).

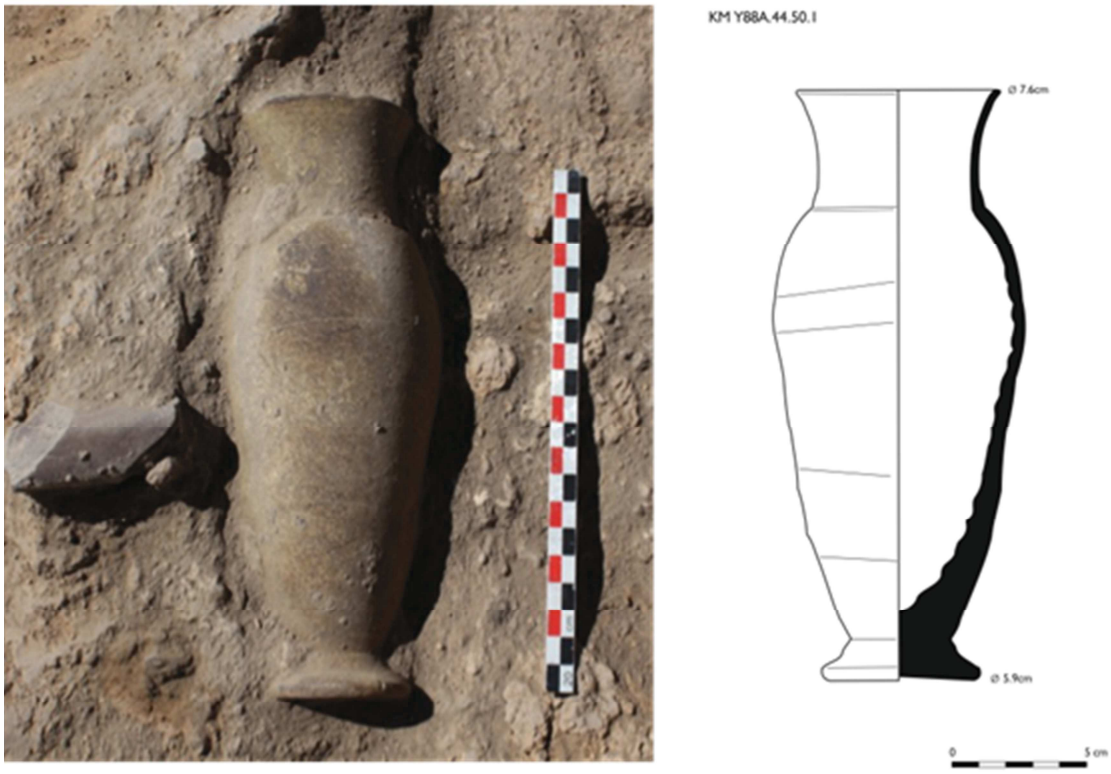


Figure 5.3: Left- Picture of a Kassite goblet in situ; Right: Drawing of the same Kassite goblet (H=22.5cm – rim ø 7.6cm – base ø 5.9cm)

5.1.1.2 Cups

My corpus also includes **20 cups** of different sizes and forms recovered primarily from trenches Y88 and Y89, and a smaller proportion from trenches V85 and L80. Nineteen of those 20 cups are footed cups (**Figure 5.4**). Within these 19 footed cups, four were identified as high-neck footed cups (**Figure 5.5**). These footed cups are characterised by a rounded body and a high straight neck finishing in an everted rim. Finally, one cup, also analysed for this study for comparison, was recovered in 2017 in trench K136D on SRP 94 (**Figure 5.6**).

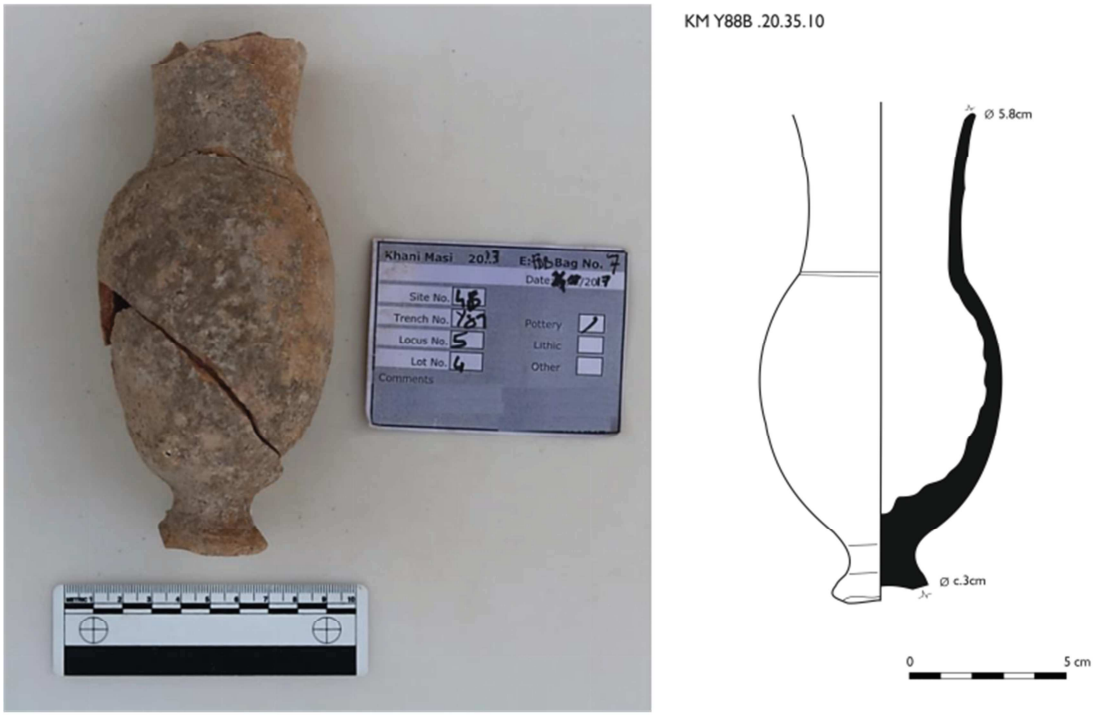


Figure 5.4: Left - Picture of the complete profile of a footed cup from Y89; Right - Drawing of a similar footed cup from Y88

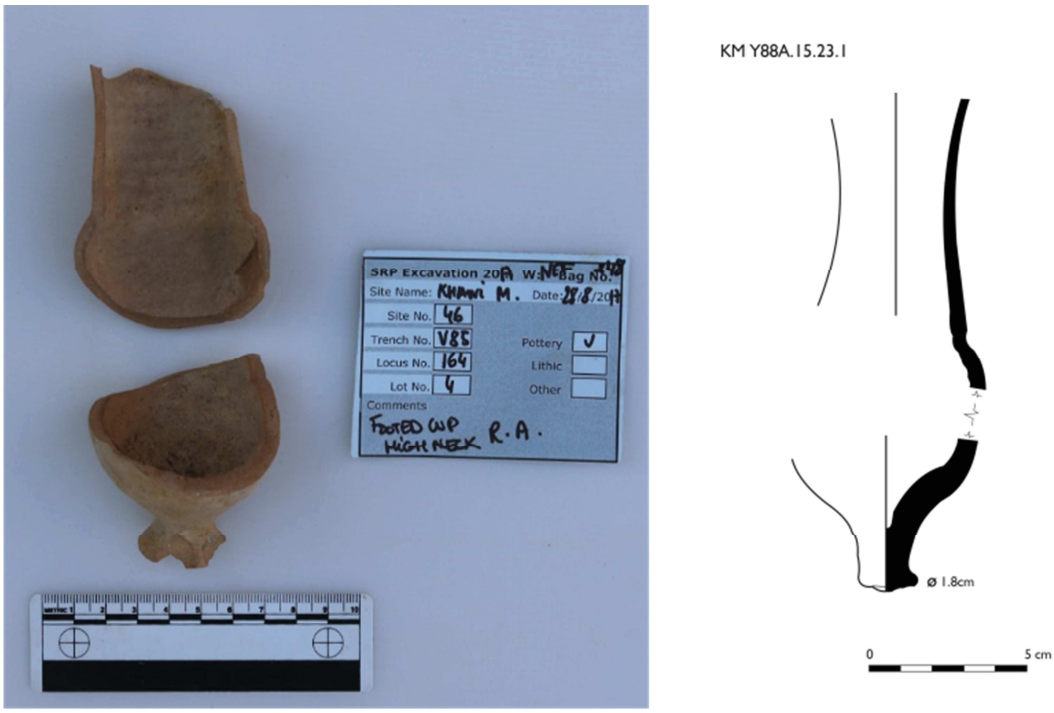


Figure 5.5: Two examples of high-neck footed cups sampled and analysed. Left: Picture of sample BECS 2608; Right: Drawing of sample BECS 1781

Figure 5.6: Pictures of a cup recovered in trench K136D (SRP94), sampled and analysed (BECS 2736)

5.1.1.3 Juglets

Cups with a wide body and a small flat disc base have been defined in this thesis as juglet or small jar (**Figure 5.7**). Their small flat bases do not provide enough stability for the juglets to stand straight on their own, and thus it is possible that they could have a different place in the sphere of consumption (utility or meaning).

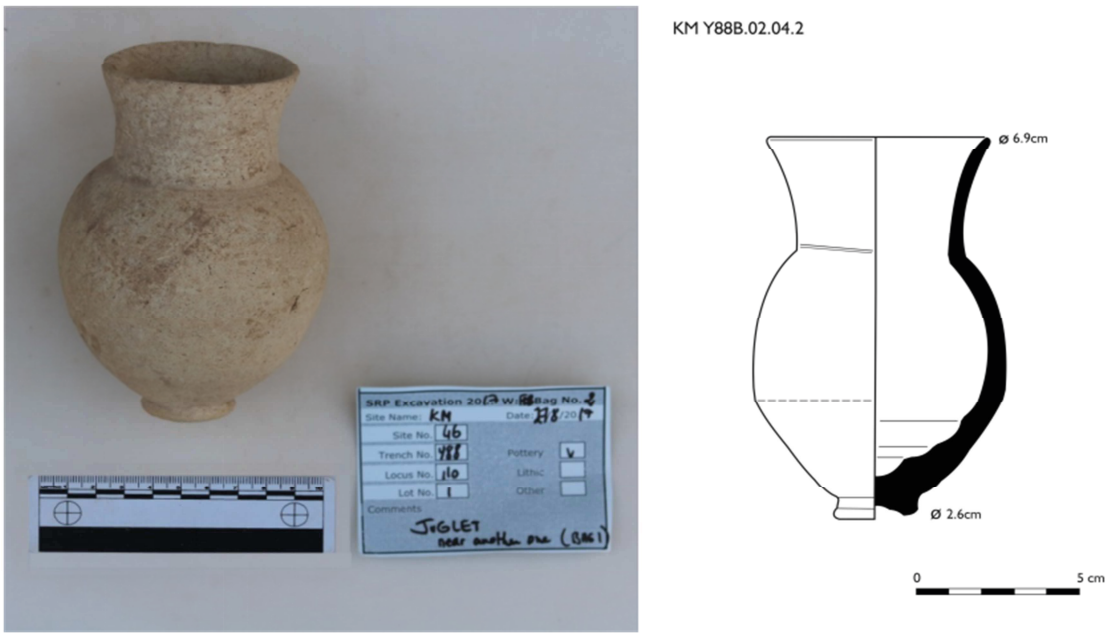


Figure 5.7: Two examples of juglets sampled and analysed. Left: Picture of sample BECS 2013; Right: Drawing of sample BECS 1750.

5.1.2 Larger vessels

5.1.2.1 Namzitu

Two large vats (**Figures 5.8 and 5.9**) have been identified as beer vats called *namzitu* due to their small perforated bases (Gates, 1988).

The main hypothesis on the role of the *namzitu* is that it acted as a fermentation vat in brewing beer. The malted grain, together with water, would have been poured in the *namzitu* where it was kept for a while. The perforation on the bottom would have allowed the fermenting mash to drip into a vessel positioned underneath to collect the wort. However, we do not have concrete evidence on when and for what purpose *namzitu* were involved in the brewing process. However, following the incomplete ancient recipe from the Hymn of Ninkasi and the ingredients identified through residue analysis (**Section 5.3**), we attempted to brew beer the way of the ancients during the Archaeology Honours/Postgraduate Taught Joint Course at the University of Glasgow. For this purpose we also used replicas of vessels found on site such as the *namzitu* that we used as filtering vat (**Figure 5.10a**) as described in the Hymn of Ninkasi :

"You are the one who handles the dough [and] with a big shovel,
Mixing in a pit, the bappir with [date] - honey,
You are the one who bakes the bappir in the big oven,
[…] You are the one who waters the malt set on the ground,
[…] You are the one who soaks the malt in a jar,
The waves rise, the waves fall.
[…] You are the one who spreads the cooked mash on large reed mats,
Coolness overcomes,
[…] You are the one who holds with both hands the great sweet wort,
Brewing [it] with honey [and] wine,
[…] The filtering vat, which makes a pleasant sound,
You place appropriately on a large collector vat.
[…] The filtering vat, which makes a pleasant sound,
You place appropriately on a large collector vat.
[…] When you pour out the filtered beer of the collector vat,
It is [like] the onrush of Tigris and Euphrates."
(translated by Miguel Civil, 1964)

Interestingly, the filtering of the mash using the replica of *namzitu* (**Figure 5.10b**) was more efficient than the one using a modern strainer (**Figure 5.10c**).

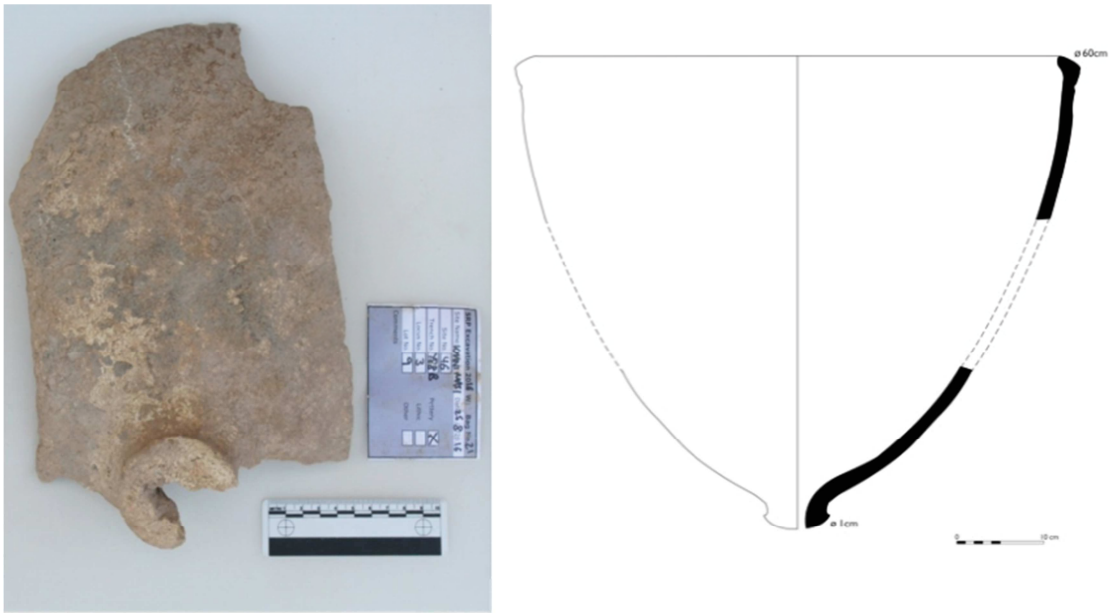


Figure 5.8: Pictures of a namzitu sampled and analysed (BECS 2752). Left: Picture of the rim; Right: Picture of the perforated base.

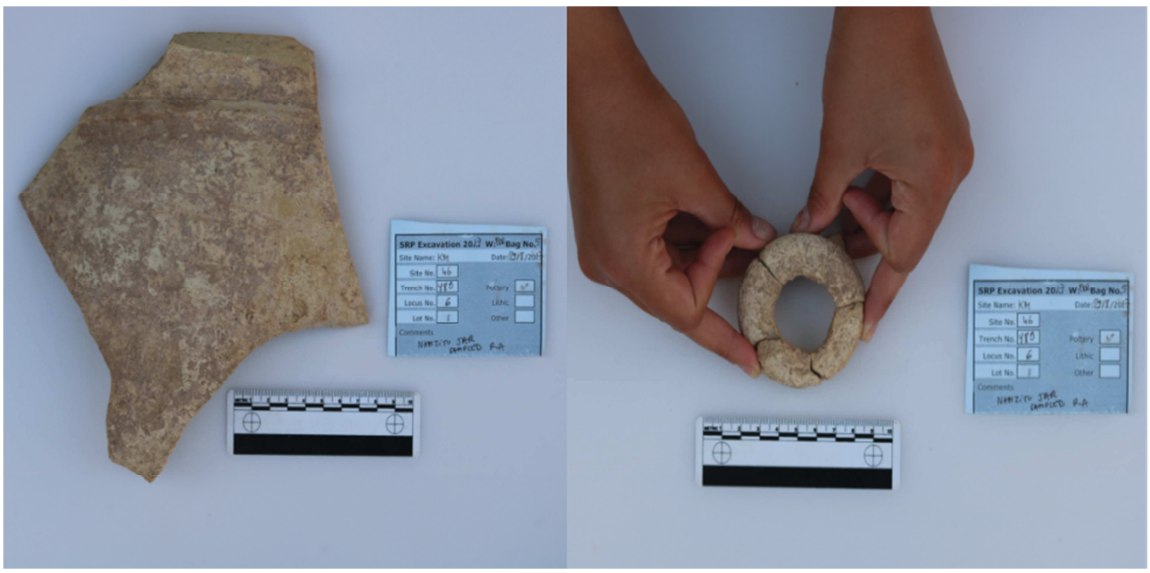


Figure 5.9: Left – Picture of a piece of *namzitu* sampled and analysed (BECS 1910); Right - Drawing of BECS 1910

Figure 5.10: Pictures of experimental archaeology of beer brewing taken during the Archaeology Honours/Postgraduate Taught Joint Course at the University of Glasgow (2017-2018). a. and b. filtering of the mash using a replica of *namzitu* (pottery artist : Leah Blackburn); c. wort collected after filtration with a modern strainer (left) and the replica of *namzitu* (right).

5.1.2.2 Other jars

I sampled and analysed **a large slender reddish ovoid jar** with a body that tapers slightly to a convex base (**BECS 2332**) (similar to the one showed in **Figure 5.10**). The maximum body diameter for this jar is just above the middle of its body. It has an outward flared neck that terminates in a band rim.

One large and deep vessel with the body decorated with one single broad wavy-line incision just below the neck (**Figure 5.11**) was also sampled and analysed. Unfortunately we were unable to recover the base of this vessel and thus we do not have its complete profile. Yet, it looks like the body of the vessel is "barrel"

shaped. The vessel has a heavy rolled and rounded rim and two ridges at the end of its neck.

Figure 5.11: Picture of the rim and body of a large ovoid jar recovered in trench Y88

Figure 5.12: Picture of a large and deep vessel sampled and analysed (BECS 2313)

Finally, **two large bowl-like vessels** were also sampled and analysed (**Figures 5.12** and **5.13**): one round, thick walled open vessel with a disc/ring base and one large and deep straight side bowl-like vessel with thinner walls and a disc/ring base.

Figure 5.13: Picture of a large bowl-like vessel sampled and analysed (BECS 2324)

Figure 5.14: Picture of a second large bowl-like vessel sampled and analysed (BECS 2320)

5.1.3 Other types of vessels

5.1.3.1 Bowls

Six medium-sized bowls (**Figure 5.14**) were collected and analysed for this study. They are all wave-sided bowls characteristic of the Kassite ceramic tradition.

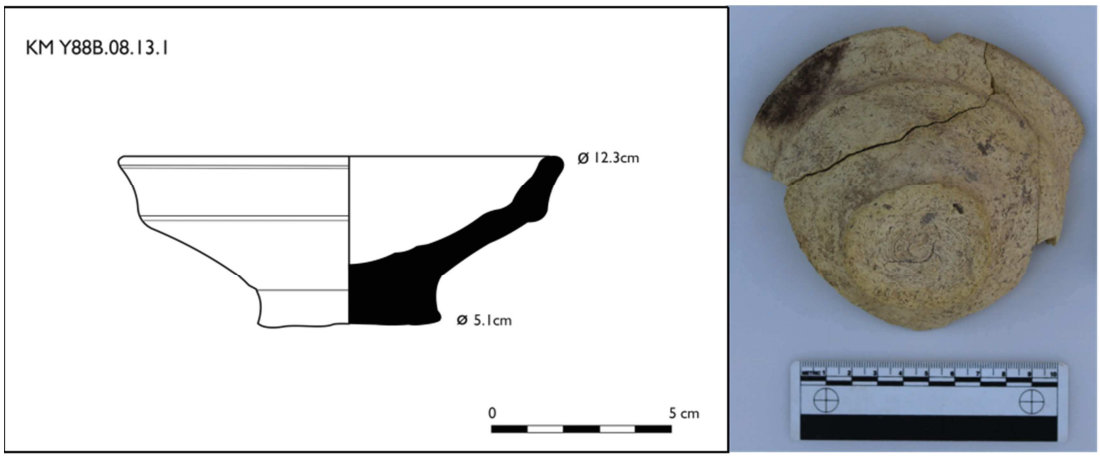


Figure 5.15: Two examples of wave-sided bowls discovered at Khani Masi. Left: Drawing of a complete bowl recovered in trench Y88 (Locus 8 lot 13); Right: Picture of bowl sampled and analysed (BECS 2807)

Based on iconography of seated figures drinking from small rounded bowls (Frankfort, 1939: 185 and 187, Pl. 105 and 107), we know it is entirely possible that bowls could have been used for beverage consumption and could have been part of drinking sets at Khani Masi. However, without further evidence from residue analysis, I decided to classify bowls into a separate category.

5.1.3.2 Faïence buckets

Two faïence buckets were also recovered in the abandonment layer of trench Y88, one with a simple rim and one with a loop handle which have been sampled for residue analysis (**Figure 5.15**). "Faience buckets" have been uncovered in 13th and 12th century BCE burial contexts, such as those discovered at Ur (Woolley, 1965) or Tell Zubeidi (Boehmer and Dämmer, 1985: Taffel 27, Fig. 14-17). They have been generally thought to be associated with incense offerings although no real evidence corroborates this hypothesis (Clayden, 1998; Glatz et

al., 2019) This type of artefact is made of glazed frit, a highly friable vitreous material, generally associated with the Late Kassite period (ca. 1350-1150 BCE) (Clayden, 1998; 2014; Armstrong, 2017: 421). This study presents the first residue analysis of a faïence bucket.

Figure 5.16: Left: Picture of one of the offering sets recovered in Y88 containing the faïence bucket sampled and analysed in this study (BECS 1760) Right: Drawing of BECS 1760

Organic residue analysis was performed on these 59 vessel fragments. No visible residues were discernible in any of these vessels. However, it is commonly accepted that in residue analysis of pottery the most important archaeological information is gained from analysis of the absorbed residues; surface or visible residues are more subject to post-burial or post-excavation contamination due to their exposed nature (Heron and Evershed, 1993). With that in mind, our sampling strategy was to analyse associated soil samples and vessel fill as controls and analyse absorbed and surface residues via crushing inner pottery walls and recovering all extractable residue via ASE350 using DCM: MeOH (v/v 9:1).The results are presented in **Section 5.2**.

The results of organic residue analysis could not be predicted in our case since 1) no visible residue was observed and 2) this is the first time that the function of these types of vessels has been explored chemically. This is the reason why, in this work, I employed Gas Chromatography, a methodology that allows a mixture of a large range of compounds to be separated and identified.

To secure the interpretation of the data (**Section 5.3**), comparative material such as reference samples of modern food were also analysed. Chromatographic profiles of modern and ancient food items may differ. For instance, beer brewing today involves the use of modern techniques and ingredients which were unknown to people in the ancient Near East (e.g. hops used as flavouring and stability agent in beer). Yet, the analysis of reference samples of modern food may present similar compounds to residues of ancient food which could be essential to our interpretation and could help us identify the contents of ancient vessels.

5.2 Organic residue analysis: Results

Fifty-nine vessels collected during the seasons 2016 and 2017 were sampled and analysed for this PhD using Gas chromatography-mass spectrometry (GC-MS), an instrument widely used for the separation, quantification and identification of organic compounds in complex mixtures such as organic residue in archaeology, using the NIST mass spectra library.

However, the NIST spectral library has been created largely for the pharmaceutical and biotechnology fields, and it could happen that peaks' mass spectra do not yield an acceptable match with any of the reference spectra from the NIST spectral library (Tzedakis, Martlew and Jones, 2008; Dimitrakoudi *et al.*, 2011; Debono Spiteri, 2012). It is also not advisable to identify compounds based purely on spectrum matches with the NIST library; doing so will often lead to false identification. It is thus important to also look at compound distribution, retention time index, and the fragmentation pattern of the mass spectra to identify and differentiate archaeologically relevant compounds from compounds which most likely come from modern contamination.

In this study, several peaks had a retention time and mass spectrum that did not yield an acceptable match with any of the reference spectra from the NIST spectra library or in our own created reference material. Peaks corresponding to obvious modern contaminants in the sherd samples (e.g. plasticizers, or other modern synthetic chemicals and impurities introduced from the laboratory) are not included in the chromatograms (**Appendices C and D**) but can be found in the compound table (**Figure 1** at **http://dx.doi.org/10.5525/gla.researchdata.875**).

Furthermore, even in the case in which the chemical compound is successfully identified, a definite association between a particular compound (or co-occurrence of compounds) and a specific source is very rare without further research. By using comparative data, analysing authentic reference material of food that would have been used in ancient times (e.g. barley, barley and wheat beer, nutmeg, dates) (**Appendix E**) based on textual, iconographic evidence, as well as faunal and ethnobotanical remains, I am able to present a more grounded interpretation of my data.

5.2.1 Methodology

Due to this project's innovative approach to the sampling regime specifically designed for residue analysis (described in **Section 4.3**), organic residues were well-preserved with only small amounts of modern contamination such as plasticizers (i.e. phthalates and phenols) compared to other compounds for the majority of our results (**Appendices C and D**). Comparisons were made with soil residues and residues extracted from both the outer and inner vessel surfaces to ensure that identified compounds are of archaeological significance and not the results of contamination. The majority of the compounds that were also associated with the soil samples and identified in vessels outer surfaces were not considered in the results. Laboratory blanks were also analysed to identify the possible contamination coming from the chemical procedure (see **Appendices C and D, Figures 104-109 and 258-264**).

The most basic procedure is a straightforward solvent extraction, either by sonication, Soxhlet extraction or accelerated solvent extraction (ASE). The latter was used for the extraction of residues preserved in their fabrics. The ASE also performs rinses between each extraction, to avoid any cross-contamination.
While the Soxhlet extraction is the conventional lipid extraction method in archaeology, it is rather tedious. In addition to being less time- and solvent-consuming, using the accelerated solvent extraction offers a better extraction in certain cases (e.g. Hubert *et al.*, 2000) and reduces human error. Furthermore, by using ASE on laboratory blanks (combusted sand - 450°C for 8hrs), we are able to check for laboratory contamination from beginning to end of the sample preparation and analysis protocol. By comparing the data from the laboratory

blanks and the archaeological samples, we can exclude from consideration possible contaminant compounds. To demonstrate that the accelerated solvent extraction technique does not result in carry-over or cross contamination in-between samples, two blanks were extracted, one at the beginning and one at the end of each ASE run, then prepared and analysed in the same way as my archaeological samples.

Several DCM and hexane blanks were also analysed during each GCs run to check that no contamination came from the GCs injection.

While DCM and hexane blanks show that no contamination is coming from the GC column, the laboratory blanks revealed that contamination (albeit a minor one) can come from the sample preparation protocol (**Appendices C and D, Figures 104-109 and 258-264)**. The contaminant compounds have been identified mainly as the fatty acids $C_{16:0}$ and $C_{18:0}$ and plasticizers; these have been taken into account when interpreting the results. Again, contaminant compounds from the laboratory procedure have been listed in the compounds table (**Appendices C and D** as well as **Table 1** at **http://dx.doi.org/10.5525/gla.researchdata.875.**).

In **Section 4.2**, I touched upon the difficulty of determining the relevance of compounds with multiple possible origins without a proper sampling strategy and control samples (inner and outer surfaces as well as soil sample), particularly when the compound can be found in nature as well as in modern products (see **Section 4.2.3**). For instance, we mentioned the presence of benzophenone in my first results (**Appendix B** as well as **Table 1** at **http://dx.doi.org/10.5525/gla.researchdata.875.**), a compound consistent with wine but that can also be found in sunscreen and other cosmetics products, which makes it difficult to identify whether this compound was archaeologically significant or the consequence of modern contamination. This same compound was identified in one of our samples (**BECS 2599**) collected in 2017: a bowl recovered in trench V85, Locus 164 (**Appendix D, Figure 155**). With this new methodology, I was able to clearly identify benzophenone as a contaminant by comparing the sample results with the control samples (**Appendix D, Figures 155-159**).

The new sampling strategy gives us the confidence that we can identify archaeologically significant compounds in our samples, allowing us to present a more grounded and reliable interpretation of our results.

5.2.2 Absence and presence of archaeologically significant compounds

Nineteen vessels out of the 59 analysed revealed no clear organic archaeological compounds, i.e. solely compounds of modern origin (e.g. plasticizers) or compounds found in both the matrix sample and in the control samples.
Several interpretive scenarios are possible. It is possible that: 1) no compounds survived in these vessels, 2) they did not contain anything, 3) they only contained water in the case of drinking/serving vessels, or 4) substances were not absorbed into the vessel fabric (e.g., were not in the vessel long enough).
The large jars (LV) and the bowls (B) are the main vessel categories where the least amount of archaeologically-consistent compounds was retrieved (**Figure 5.16**). It is possible that they would have contained dried goods (e.g. cereals) which, contrary to liquids, would not have seeped into the clay wall of the vessels.

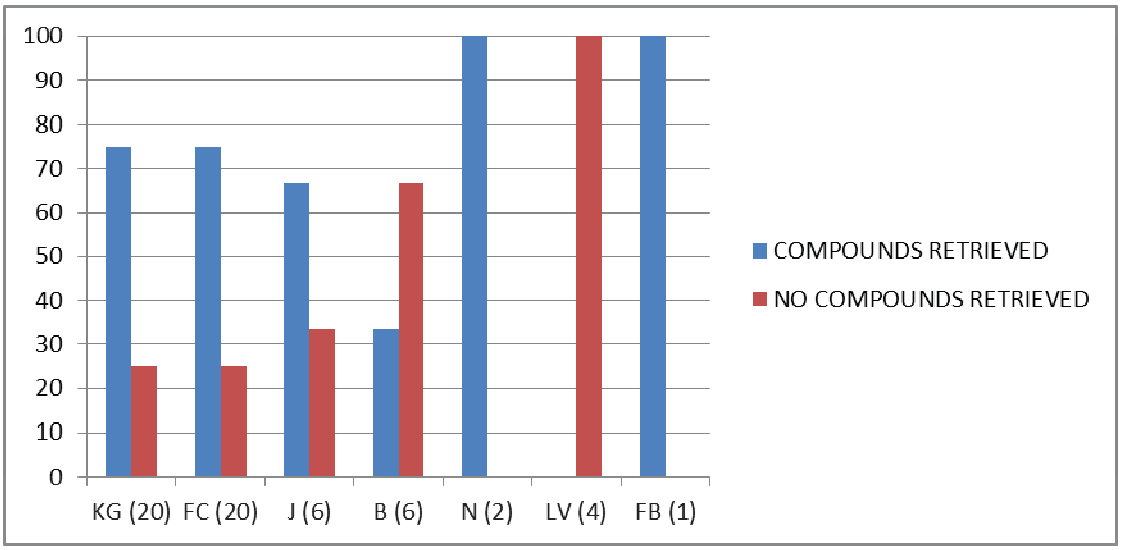


Figure 5.17: Percentage of ceramic samples for which archaeologically significant compounds were retrieved by vessel type (KG= Kassite goblet, FC=footed cup, J= juglet, B= bowl, N=*namzitu*, LV=large jar, FB=faïence bucket)

Figures 5.17 and **5.18**, show that the context of discovery of the vessels could partly explain the lack of archaeologically consistent compounds retrieved in some of the samples. For instance, we can observe that the majority of the vessels in which no clear archaeologically significant compounds were retrieved came from the trench V85. This trench has been identified as an area of domestic habitation (which includes Locus 164), which was later reused as an industrial space used in the production of ceramic vessels. This interpretation is supported by the presence of a kiln and a large amount of over-fired ceramic vessels (Locii 103 and 105) and a kiln refuse area (Locus 117). The area has also been heavily damaged by a succession of pits and cuts, as is the case for Locii 157 and 159. We can see a clear pattern of material bare of archaeologically significant compounds near the kiln (apart for the kiln refuse area) and in the pits, while the material coming from the domestic habitation produced interpretable results (**Figure 5.18**).

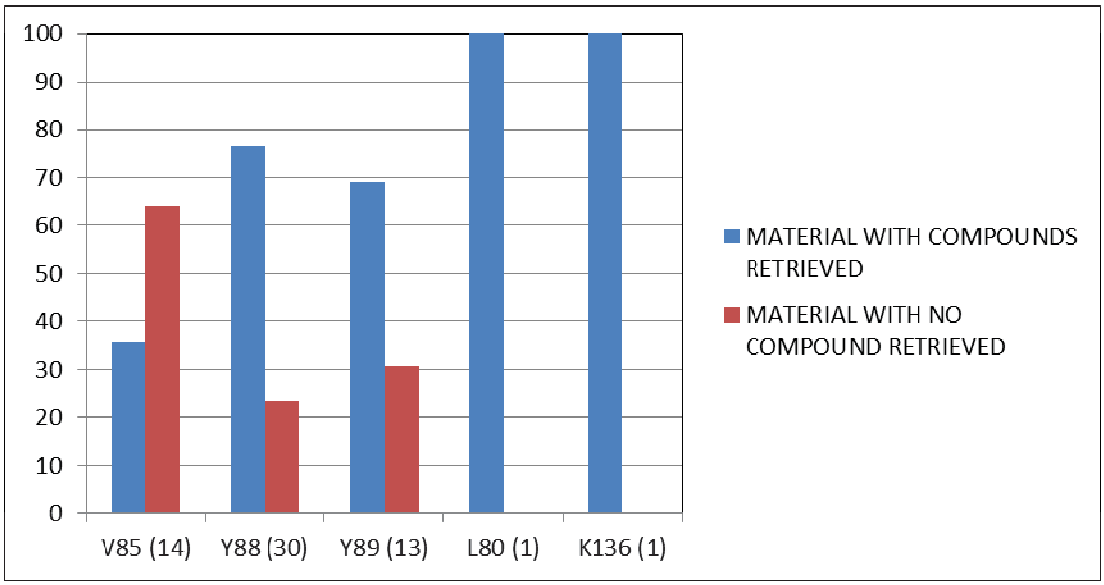


Figure 5.18: Percentage of ceramic samples for which archaeological significant compounds were retrieved by context of discovery (trenches=V85, Y88, Y89; L80 and K136)

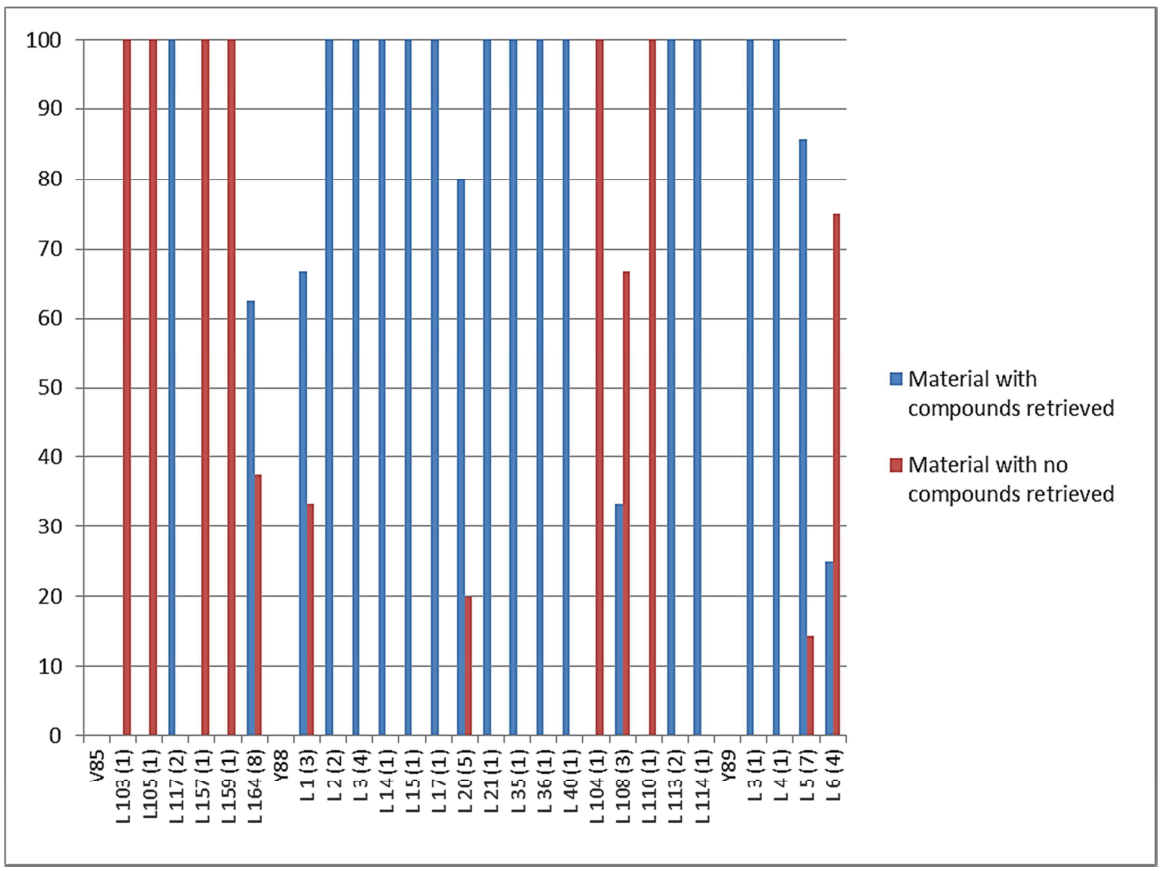


Figure 5.19: Percentage of ceramic samples for which archaeological significant compounds were retrieved by context of discovery (Trenches and L=Locii)

5.2.3 Drinking vessels

The drinking vessels category consists of three typological groups: (1) 'Kassite' goblets (KG), (2) juglets (J) and (3) cups (C). As previously stated, the majority of the compounds identified in my ceramic samples were not detected in the control samples (soil samples and outer surfaces of vessels) (**Appendices C, D** and **G**) and thus I interpret these to be of archaeological significance and not the product of contamination. The archaeologically significant compounds were presented in a paper (Perruchini *et al.*, 2018) and are discussed in more extensive details in **Sections 5.2.3.1**, **5.2.3.2** and **5.2.3.3**.

5.2.3.1 Kassite goblets

Twenty Kassite Goblets were analysed for this study, ten of which gave us interpretable results (**BECS 2652, 1757, 1747, 1756, 1935, 1938, 1777, 2223, 1918, 1915, 2306, 2537) (Appendices C and D, Figures 178, 50, 12, 46, 54,**

62, 38, 87, 24, 110 and 250). Five of these goblets have not yielded any archaeologically significant results (**BECS 2218, 2018, 2594, 2591, 2534**) and five have not given us enough co-occurring compounds to interpret their results (**BECS 2328, 2309, 2531**).

A large proportion of these Kassite goblets show a similar chromatographic profile and the presence of co-occurring types of compounds.
Fourteen Kassite goblets (**BECS 2223, 2652, 1757, 1747, 1756, 1935, 1915, 1938, 1918, 1777, 2328, 2306, 2309, 2537**) yielded residues containing a series of odd- ($C_{9:0}$ to $C_{25:0}$) and even- chain fatty acids ($C_{8:0}$ to $C_{28:0}$). The most abundant ones $C_{16:0}$ (palmitic acid) and $C_{18:0}$ (stearic acid), are the most common fatty acids in both plant and animal tissues (Heron and Evershed, 1993; Evershed *et al.*, 1997; Evershed, 2008). Unlike the majority of the compounds presented below, fatty acids (in particular $C_{16:0}$ and $C_{18:0}$) were present in both the inner and outer surfaces of sampled vessels and the surrounding soil samples. As a result, it is difficult to interpret their presence. Furthermore, after quantification of compounds, we can observe that C16:0 and C18:0 compounds are generally found in higher quantity in the control samples than in the sherds (**Tables 3** at **dx.doi.org/10.5525/gla.researchdata.875**). I thus chose not to include these ubiquitous compounds as significant to our archaeological analysis but do recognise that they may have ancient origins. Future analyses and techniques could be undertaken, such as compound-specific radiocarbon or stable isotope analysis to investigate these further, but are outside the scope of this thesis.

The following compounds were identified solely in the sherds and not in the control samples (**Tables 2** at **dx.doi.org/10.5525/gla.researchdata.875**).
Ten Kassite goblets yielded residues containing mid-chain monounsaturated $C_{16:1}$ and $C_{18:1}$ fatty acids (**BECS 2223, 1757, 1747, 1756, 1935, 1915, 1938, 1918 and 1777**). One of which (**BECS 1777**) also contained monounsaturated fatty acids $C_{14:1}$ (**Appendix F, Figure 277**) and $C_{20:1}$ **(Appendix F, Figure 296)** and the diunsaturated fatty acid $C_{18:2,}$ not identified in control samples, and therefore considered archaeologically significant.
We identified the presence of carboxylic and dicarboxylic acids in three of the ten Kassite goblets (**BECS 2652, 1777, 2306**): butanedioic acid (**Appendix F,**

Figure 280), pimelic acid (**Appendix F, Figure 279**), suberic acid (**Appendix F, Figure 281**) and azelaic acid (**Appendix F, Figure 282**).

The samples of four Kassite goblets residues also contained the compound glycerol 3TMS (**Appendix F, Figure 283**) in low relative concentration (**BECS 2652, 1935, 1938, 2537**).

Eight Kassite goblets yielded residues containing alkanes, in particular odd-numbered alkanes (**BECS 2652, 1757, 1747, 1756, 1935, 1938, 1777, 2328, 2534)**. Odd-numbered alkanes (C_{17}-C_{31}) are ubiquitous compounds in nature and that is why they have also been identified in control samples. However odd-numbered alkanes (e.g. C_{27}, C_{29} or C_{31}) are usually associated with plant waxes (Marshall *et al.*, 2008; Baeten *et al.*, 2013; Soberl *et al.*, 2014).

Six Kassite goblets (**BECS 2652, 1757, 1747, 1756, 1938, 1777**) yielded residues containing phenolic acids: hydrocinnamic **(Appendix F, Figure 284)**, methoxycinnamic (**Appendix F, Figure 284**), and o-coumaric (**Appendix F, Figure 286**) acids.

A compound from the class terpene is also present in nine of our Kassite goblets (**BECS 1757, 1747, 1935, 1915, 1938, 1918, 1777, 2537, 2531**). Although not identified precisely through the NIST library, the mass spectrum shows two predominantly high m/z ions 69 and 81 m/z as well as 136/7 m/z and smaller peaks 341 and 410 m/z (**Appendix F, Figure 288**). Those are peaks found in the mass spectrum of squalene, a triterpene (Middleditch, 1989: 652). Squalene is a natural organic compound found in bacteria. In order to confirm my identification, a sample of bacteria type I methanotroph *Methylomonas methanica* was used as reference sample (**Appendix F, Figure 288**). The retention time and mass spectrum confirm the identification of squalene in my results. Squalene is also a common contaminant and a component in skin sebum, but because this compound was 1) found exclusively in our drinking vessels, 2) not identified in soil samples or the outer and inner surfaces and 3) because our vessels were not handled with bare hands and with only sterilized equipment, its presence is interpreted here as archaeologically significant.

Another notable compound pyrrolo[1,2-a]pyrazine-1,4-dione, hexahydro-3-(phenylmethyl) (**Appendix F, Figure 287**) was found in one of the Kassite goblet (**BECS 2537**) (**Appendix D, Figure 250**), only in the sherd sample (and not in the control samples) and is thus interpreted here as archaeologically significant.

Other less consistent compounds were identified in five of the Kassite goblets.

One Kassite goblet (**BECS 1935**) (**Appendix C, Figure 54**) yielded a residue containing long-chain fatty alcohols (C_{10}, C_{18}-C_{30}) as well as the presence of 1-Isobutyl 4-isopropyl 3-isopropyl-2,2-dimethyl succinate (2,2,4-trimethyl-3-carboxy isopropyl-isobutyl pentanoate) (**Appendix F, Figure 289**).
Three Kassite goblets yielded residues containing an aldehyde, octadecenal (**BECS 1747, 1935, 1777**). Two of those three Kassite goblets (**BECS 1747, 1935**) also showed the presence of erucylamide (**Appendix F, Figure 297**). The results for samples **BECS 2328** and **2309** show the presence of another amide octadecanamide, although it was also identified in the samples of inner surface vessels and so might be the result of contamination.

5.2.3.2 Cups

Twenty footed cups were analysed for this study, 14 of which gave us interpretable results (**BECS 1769, 1781, 1766, 1774, 1922, 2215, 2015, 2317, 2303, 2749, 2739, 2746, 2732** and **2608**). The majority of these cups show a similar chromatographic profile and the presence of the same co-occurring types of compounds as the Kassite goblets.

Eleven cups (**BECS 1769, 1781, 1766, 1774, 1922, 2215, 2015, 2317, 2303, 2749, 2739**) yielded residues containing a series of odd ($C_{9:0}$ to $C_{23:0}$) and even-chain fatty acids ($C_{10:0}$ to $C_{26:0}$). The most abundant ones $C_{16:0}$ (palmitic acid), and $C_{18:0}$ (stearic acid), are the most common fatty acids found in both plant and animal tissues (Evershed *et al.*, 1997; Evershed, 2008; Heron and Evershed, 1993). Unlike the majority of the compounds presented below, fatty acids (in particular $C_{16:0}$ and $C_{18:0}$) are present in both the inner and outer surfaces of the sampled vessels and the surrounding soil samples. Furthermore, after quantification of compounds, we can observe that C16:0 and C18:0 compounds are generally found in higher quantity in the control samples than in the sherds (**Tables 3** at **dx.doi.org/10.5525/gla.researchdata.875**). I thus chose not to include these ubiquitous compounds as significant to our archaeological analysis, but do recognise that they may have ancient origins.

The following compounds were identified solely in the sherds and not in the control samples (**Appendix G**).

The sample residues of six cups (**BECS 1922, 1766, 1769, 1781, 1774, 2215**) also contained mid-chain monounsaturated fatty acids ($C_{16:1}$ and $C_{18:1}$). Four of these cups (**BECS 1766, 1769, 1781** and **1774**) also contained monounsaturated fatty acids $C_{14:1}$ (**Appendix F, Figure 277**) and $C_{20:1}$ (**Appendix F, Figure 296**) and the diunsaturated fatty acid $C_{18:2,}$ not identified in control samples, and therefore considered archaeologically significant.

We identified in five of the cups (**BECS 2736, 1769, 1766, 1774, 1922**) the presence of carboxylic and dicarboxylic acids: benzoic acid (**Appendix F, Figure 278**), butanedioic acid (**Appendix F, Figure 280**), pimelic acid (**Appendix F, Figure 279**), suberic acid (**Appendix F, Figure 281**) and azelaic acid (**Appendix F, Figure 282**).

We also can observe the presence of long-chain fatty alcohols (C_{18} to C_{30}) in **BECS 1922** and n-alkanes (in particular odd-numbered alkanes C_{13} to C_{35}) in **BECS 1769, 1781, 1766, 1774, 1922, 2215, 2015, 2317, 2303, 2749, 2739, 2746, 2732** and **2608**. However as they are ubiquitous compounds they have also been identified in control samples.

Methoxycinnamic (**Appendix F, Figure 284**) has also been identified in four of the cups (**BECS 1769, 1781, 1766, 1774**) as well as squalene (**Appendix F, Figure 288**) present in the results for **BECS 1769, 1781, 1766, 1774** and **1922**.

Three of these cups yielded residues containing an aldehyde, octadecenal (**BECS 1769, 1781** and **1766**) (**Appendix C, Figures 30, 27 and 34**) and the presence of erucylamide (**Appendix F, Figure 297**).

Other less consistent compounds were identified in six of the cups.

BECS 2736, sampled from the cup recovered in trench K136D (**Appendix D, Figure 114**), yielded a residue containing the organoheterocyclic compound hexathiepane (**Appendix F, Figure 298**).

BECS 2317 (**Appendix D, Figure 134**) yielded a residue containing two compounds of interest identified as neophytadiene, a phytadiene isomer (terpene) (**Appendix F, Figure 290**), and the triterpenoid friedelin (**Appendix F, Figure 291**).

Finally, four cups (**BECS 2015, 2746, 2732** and **2608**) have shown a completely distinct chromatographic profile (**Appendices C and D, Figures 75, 214, 194 and 202**) with the main compounds present being even and odd-chain n-alkanes (C_{13} to C_{35}) as well as three isoprenoid hydrocarbons phytane (**Appendix F,**

Figure 292), pristane (**Appendix F, Figure 293**) and norpristane (**Appendix F, Figure 294**), the hopane 28-nor-17B(H)-hopane (**Appendix F, Figure 295**) and the sterane stigmastane.

5.2.3.3 Juglets

Six juglets were analysed for this study, four of which yielded archaeologically significant compounds (**BECS 2758, 1750, 2649** and **2602**). These four juglets show a similar chromatographic profile and the presence of the same co-occurring types of compounds as the Kassite goblets and cups.

The four juglets (**BECS 2758, 1750, 2649** and **2602**) yielded residues containing a series of odd ($C_{9:0}$ to $C_{23:0}$) and even-chain fatty acids ($C_{8:0}$ to $C_{26:0}$). The most abundant ones $C_{16:0}$ (palmitic acid) and $C_{18:0}$ (stearic acid), are the most common fatty acids found in both plant and animal tissues (Evershed *et al.*, 1997; Evershed, 2008; Heron and Evershed, 1993). Unlike the majority of the compounds presented below, fatty acids (in particular $C_{16:0}$ and $C_{18:0}$) are present in both the inner and outer surfaces of sampled vessels and the surrounding soil samples. Furthermore, after quantification of compounds, we can observe that C16:0 and C18:0 compounds are generally found in higher quantity in the control samples than in the sherds (**Tables 3** at **dx.doi.org/10.5525/gla.researchdata.875**). I thus chose not to include these ubiquitous compounds as significant to our archaeological analysis, but do recognise that they may have ancient origins.
We can also note the presence of several n-alkanes (C_{16}, C_{17}, C_{25}, C_{27}, C_{29} and C_{31}) in the results obtained for the four juglets (**BECS 2758, 1750, 2649** and **2602**).

The following compounds were identified solely in the sherds and not in the control samples (**Appendix G**).

Two of the juglets (**BECS 2758** and **2649**) also yielded residues containing the compound glycerol in low relative concentration but it was excluded from consideration as it was also detected in the control samples.

The sample residues of three juglets (**BECS 2758, 1750** and **2602**) also contain mid-chain monounsaturated fatty acids ($C_{16:1}$ and $C_{18:1}$) and the diunsaturated fatty acid $C_{18:2}$ (**BECS 2758** and **2602**).
We identified in two of the juglets (**BECS 1750** and **2649**) the presence of carboxylic and dicarboxylic acids: suberic acid (**Appendix F, Figure 281**) and azelaic acid (**Appendix F, Figure 282**).
One of the juglets (**BECS 1750**) (**Appendix C, Figure 20**) yielded a residue containing the compound methoxycinnamic (**Appendix F, Figure 284**), the same terpene identified as squalene (**Appendix F, Figure 288**) as well as the compound pyrrolo[1,2-a]pyrazine-1,4-dione, hexahydro-3-(phenylmethyl) (**Appendix F, Figure 287**), all three mentioned previously.

5.2.4 Namzitu

Two *namzitu* have been sampled for this study (**BECS 1910** and **2752**), one of which (**BECS 1910**) showed a similar chromatographic profile and the presence of the same co-occurring types of compounds as the three types of drinking vessels discussed above (**Appendix C, Figure 66**).

Both samples (**BECS 1910** and **2752)** yielded residues containing a series of odd ($C_{9:0}$ to $C_{17:0}$) and even- chain fatty acids ($C_{8:0}$ to $C_{22:0}$). $C_{16:0}$ (palmitic acid) and $C_{18:0}$ (stearic acid) are the most common and abundant fatty acids and can be found in both plant and animal tissues (Evershed *et al.*, 1997; Evershed, 2008; Heron and Evershed, 1993). Unlike the majority of the compounds presented below, fatty acids (in particular $C_{16:0}$ and $C_{18:0}$) are present in both the inner and outer surfaces of sampled vessels and the surrounding soil samples. Furthermore, after quantification of compounds, we can observe that C16:0 and C18:0 compounds are generally found in higher quantity in the control samples than in the sherds (**Tables 3** at **dx.doi.org/10.5525/gla.researchdata.875**). I thus chose not to include these ubiquitous compounds as significant to our archaeological analysis, but do recognise that they may have ancient origins.

We also can observe the presence of odd-numbered n-alkanes (C_{27}-C_{31}) in both samples (**BECS 1910** and **2752**) however as they are ubiquitous compounds they have also been identified in our associated soil samples.

The following compounds were identified solely in the sherds and not in the control samples (**Appendix G**).

BECS 1910 contained mid-chain monounsaturated fatty acids ($C_{16:1}$ and $C_{18:1}$) not identified in control samples, and therefore considered archaeologically significant.

We identified in **BECS 1910** the presence of carboxylic and dicarboxylic acids: benzoic acid (**Appendix F, Figure 278**), and butanedioic acid (**Appendix F, Figure 280**).

The residue also contained the phenolic compound hydrocinnamic (**Appendix F, Figure 285**).

The same terpene identified as squalene (**Appendix F, Figure 288**) is also present in the results for **BECS 1910** (**Appendix C, Figure 66**) as well as the ester 1-Isobutyl 4-isopropyl 3-isopropyl-2,2-dimethyl succinate (**Appendix F, Figure 289**) previously mentioned.

Finally, **BECS 2752** yielded a residue containing the compound 2,6-diisopropylnaphthalene, also known as 2,6-DIPN, belonging to the class of organic compounds known as naphthalenes (**Appendix D, Figure 210**). However, traces of 2,6-DIPN have also been identified in the outer surface sample.

5.2.5 Bowls

Six medium-sized wave-sided bowls, whose function was not likely associated with the preparation and consumption of alcoholic drinks, were also sampled for residue analysis. Only in two of these bowls archaeologically significant compounds were detected (**BECS 1772** and **2540**) (**Appendices C and D, Figures 70 and 138**).

BECS 1772 yielded a residue containing a series of even- chain fatty acids ($C_{14:0}$ to $C_{18:0}$). $C_{16:0}$ (palmitic acid) and $C_{18:0}$ (stearic acid), are the most common and abundant fatty acids in both plant and animal tissues (Evershed *et al.*, 1997; Evershed, 2008; Heron and Evershed, 1993). But again, unlike the majority of the compounds presented below, fatty acids (in particular $C_{16:0}$ and $C_{18:0}$) are present in both the inner and outer surfaces of sampled vessels and the surrounding soil samples. As a result, it is difficult to interpret their presence. Furthermore, after quantification of compounds, we can observe that C16:0 and

C18:0 compounds are generally found in higher quantity in the control samples than in the sherds (**Tables 3** at **dx.doi.org/10.5525/gla.researchdata.875**). These ubiquitous compounds were not identified as significant to our archaeological analysis, but I do recognise that they may have ancient origins.
The following compounds were identified solely in the sherds and not in the control samples (**Appendix G**).
BECS 1772 also contained a mid-chain monounsaturated fatty acid ($C_{18:1}$) not identified in control samples, and therefore considered archaeologically significant, as well as odd-numbered n-alkanes (C_{27}-C_{31}); however, as they are ubiquitous compounds they have also been identified in our associated control samples.
BECS 1772 also contained diacylglycerols (DAG) and long chain ketones (K_{29} or nonacosan-15-one and K_{31} or 16-hentriacontanone) in (**Appendix C, Figure 70**).
The other bowl sampled (**BECS 2540**) presented a very distinct chromatographic profile (**Appendix D, Figure 138**) similar to the results obtained for the four cups (**BECS 2015, 2746, 2732** and **2608**) with the main compounds present being even and odd-chain n-alkanes (C_{13} to C_{35}) as well as isoprenoid hydrocarbons (e.g. phytane and pristane) (**Appendix F, Figures 292-294**), hopanes (e.g. 28-nor-17B(H)-hopane) (**Appendix F, Figure 295**) and steranes (e.g. stigmastane).

5.2.6 Faïence Bucket

It is important to note that due to the fragile nature of the faience bucket (**BECS 1760**), it was impossible to collect the outer and inner surfaces of the sample and thus also impossible to exclude and identify a possible contamination coming from the excavation and post-excavation process. Still, the sample gave us interpretable results as the presence of known modern contaminants, such as plasticizer compounds was negligible (**Appendix C, Figure 73**).

The sample of the faïence bucket yielded a residue containing a series of even-chain fatty acids ($C_{16:0}$ to $C_{20:0}$) present in the surrounding soil samples. Furthermore, after quantification of compounds, we can observe that C16:0 and C18:0 compounds are generally found in higher quantity in the control samples than in the sherds (**Tables 3** at **dx.doi.org/10.5525/gla.researchdata.875**). As a

result, it is difficult to interpret them as archaeologically significant, but I do recognise that they may have ancient origins.

The following compounds were identified solely in the sherds and not in the control samples (**Appendix G**).
BECS 1760 also presented a chromatogram containing two long-chain fatty alcohols $C_{34:0}$ and $C_{36:0}$ as well as two wax esters (dodecyl oleate and octadecyl palmitate). We can also note the presence of diacylglycerols (DAG).

5.3 Organic residue analysis: Interpretation

5.3.1 Beverages at Khani Masi

Analytical results show that the majority of the 'Kassite' goblets, juglets and cups present similar chromatographic profiles and show a co-occurrence of chemical compounds which, in concert, point to the presence of a cereal-derived fermented beverage, i.e. barley beer (Perruchini *et al*. 2018).
Beer (Sumerian kaš, Akkadian šikaru) is well attested in a range of cuneiform genres from the Uruk period (ca. 4000 - 3100 BCE) onwards, as well as in iconography. But while ancient Near Eastern cuneiform texts and iconography unambiguously demonstrate the social, economic, and ritual significance of beer, direct archaeological evidence for beer production or consumption remains surprisingly rare and restricted to the identification of production vessels associated with beer brewing. Furthermore, as previously mentioned (see **Section 3.1.1**), the chemical identification of beer is to date confined to a small number of cases in which archaeological context, inferences from textual sources about vessel function or the presence of visible residues (beerstone) in relatively unambiguous terms point to the brewing and storage of beer (Michel *et al.*, 1993; Otto, 2012).

With my novel field sampling protocol that prevents contamination along with a refined organic residue analysis methodology that relies on a series of co-occurring compounds, I was able to confidently identify beer in ceramic drinking vessels. The same compounds were identified in several modern beer samples and, thus, support our identification of a similar fermented barley-based beverage in archaeological samples from the late second millennium BCE site of

Khani Masi in northeastern Iraq. Indeed, with the aim to certify with greater certainty the identification of beer in our archaeological samples, a sample of malted barley (**BECS 2367**) and two samples of modern beers - a wheat beer containing a mixture of wheat malt and barley malt (Erdinger Weißbier, Germany) (**BECS 3044**), and a barley beer made from barley malt (Budweiser original, Czech Republic) (**BECS 3043**) - were freeze dried for two days, prepared and analysed following the same methodology as our archaeological samples (Perruchini *et al.*, 2018). The results of Gas chromatography obtained for these modern standards were then used as comparative material (**Appendix E, Figures 265-268**).

Among the observed compounds, carboxylic and dicarboxylic acids, benzoic, pimelic, butanedioic, fumaric and azelaic acids are present in a number of plants (e.g. Lohaus, Bios and Rüdiger, 1983) and derivative products (e.g. Hanuš and Ben-Yehoshua, 2013) such as fermented alcoholic beverages (Nykänen and Suomalainen, 1983; Klopper *et al.*, 1986; Briggs *et al.*, 2004; Pecci *et al.*, 2013) (**Table 1** at **dx.doi.org/10.5525/gla.researchdata.875).** However, no traces of compounds usually associated with wine, such as tartaric acid or polyphenols (e.g. malvidin and syringic acid) were detected (Barnard *et al.*, 2011). Benzoic acid has multiple possible origins (Perruchini *et al.*, 2018). It has been identified in smoke and charred materials. It can occur in many plants and their decomposition process (Namdar *et al.*, 2013; Jones, 2016) and has been identified as a minor compound of plant resin (Tzedakis, Martlew and Jones, 2008); however, it is also a by-product of fermentation processes (Pecci *et al.*, 2013). It is important to note that benzoic and butanedioic acids were identified in our samples of modern beers (**BECS 3043** and **3044**) (**Appendix E, Figures 267-268**) and in the *namzitu* sample **BECS 1910** (**Appendix C, Figure 66**), and only in a few of our drinking vessels, perhaps indicating a better preservation of compounds in the *namzitu* where beer would have sat longer. Finally, azelaic acid could be, like the hydroxy fatty acids 10-oxo-octadecanoic acid (10-oxo-C_{18}:0) (**BECS 1915 and 2215**), the product of the oxidation of oleic acid (Colombini *et al.*, 2005; Koh and Birney, 2017); however, it should be noted that they also occur naturally in cereals grains wheat, rye, and barley (McGovern, Hall and Mirzoian, 2013). Here, in the context of the other compounds identified, our rigorous methodology to avoid contamination, and three control

samples (soil, inner and outer surfaces), I suggest that the presence of azelaic is most likely indicative of beer made of cereal grains.

While squalene is a common lipid in many organisms and highly commercialized today for its antioxidant properties (Steele, 2013), it has also been widely reported to occur in germinated grain (Briggs, 1978: 116) and yeast (Blagovic *et al.*, 2001), which is the most important ingredient in brewing beer. Indeed, yeast is a single-cell organism, one of the simplest forms of plant life, which is responsible for the fermentation process in beer. This terpene was also identified in our sample of malted barley (**BECS 2367**) and two samples of modern beers (**BECS 3043** and **3044**) (**Appendix E, Figures 265-268**).

Another notable compound consistent with beer was found in two vessels, one Kassite goblet (**BECS 2537**) and one juglet (**BECS 1750**): pyrrolo[1,2-a]pyrazine-1,4-dione, hexahydro-3-(phenylmethyl). Produced by fungi, pyrazine derivatives have been identified as antioxidants present in roasted barley malt and modern beer (Buckingham, 1993: 1226; Gautschi *et al.*, 1997; Briggs *et al.*, 2004: 318). This compound was indeed identified in our sample of malted barley (**BECS 2367**) and our two samples of modern beers containing malted barley (**BECS 3043** and **3044**) (**Appendix E, Figures 265-268**).

Hydrocinnamic acid, methoxycinnamic acid and o-coumaric acid are cinnamic derivatives that have been in previous studies identified in a large number plants including pulses and cereal grains such as barley (Hernanz *et al.*, 2001; Nollet, 2004: 696; Kuete, 2013: 227; Khakimov, Bak and Engelsen: 2014; Boz, 2015) as well as in modern beer (Briggs *et al.*, 2004; Bokulich, 2017; Sandoval-Ramírez *et al.*, 2017) as sign of alcoholic fermentation (Salameh *et al.*, 2008) but were not identified in the two samples of modern beers (**Appendix E, Figure 267**). These compounds are also formed by fungi (Guzman, 2014), degradation of wax (Regert *et al.*, 2001) and in honey (Trautvetter, Koelling-Speer and Speer, 2009). However, these three compounds have not been found in the control samples and no other compounds indicative of of honey were identified in our samples.

The remaining compounds identified in the ceramic vessels (**Appendix G**), though not directly contributing further evidence to the identification of beer, by no means contradict it. For instance, $C_{18:1}$, oleic acid, and $C_{16:1}$, palmitoleic acid, can be found in varying quantities in all animal and plant lipids (Gunstone,

Harwood and Padley, 1994), including cereal grains (Asuman, 2015). Indeed, our samples of malted barley (**BECS 2367**) and modern beers (**BECS 3043** and **3044**) contain, like our archaeological samples, mid-chain monounsaturated and diunsaturated fatty acids ($C_{16:1}$, $C_{18:1}$ and $C_{18:2}$) as well as glycerol (**Appendix E, Figures 265-268**). Glycerol has been identified in previous studies in high quantities in different kinds of beers, even alcohol-free ones (Klopper *et al.*, 1986).

The reliability of the above results and interpretation are further corroborated by the similar chromatographic profile and compounds identified in the results obtained from the *namzitu* sample **BECS 1910**. Indeed, as previously mentioned, *namzitu* are vessels that have been associated with beer production through textual sources (Gates, 1988). The second sample of a *namzitu* (**BECS 2752**) while yielding a residue not containing any of the compounds consistent with beer, presented the compound 2,6-diisopropylnaphthalene, also known as 2,6-DIPN, a polycyclic aromatic hydrocarbon (PAH) also identified in the outer surface sample. The appearance and accumulation of such compounds have been interpreted in the past to be the consequence of pyrogenous processes (Srogi, 2007).

Finally, systematic sampling for archaeobotanical material has been undertaken across all trenches at Khani Masi, with the purpose of investigating the crop economy of the site. While no charred grains have been recovered from the monumental structure in trench Y88, a few charred plant remains have been collected from other contemporary contexts of SRP 46 and analysed. The results indicate that barley, the most common ingredient in Mesopotamian beer, was one of the major crops at the site, as well as few instances of wheat identified to date. The archaeobotanical record produces another strong evidence of beer production and consumption at Khani Masi.

5.3.2 Spices and aromatics

5.3.2.1 Nutmeg

In addition to the co-occurring compounds indicative of barley beer described above (Perruchini *et al.*, 2018), the lipid extracts from five vessels exclusively

(**BECS 1769, 1781, 1766, 1774 and 1777**) indicate the presence of three compounds observed only in the vessel matrices and not in the inner or outer vessel walls or the surrounding soil samples, which indicates that they were not introduced by post-depositional and post-excavation contamination (**Appendix C, Figures 30, 27, 34, 42 and 38**).

These five vessels were recovered in trench Y88 in the abandonment layer (**Figure 5.19**), the same layer as the two offering sets (circled in red in **Figure 5.20**): one Kassite goblet (**BECS 1777** – Locus 3) and four footed cups (**BECS 1769, 1781, 1766, 1774** respectively in Locii 21, 15, 17 and 3).

The most significant of these three compounds is myristoleic acid ($C_{14:1}$), a compound rare in nature. It is a minor compound in certain meats and dairy butter, and occurs in *Serenoa repens*, a small saw palmetto native to the U.S. South Atlantic coast, Southern Europe and North Africa (Iguchi *et al.*, 2001). Myristoleic acid has also been identified in negligible amounts in the seeds of two modern date palm (*Phoenix dactylifera* L.) cultivars, Deglet Nour and Allig, from the Degach region of Tunisia (Besbes *et al.*, 2004), but has not been associated with Middle Eastern varieties of date palms (Al-Shahib and Marshall, 2003). Our own reference sample of modern dates (with their seeds) imported from Iraq did not contain any traces of myristoleic acid ($C_{14:1}$) (**BECS 3090**) (**Appendix E, Figure 269**). Dates can therefore be excluded as a potential source of this compound in the archaeological samples analysed.

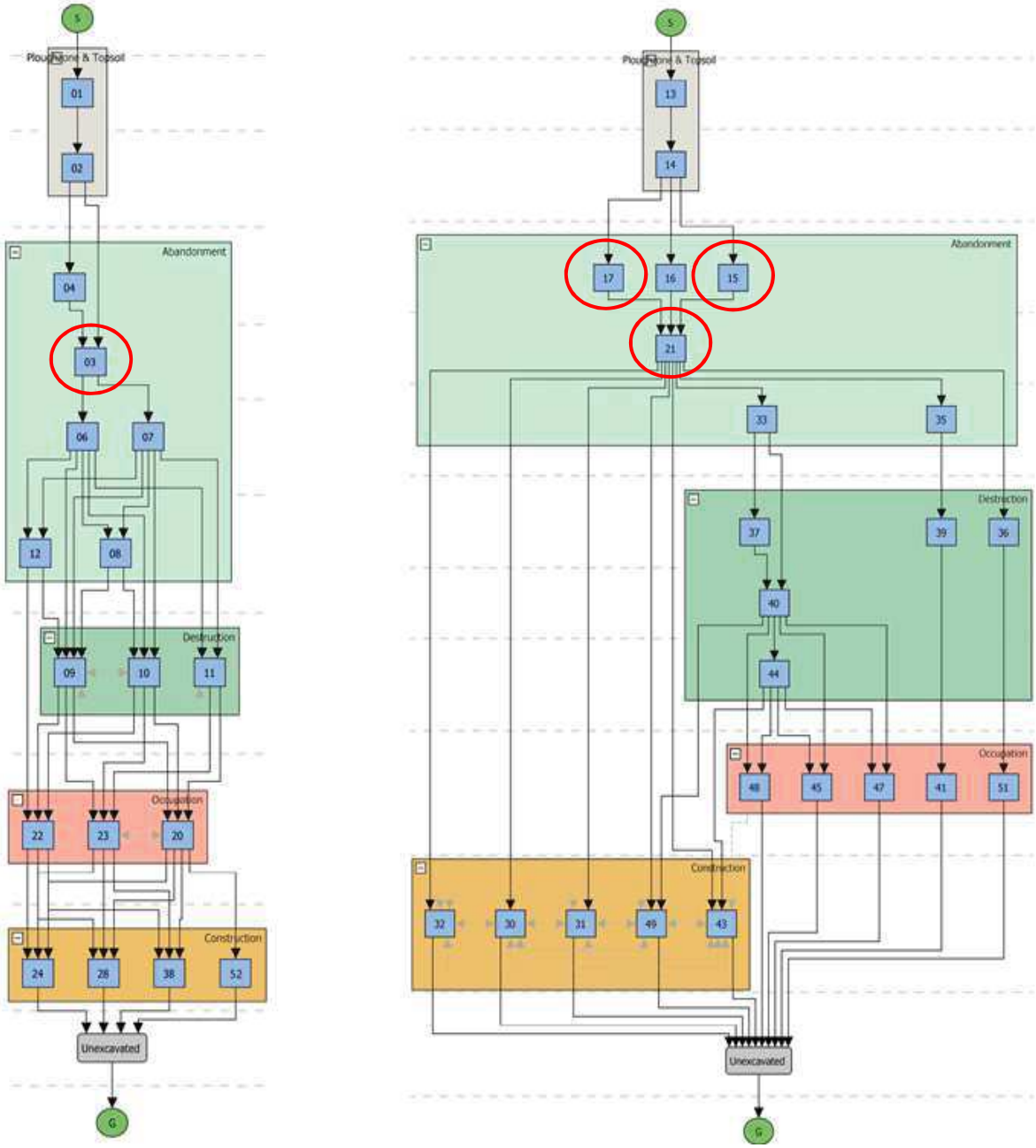


Figure 5.20: Archaeological matrix representing the loci stratigraphy of trench Y88/89 (from the excavations report by Neil Erskine and Dr Francesca Chelazzi, *unpublished*)

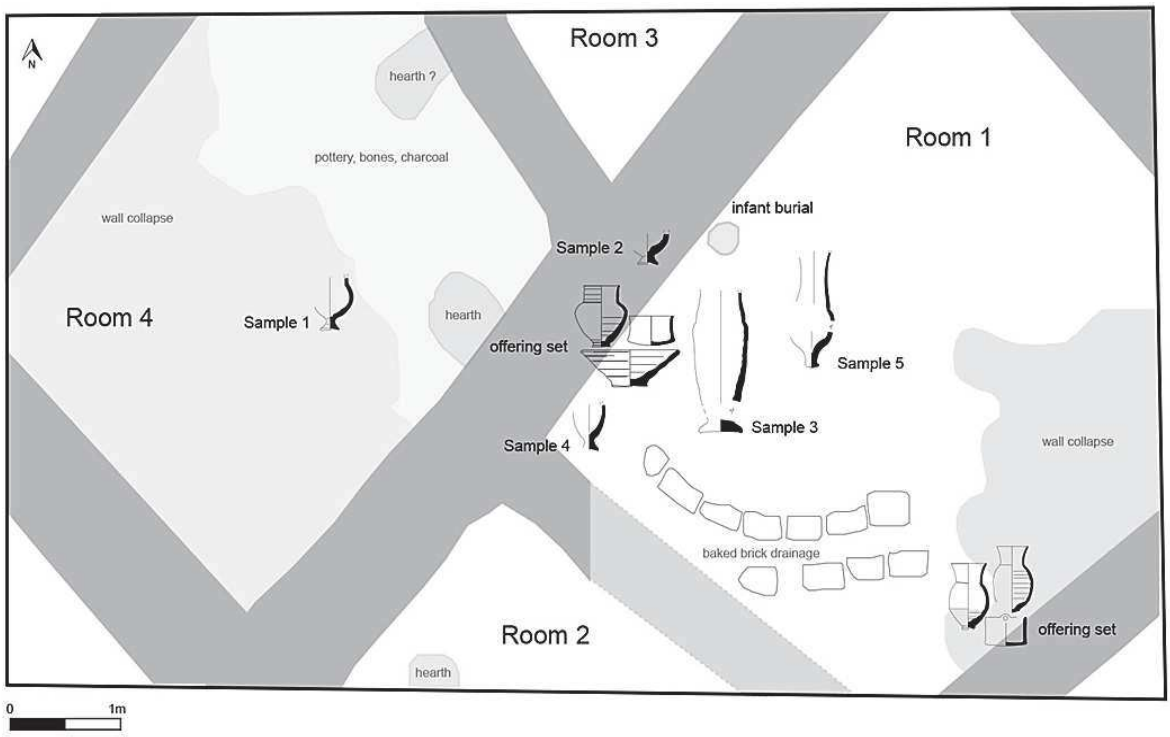


Figure 5.21: Plan of Trench Y88/89, which exposed the north-east part of the monumental structure, showing the distribution of post-destruction ritual depositions and associated drinking vessels (adapted from Perruchini *et al.*, 2018).

The most significant of these three compounds is myristoleic acid ($C_{14:1}$), a compound rare in nature. It is a minor compound in certain meats and dairy butter, and occurs in *Serenoa repens*, a small saw palmetto native to the U.S. South Atlantic coast, Southern Europe and North Africa (Iguchi *et al.*, 2001). Myristoleic acid has also been identified in negligible amounts in the seeds of two modern date palm (*Phoenix dactylifera* L.) cultivars, Deglet Nour and Allig, from the Degach region of Tunisia (Besbes *et al.*, 2004), but has not been associated with Middle Eastern varieties of date palms (Al-Shahib and Marshall, 2003). Our own reference sample of modern dates (with their seeds) imported from Iraq did not contain any traces of myristoleic acid ($C_{14:1}$) (**BECS 3090**) (**Appendix E, Figure 269**). Dates can therefore be excluded as a potential source of this compound in the archaeological samples analysed.

Comparatively higher concentrations of myristoleic acid ($C_{14:1}$) are found exclusively in the seed oil of plants of the *Myristicaceae* or nutmeg family (Leray, 2012: 20), evergreen trees notable for their blood-red sap and for their aromatic smell. The most well-known member of the *Myristicaceae* family is *Myristica fragrans Houtt.*, the common nutmeg tree, whose products include the

nutmeg spice and mace (Nybe, Mini Raj and Peter, 2007). Also consistent with a spice-related chemical source is gondoic acid (cis-11 $C_{20:1}$), which occurs in plant seeds and spices and has been associated with mustard seeds in archaeological samples (Zubr, 1997; Colombini *et al.*, 2005). A lesser identifier is linoleic acid ($C_{18:2}$), which is consistent with the presence of seed plants (Colombini *et al.* 2005).

In order to confirm the identification of nutmeg in our archaeological samples, we analysed modern nutmeg to create a chemical standard. The total lipid extract of the modern sample of ground nutmeg presented a high quantity of co-eluting compounds (**BECS 2366**) (**Appendix E, Figure 270**) and was therefore further separated into acid (TAF – Total acid fraction) and neutral (TNF – Total neutral fraction) fractions before analysis (**Appendix E, Figures 271-274**). The TAF of nutmeg shows the presence of a series of saturated ($C_{10:0}$-$C_{26:0}$) and unsaturated ($C_{13:0}$-$C_{17:0}$) fatty acids also present in our five vessels, but most importantly it confirms the co-occurrence of myristoleic acid ($C_{14:1}$), gondoic acid (cis-11 $C_{20:1}$) and linoleic acid ($C_{18:2}$) in the nutmeg spice (**Appendix E, Figure 271**).

5.3.2.2 Possible other adjuncts of aromatics

The lipid extracts from two vessels (**BECS 1935** and **2317**) presented the co-occurrence of peculiar compounds which could indicate the adjunct of other aromatics (**Appendices C and D, Figures 54 and 134**).

In addition to the co-occurring compounds indicative of barley beer mentioned above (Perruchini *et al.*, 2018), one Kassite goblet (**BECS 1935**) yielded a residue containing long-chain fatty alcohols (C_{10}, C_{18}-C_{30}) as well as the presence of erucylamide (or erucamide) and the compound ester 1-Isobutyl 4-isopropyl 3-isopropyl-2,2-dimethyl succinate.

Erucylamide is a derivative of erucic acid. This compound was only observed in the vessel matrix and not in the inner or outer vessel walls and thus is not the product of modern contamination. In nature, erucic acid (cis-13-docosenoic acid) is mostly known to occur at high concentrations mainly in the seeds of species of the *Brassicaceae* such as rape flowers (*B.napus*) and mustard (*B. juncea*) (Colombini *et al.*, 2005; Colombini, Modugno and Ribechini, 2005; Eerkens, 2007;

Hu *et al.*, 2017). However, it has also been identified in numerous types of food (Zubr, 1997; Buonasera, 2007), including citrus fruits (Bhuiyan *et al.*, 2009).
The ester 1-Isobutyl 4-isopropyl 3-isopropyl-2,2-dimethyl succinate has been detected in natural sources, such as fungus *Polyporus sulphureus* (Bull.) Fr. (Wu *et al.*, 2005), cabbage and lettuce (Barry-Ryan *et al.*, 2009). It has also been detected in fruits of *Crataegus azarolus* L. species that grow mostly in temperate zones (Agiel *et al.*, 2019), including the Khabur Region in Syria (Charles, Pessin and Hald, 2010). However, this compound is also found in high quantity in the *Cousinia sivasica* Hub.-Mor. from the *Asteraceae* family, endemic flowering plants of Turkey known for their aromatic and medicinal properties (Tekin *et al.*, 2019).

Without any other evidence, it has thus been impossible to identify the origin(s) of these two compounds, but they seem to indicate another possible adjunct of aromatics in the beer production. Interestingly, the sample of *namzitu* (**BECS 1910**) (**Appendix C, Figure 66**) recovered in the same layer as the Kassite goblet sampled (**BECS 1935**) yielded a residue containing the same compound 1-Isobutyl 4-isopropyl 3-isopropyl-2,2-dimethyl succinate. It would mean that, regardless of the type of aromatic, it would have been added at the beginning of the brewing process to create an aromatic beer.

BECS 2317 (**Appendix D, Figure 134**) yielded a residue containing two compounds of interest identified as neophytadiene (7,11,15-trimethyl-3-methylene-1-hexadecene), a phytadiene isomer (terpene) that has been identified in plants oils and as a degradation product of chlorophyll (Abdel-Aal, Haroon and Mofeed, 2015; Jambrina-Enríquez, Herrera-Herrera and Mallol, 2018) and the triterpenoid friedelin, which is considered a biomarker of angiosperms but is also found in other types of plants (Chandler and Hooper, 1979). Interestingly, those two compounds are recognized for their medicinal properties in plants with analgesic, anti-inflammatory, antimicrobial, and antioxidant actions (Antonisamy, Duraipandiyan and Ignacimuthu, 2011).
Again, without any other evidence, it has thus been impossible to identify the origin(s) of these two compounds.

5.3.3 Crude oil

One bowl (**BECS 2540**) and four footed cups (**BECS 2015, 2746, 2732** and **2608**) presented a similar compound composition (**Appendices C and D, Figures 138, 75, 214, 194, 202**).

The main compounds observed are even- and odd-chain n-alkanes ranging from n-C*13* to n-C*35* identified from their mass spectra and the m/z 57 fragment. The samples also contained the isoprenoid hydrocarbons pristane ($C_{19}H_{40}$) (2,6,10,14-Tetramethylpentadecane) and phytane ($C_{20}H_{42}$) (2,6,10,14-Tetramethylhexdecane), these were identified from their elevated m/z 183 fragment in the mass spectra and their molecular ion (M+) (respectively M+ = 268 and M+ = 282) – consistent with the degradation of plant material (Bayliss, 1968). The lipid extract also contained hopanes (e.g. 28-nor-17ß(H)-hopane) and steranes (e.g. stigmastane). These compounds altogether are characteristic of petroleum (Pollard *et al.*, 2007; Colombini and Modugno, 2009: 20).

The term petroleum in literature covers both naturally occurring unprocessed crude oils and petroleum products that are made up of refined crude oils. To remove any confusion, in this study, petroleum refers only to the naturally occurring crude oil, a yellow-to-black liquid usually found in geological formations beneath the Earth's surface.
The geological conditions that would eventually create petroleum formed millions of years ago where algae, plants and plankton lived in shallow seas. After dying these organisms sank to the seafloor, the organic material was buried and mixed with other sediments and plant debris. Over millions of years, under high pressure and high temperature, the remains of the buried organisms transformed into what we know today as fossil fuels like petroleum. There are huge quantities of petroleum found under Earth’s surface, but they sometimes bubble to the surface in pits.

We know that natural petroleum was widely used in the ancient world with evidence dating as far back as the Mousterian period (40 000 BCE) (Connan, 1999; Boëda *et al.*, 2008). Evidence of petroleum in Mesopotamian, and more generally Near Eastern, history through archaeology has been restricted to the

identification of a visible, viscous black residue: bitumen (Schwartz and Hollander, 2016).

Bitumen was a utilitarian commodity used for various activities. To name a few, bitumen was used 1) as a mortar for bricks for example in the building of ziggurat (Forbes, 1936), 2) as a pigment, but also 3) to repair or waterproof material such as pottery, thus enabling them to become impermeable to liquids as is probably the case for our five vessels (Connan, 1999; Perini, 2014; Schwartz and Hollander, 2016). We also know that bitumen has been one of the ingredients of balms in Egyptian mummification (K. A. Clark, Ikram and Evershed, 2016).

Due to its varied uses, bitumen was a popular and widely-traded product (Connan, 1999; Schwartz, Hollander and Stein, 1999; Schwartz and Hollander, 2000, 2016; Boëda *et al.*, 2008; Burger *et al.*, 2016).

Petroleums have a very distinct chemical composition that reflects their geological and thermal history and thus it is possible to identify the source of ancient (and modern) bitumen through chemical analyses (Mohialdeen and Hakimi, 2013). For instance, samples of bitumen from the site of Hacinebi (4th millennium BCE) in Turkey were analysed and compared with possible sources of ancient bitumen using stable carbon isotope and molecular organic geochemical analyses. Not only did they identify geographically the sources of the bitumen artefacts, but this research also yielded a better understanding of interregional interactions by tracing sources of bitumen (Schwartz, Hollander and Stein, 1999).

Yet, in our samples, while the clear chemical evidence of the presence of petroleum is incontestable, no presence of a macroscopic black residue has been detected, contrary to other sites such as at Tell Ahmar, where residues were clearly visible (ca. 1800-1600 BCE) (Perini, 2014: 160) (e.g. **Figures 5.21 and 5.22**). It is possible that our five samples would not have yielded macro-traces of bitumen visible to the naked eye and that bitumen could have been identified only microscopically as was the case on small objects such as lithic tools from Umm el Tlel (Syria) (Boëda *et al.*, 2008). However, we know that naturally occurring petroleum can have different textures and colours. Indeed, while crude oil is usually thick, black or dark brown in colour, it can also appear

colourless, yellowish, reddish, tan, or even greenish; variations in colour indicating the distinct chemical compositions of different supplies of crude oil.
As previously mentioned, the chemical composition of petroleum is the result of the original composition of the algae, plants, or plankton from millions of years ago as well as the amount of heat and pressure to which the plants were exposed to. Crude oil is mainly composed of hydrocarbons, hydrogen and carbon as well as other elements such as nitrogen, sulfur, oxygen, and metals (e.g. iron, nickel, and copper). Because crude oil is a mixture of such widely varying constituents and proportions, its physical properties can vary widely.

Oil is classified according to two parameters: its sulfur content and its API gravity ("World Oil Review, Vol.1", ENI, 2018[6]). The American Petroleum Institute (API) has established accepted systems of standards for a variety of oil- and gas-related products and has also established several units of measurement. The API gravity is a measure of the density of petroleum liquid compared to water. If a petroleum's API gravity is greater than 10°, it is qualified as light and floats on top of water ("World Oil Review, Vol.1", ENI, 2018). Petroleums with greater concentrations of sulfur and metals have an API gravity inferior to 10°. They are qualified as heavy oils and as such have a thicker/viscous texture ("World Oil Review, Vol.1", ENI, 2018). For instance, bitumen is qualified as extra heavy (crude oil with an API gravity that is lower than 10°API). Sulfur is considered an "impurity" in petroleum. Crude oil is also categorized as "sweet" or "sour" depending on the level of sulfur. Sweet crude oils have sulfur contents of 0.42 percent or less by weight, and sour crudes have sulfur contents of 1 percent or more by weight ("World Oil Review, Vol.1", ENI, 2018). Petroleum that has few metals or a low concentration of sulfur tends to be lighter and nearly clear in colour (Forbes, 1958: 94–95).

The Diyala Valley and the overall Kurdish Region are constituted of stratigraphic sections from the Jurassic through Tertiary geologic ages and comprise marine and subordinate lagoon sediments, which are composed of carbonate, shale and anhydrite sediment. The Kurdistan region is an oil-rich area and has become the largest oil-producing portion of Iraq (Mohialdeen and Hakimi, 2013). Petroleum

[6] https://www.eni.com/docs/en_IT/enicom/company/fuel-cafe/WORLD-OIL-REVIEW-2018-Volume-1.pdf

(crude oil; conventional petroleum) is found in the microscopic pores of sedimentary rocks such as sandstone and limestone.

The Kurdistan oilfields include more than 15 oilfields with various sizes; the largest are the Kirkuk and Hamrin oilfields (Mohialdeen *et al.*, 2013). The different sources of crude oils present different qualities (Karim, Khanaqa and Shukur, 2017). For instance, while the crude oil of Kirkuk presents a percentage of sulfur content above 2% and thus is considered to be heavy oil, the crude oil from the nearby Taq-Taq source has a sulfur content below 1% and thus is considered to be light sweet oil (Karim, Khanaqa and Shukur, 2017).

The existence of a source of light natural crude oil not too far from the site of Khani Masi (ca. 155km, as the crow flies, according to Google maps) proves that the population living at Khani Masi could have access and used of clear sweet crude oil in ceramic production.

Figure 5.22: Picture of sample BECS 2746 showing no trace of black residue

Figure 5.23: Pictures of sample BECS 2540 (outside and inside) showing no trace of black viscous residue

5.3.4 Food

We obtained a distinct chromatographic profile for one of the medium-sized bowls (**BECS 1772**) (**Appendix C, Figure 70**).

The sample **BECS 1772** yielded a residue containing alongside even- chain fatty acids ($C_{14:0}$ to $C_{18:0}$) which can be found in plant and animal tissues (Heron and Evershed, 1993; Evershed *et al.*, 1997; Evershed, 2008), odd-numbered n-alkanes (C_{27}-C_{31}). However, like the fatty acids, n-alkanes are rather ubiquitous compounds in nature and they have also been identified in our associated control samples. However odd-numbered alkanes (e.g. C_{27}, C_{29} or C_{31}) are usually associated with plant waxes (Marshall *et al.*, 2008; Baeten *et al.*, 2013; Soberl *et al.*, 2014).

BECS 1772 also contained a mid-chain monounsaturated fatty acid ($C_{18:1}$) not identified in control samples that can be identified in varying quantities in all animal and plant lipids (Gunstone *et al.*, 1994).

We can also note the presence of diacylglycerols (DAG), which could indicate the presence of degraded animal fats (Evershed, Dudd, Copley, Berstan, *et al.*, 2002), as well as long chain ketones nonacosan-15-one and 16-hentriacontanone. Long-chain ketones have been widely reported as evidence of higher plants (i.e.

trees, shrubs, flowering herbs, ferns and fern relatives) as well as compounds produced by pyrolysis of fatty acids or cooking (Evershed *et al.*, 1995). These compounds taken together could indicate that the bowl (**BECS 1772**) would have contained some sort of stew or broth, a mix of meat and vegetables.
Future analyses and techniques could be undertaken, such as compound-specific radiocarbon or stable isotope analysis to investigate these further, but are outside the scope of this thesis.

To conclude, the data described and discussed above give us a picture of food practices and choices at the Late Bronze Age site of Khani Masi. They provide us with a small window on a crucial aspect of life to human biological, social and cultural existence and experience.
What we can observe is that people at Khani Masi made clear consumption choices, not only in terms of food and beverages but also with regards to the practices through which they produced and consumed their food and drink. For instance, the results show the use of different type of individual goblets and cups of various sizes and forms to consume the same beverage: beer; which was clearly the beverage of choice at Khani Masi. The presence of *namzitu* vessels at the site, unsurprisingly, also attests to the production of beer at Khani Masi.
The evidence for the addition of aromatics, in particular nutmeg, would have transformed simple, locally produced beer into a stimulating aromatic beverage and, given the product's distant origin, is likely to have represented a socially restricted delicacy reserved for special and, in this case, cult-related events. Indeed it appears to have been associated with specific ritual practices at the site, as vessels associated with a pre-destruction occupation phase contained chemical compounds consistent with beer, but not the three compounds indicative of the spice.
We established in **Chapter 2**, that choices in diet and consumption practices are driven by different individual and communal determinants: 1) biological determinants such as hunger, appetite (**Section 2.2**) but also 2) taste and affinity to certain flavour and smell (**Section 2.3**) often influenced by social and economic determinants such as socio-economic status and cultural traditions.
With the results obtained and presented in this chapter, we can now begin to consider questions of food choices at Khani Masi and to reconstruct the sensory experiences these would have evoked.

6 Making senses of beverage consumption at Khani Masi: A taste of unity

Following the growing interest by social sciences in food consumption in contemporary societies, attention has shifted to ancient societies with food becoming not only a topic of interest but also a research object and a material component intrinsic to the creation and cultivation of social relationships (e.g. Goody, 1982; Wood, 1995; Twiss, 2003; 2012a; Dietler, 2007; VanDerwarker, Scarry and Eastman, 2007; White and Beaudry, 2009). The apparent banality of food and eating habits is deceptive. Food and eating habits are not simply matters of fuelling ourselves or alleviating hunger pangs; there is intentionality behind any food choices and practices. They involve a complex interplay of biological tendencies and environmental influences (Ventura and Worobey, 2013). Indeed, substances not only have to be edible but also have to be socially and culturally accepted as food that is good to eat (de Garine, 1972; Rozin, 1996).

However, archaeological studies have mainly been carried out on evidence of food and beverages production rather than consumption (Pitts, 2015). When looking at the interpretation of their discoveries, these studies have focused their attention mainly on one dimension: the display of social status and economic differences (Arnold, 1999; van der Veen, 2003; White, 2005; Pollock, 2012). Yet, food and beverages consumption is intricately connected to many other central processes of life, such as human connection and social closeness, that can be explored by not regarding food simply as a tool but as something experienced through the five senses.

By recreating the sensuous experience of drinking at Khani Masi, I argue that the alcohol consumed at Khani Masi is central to creating a sense of belongingness, connecting the individual to the community, its traditions and history.
In this chapter, I analyse the relationship between sociocultural values and food preferences evidenced at the Khani Masi site to try to build a better understanding of expression of community at the settlement.

In **section 6.1**, I will explore the evidence for food preferences at Khani Masi revealed through organic residue analysis and supported by ethnobotanical remains and faunal data, as well as textual and iconographic sources. I will also use comparative data recovered at contemporaneous archaeological sites in the region.

In **section 6.2**, I will look more closely at choices in practices and vessels involved in food and drink consumption, as they will have an impact on the overall experience of eating, sociability and social expression. By illuminating not only consumption preferences but associated practices at Khani Masi, we can start thinking about the reasons behind these choices, especially relating to the five senses and how they will convey new information about group identity and help us look at social relationships in a new way.

In the final **section 6.3**, I will explore the role of the five senses involved in individual experiences of food and try to recreate the sensory experience of drinking at Khani Masi with material traces recovered using organic residue analysis. We will then look at how the sensual experience of consuming specific beverages at Khani Masi would have instilled nostalgia, memory and emotions that would have, in turn, created a sense of community and belongingness, accentuated by the communal activity of sharing this experience with other people in a same space.

6.1 Evidence of beverage preferences at Khani Masi

6.1.1 Beverages at Khani Masi

The first observation that we can make about beverage choices at Khani Masi, after consideration of the evidence collected from residue analysis, ethnobotanical remains and contextual analyses, is that beer predominates. This is the first use of Gas chromatography enabling the clear identification of beer in consumption vessels whose content and function is unknown or difficult to discern from archaeological contexts alone. Previous studies on ancient beer focused on production and storage vessels and relied on the presence of visible residue (i.e. oxalate as indication of beerstone), but these analytical approaches are only suitable in scenarios where the result can be anticipated with some degree of certainty (i.e. Feigl spot test) (e.g. Michel *et al.*, 1993; Otto, 2012).

The presence of beer was determined through the presence of co-occurring chemical compounds consistent with both the ingredients, including cereal grains (e.g. pyrrolo[1,2-a]pyrazine-1,4-dione, terpene and monounsaturated fatty acids) and the fermentation processes (e.g. butanedioic acid, and glycerol) involved in the production of beer (**Section 5.3.1** and Perruchini *et al.*, 2018). The analysis of reference samples of malted barley and modern beers confirms this identification.

Moreover, there is currently no evidence for wine at the site. And yet, Khani Masi is located along the upper reaches of the Sirwan/Diyala River, perched between the Zagros piedmonts and the Mesopotamian lowlands, and thus the population at Khani Masi can be expected to have had access to wine or/and contacts with winegrowing communities in higher elevations. As previously mentioned in **Section 3.2**, the cultivation of grapevines and the production of wine developed in the highland of the Caucasus, Taurus, and Zagros Mountains (e.g. Tepe Malyan and Shiraz in Iran in the lower part of the Zagros Mountains) where the environment would have been favourable for the development of viticulture (Michel, McGovern and Badler, 1993; McGovern, 2003: 148 and 164; 2009: 97). Furthermore, residues of wine have been found in jars dated to ca. 5400 BCE in the Neolithic settlement of Hajji Firuz Tepe, as well as at the site of Godin Tepe, dated to the Late Uruk period (ca. 3500-3100 BCE) (Michel, McGovern and Badler, 1993).

Beer was the most important and common beverage in the ancient Near East and based on the results outlined in the preceding chapter, it was also consumed in large quantities at Khani Masi. We know that beer was not a product that could be stored for very long, as it would have been prone to spoilage and mold colonization (Jennings *et al.*, 2005). Looking at the important quantity of drinking vessels recovered at Khani Masi, large-scale beer consumption would have required beer to be produced regularly and locally.

Two *namzitu* and the results of residue analysis performed on them (see **Sections 5.2.4 and 5.3.1**) confirm as much (note that more diagnostic *namzitu* fragments have come to light in the 2018 and 2019 seasons of excavations). Beer production was also attested at the contemporaneous site of Tell Bazi, where large vats perforated in the base (i.e. *namzitu*) were discovered (Otto, 2014). The discovery of deposits of oxalate (possible beerstone) in its interior seems to

support this theory; however, the results were never published (Otto, 2014). We are thus presenting the first chemical evidence of the role of the *namzitu* in beer production (Perruchini *et al.*, 2018).

We know from texts that different types of beers existed (**Section 3.1**); however, so far, we know very little about how these different beers were produced, what flavourings were added and in what contexts they were consumed. The results of residue analysis at Khani Masi reveal the first chemical identification of flavouring ingredients in beer, with seven drinking vessels presenting, in addition to the co-occurring compounds indicative of beer, compounds consistent with spices (i.e. nutmeg) and aromatic plants.

6.1.2 Spices and aromatic plants

Flavouring to alter the taste of staple food and beverages is a uniquely human behaviour[7]. Mid-third millennium BCE administrative records from the Mesopotamian city of Lagash mention a variety of beers including golden beer, sweet dark beer and red beer, alongside differences in beer quality (Michel, 2012). What the texts do not tell us, however, is how these different beers were produced, whether different brewing techniques were involved, and what sweeteners and flavourings were added. The results of our analyses present the chemical identification of such additives.

We do not know if crafting a well-balanced beverage, by adding the ideal amount of additives and combining their tastes and flavours to perfection, was a major concern for Khani Masi brewers, but we can assume that, like today, a pleasurable taste was a joy shared by people in the past. However, we know that crafting different kinds of beers by mixing herbs and spices requires specific knowledge and techniques, in particular when creating distinct flavoured beer, by adding herbs and spices, either during the beer brewing process or before consumption.

[7] Monkeys have been observed dipping their potatoes in the ocean to wash them and possibly to add salt and flavour to them (https://www.foodandwine.com/blogs/japanese-monkeys-are-seasoning-their-food-saltwater)

My results point towards the addition of additives at the beginning of the brewing process. *Namzitu* (BECS 1910) presented the same compound as the Kassite goblet (BECS 1935): 1-Isobutyl 4-isopropyl 3-isopropyl-2,2-dimethyl succinate. This compound may be indicative of the presence of plant oils, such as the oil of *Cousinia sivasica* (Tekin *et al.*, 2019) or even the fruits of the *Crataegus azarolus* L. (Agiel *et al.*, 2019). It would mean that, regardless of the type of aromatic, it would have been added at the beginning of the brewing process to create an aromatic beer. Textual evidence would support this hypothesis. For instance, the hymn of Ninkasi mentioned aromatic herbs added to the dough used for making beer-bread which would have been then baked in a large oven (Civil, 1964: 72). Archaeologically, the discovery of remains of palm fruit and chamomile at Wadi Kubbaniya, a Late Palaeolithic site in Upper Egypt, on starch-dusted stones, probably used for grinding sorghum or bulrush, suggest that a cereals/plants mixes may have been used for a very long time to make aromatic beer-bread (McGovern, 2009).

As mentioned in **Section 3.1**, the use of herbs and spices is well attested in cuneiform texts generally found under the generic term of *mun-gazi* as far back as the Ur III Period (ca. 2100-2000 BCE) (CDLI P361739). The discovery of few archaeological remains (e.g. Potts, 1997: 68; Gilboa and Namdar, 2015) and specialised instruments such as spice mills mentioned in first millennium BCE sources (Radner, 2014) provide also a clear evidence of the use of herbs and spices. Some aromatics plants were however more accessible than others.

For instance, the ester 1-Isobutyl 4-isopropyl 3-isopropyl-2,2-dimethyl succinate which has been detected in high quantity in the *Cousinia sivasica* Hub.-Mor. species, endemic flowering plants of Turkey (Tekin *et al.*, 2019). The ester 1-Isobutyl 4-isopropyl 3-isopropyl-2,2-dimethyl succinate may be also indicative of the presence of edible fruits of the *Crataegus azarolus* L. for which we have tentative textual evidence in the ancient Near East (Farrar, 2016:67).

Less accessible, nutmeg (*Myristica fragrans Houtt.*) is particularly interesting. Until modern cultivation techniques were introduced in the nineteenth century, the production of nutmeg and mace was confined to the remote Banda Islands located 1200 km east of Java in modern Indonesia (Freedman, 2008). For instance, archaeobotanical remains of nutmeg has been found in Neolithic sites (3500 to 3000 B.P.) on Pulau Ay, a small (ca. 4 km^2) limestone island located in the Banda Islands. The archaeobotanical analyses provide insight into early

Neolithic plant use, including early use of *Myristica fragans* (nutmeg) in a food context (Lape *et al.*, 2018). The presence of chemical compounds consistent with nutmeg in five drinking cups from Khani Masi suggests that some form of long-distance spice trade connecting the Middle East with Southeast Asia was operative by at least the 13th centuries BCE, although it does not necessarily imply direct contact. During the third millennium BCE, Mesopotamia is known to have had robust trade relationships across the Persian Gulf, with Dilmun (Bahrain), Magan (Oman peninsula) and Melluha (Indus Valley and Gujarat), bringing copper, gemstones, incense as well as yet unknown spices and aromatics to the region (Potts, 2007, 124-140). This maritime exchange network, however, is thought to have largely ceased at the time of Khani Masi's main occupation phase (Boivin, Blench and Fuller, 2009). Given the location of Khani Masi near the exit from the Zagros Mountains of two branches of the later Silk Routes, a land-route for the spice's importation is plausible. In this scenario, communities like the one residing at Khani Masi could have acted not only as consumers, but also as trade intermediaries. The so-called Diyala spice mills, for which the region was known in the first millennium BCE (Radner, 2014), could support this hypothesis. Whichever way it reached Khani Masi, the addition of nutmeg would have transformed simple, locally produced beer into a stimulating aromatic beverage and, given the product's distant origin. It is likely to have represented to the inhabitants of Khani Masi a socially restricted delicacy reserved for special events and would have played a part in shaping Late Bronze social identities (Gilboa and Namdar, 2015).

In summary, ORA supported by ethnobotanical and zooarchaeological remains reveal clear consumption preferences at Khani Masi, in particular the predominance of beer in the inhabitants' diet. As established in **Section 3.1**, beer brewing was a long and complicated technical process (whether it involved beer-bread or the cold mashing technique) that demanded a certain level of knowledge and organisation as well as the access to the right equipment. The timing of each step was also crucial in a successful brewing process. Moreover, my analyses identified for the first time the addition of local and exotic aromatic plants, in particular nutmeg spice.

We can also now ascribe a broad range of drinking equipment to the consumption of beer at Khani Masi, identify changes in wider drinking practices and begin to sketch their behavioural and social implications.

6.2 Drinking practices and sociability at Khani Masi

Over the past decades, anthropologists and archaeologists have been increasingly interested in studying alcohol in ancient societies. There is no doubt that alcohol - like other foods – forms an integral part of the material culture and more precisely "embodied material culture" (Dietler, 2001), or " cultural and social artefact" (Dietler and Herbich, 2006) of Late Bronze Age Khani Masi. Having identified the beverages consumed at the site, I now want to consider the preferences in practices and vessels involved in their consumption in order to gain new insights on social and cultural relationships between individuals (Dietler, 1990; 2006; Dietler and Herbich, 2006) at the site.

Like any archaeological artefact, a shift in trend of consumption practices and vessels could highlight possible distinctions between social and cultural groups but also the solidification of a group identity (Mintz and du Bois, 2002).

The archaeological material uncovered at Khani Masi and the results of organic residue analysis bring new evidence of a progressive shift in beverage consumption with the disappearance of communal drinking vessels in the Kassite period and the dominance of plain pottery vessels.

In this section, I explore how this shift could affect sociability between participants as well as their social and cultural expression of identities.

6.2.1 Beer drinking practices from the 4th millennium to the Late Bronze Age

As mentioned in **Section 3.3**, compared to beverage production, our understanding of the vessels and gestures involved in drinking consumption is limited and derives mostly from iconographic sources. The specific beverage depicted in those drinking scenes often cannot be identified confidently. Organic residue analysis offers the opportunity to create a bridge between the

information drawn from the iconography, the archaeological record and the vessel contents identified through organic geochemistry.

Regarding beer consumption specifically, in the fourth millennium BCE, seals depict drinking scenes and consumption of what has been interpreted as beer from large piriform jars that sat on the ground using long tubes (**Figure 3.5**). Relying on ethnographical comparisons and mentions in texts of Antiquity (Auberger and Goupil, 2010: 66), the use of straws has been demonstrated to enable the people to share and drink beer.

In the Early Dynastic period, similar scenes in the iconographic repertoire discovered in Southern Iraq and the Diyala Region show the practice of sharing beer through long straws from a communal jar was still used (**Figures 3.4, 3.7 and 3.8**). Archaeologically, drinking tubes in copper, gold and lapis lazuli were also discovered at the site of The Royal Cemetery at Ur (Moorey, 1980: 182; Potts, 1997: 148; Weber and Zettler, 1998: 139; Pollock, 2003: 26). However, they also attest to another drinking practice with beverages consumed using individualised vessels (Woolley, 1934: 102, pl. 200; Frankfort, 1939: 185 and 187, Pl. 105 and 107) (**Figure 3.7**). Archaeologically, footed goblets and small jars and cups are also attested (e.g. Moon, 1987; Delougaz, Plate 113, B.256.200) (**Figure 3.6**).

The same two drinking practices, from individualised and communal vessels, are also attested in the archaeology and iconography of the Isin-Larsa and Old Babylonian periods (2004–1595 BCE). However, it is important to note that individual drinking vessels are becoming an 'outstanding feature' (Delougaz, 1952: 115) of the ceramic assemblages at that time, presenting different body shapes, height, disc base and rim types (e.g. Delougaz, 1952: 123 and Plate 132; Ghassan, 1995: 271 and 274). Furthermore, a series of Old Babylonian erotic terracotta plaques depict couples with the woman bending over to drink beer through a straw from what seems to be a smaller jar than the communal vat (Bahrani, 2001) (**Figures 3.9 and 3.10**). It is thus possible that beer drinking practices changed with the use of more individualised vessels from which beer was drunk with a straw.

This hypothesis can be supported archaeologically in the 2nd millennium BCE. Straw strainers with perforated metal tips (Maeir and Garfinkel, 1992) are known from Syria and Iraq (e.g. Tell Bazi, Alalakh, Meskene-Emar, Chagar Bazar, and Nippur) (Gibson, 1988-1989: 13–14; Wooley, 1955, Pl. LXXIII; Beyer, 1982: 119;

McMahon *et al.*, 2009; Otto, 2014). Straws were also used in Anatolia (Özgüç, 1965, seals number 4, 25, 46, 74 and 80; Müller-Karpe, 1999; 2006). Yet, no large common vessels associated with the straws were archaeologically recovered.

However, straws were found in association with small band-painted 'Habur Ware Jars', a pottery tradition of Syria and Mesopotamia, and these small jars thus have been interpreted as containers for beer (Bieniada, 2009). Organic residue analysis performed on small decorated ring-based pots, similar to the 'Habur ware' discovered at Tell Bazi (14^{th}/13^{th} centuries BCE) in association with a bronze filter tip from a drinking straw, confirms this hypothesis (Otto, 2014) (Results not published) (**Figure 3.11**).

The ceramic repertoire of settlements dated to the Kassite period is drastically reduced from the Old Babylonian period (Armstrong and Gasche, 2014). The ceramic assemblage characteristic of the period has been found at neighbouring sites near Khani Masi in the Diyala region such as Tell Yelkhi (Valtz, 2002-2003), Tell Zubeidi, and Tell Imlihiye (Boehmer and Dämmer, 1985). Furthermore, Nippur (Armstrong, 1993), Ur (Woolley, 1965) and Uruk (van Ess, 2014) in southern Mesopotamia present vessels with the same general shapes (Glatz *et al.*, 2019). While plain pottery cups and goblets are an important part of the Kassite-Babylonian ceramic traditions, rare discoveries of metal and decorated ceramic vessels have been made (Armstrong and Gasche, 2014). More importantly, regarding beer consumption, the former method of communal drinking seems to have gone out of practice as we can note the complete disappearance of large communal jars of the type depicted on earlier beer-drinking scenes, as well as straws, which would suggest a shift in consumption practices, at least as far as the use of ceramic vessels is concerned (Perruchini *et al.*, 2018; Calderbank, 2018). Iconography is not giving us supplemental information since, following the Old Babylonian period, drinking scenes become rare in the iconographic repertoire of Mesopotamia. And in the Kassite or Middle Babylonian period, few to none cylinder seals, stele, wall reliefs and moulded brick façades depict banquet or other scenes involving the consumption of food and drink.

In **Section 3.1**, we discussed a change in vocabulary associated with beer brewing with the evolution of the term 'brewer' from the third millennium BCE

LÚ.ŠIM + GAR/LÚ.BAPPIR, which includes the term 'beer-bread' to simply LÚ.ŠIM in the Kassite-Babylonian Period. Ellison suggested it could indicate changes in production practices which no longer involved the use of beer-bread (Ellison, 1984). The disappearance of straws may also indicate differences in beer brewing techniques. Straws depicted protruding from the beer jars were used to filter out thick and cloudy beer full of pieces of beer bread and herbs and other impurities (Ellison, 1978). Archaeologically attested are also metal strainers that would have been placed at the tip of the straws to filter the beer. The disappearance of straws and metal strainers could be either the consequence of bad material preservation or recycling of metal. However, their disappearance and the use of cups and goblets could suggest, like already partly theorized by Ellison (1978), the consumption of a less kräusen beer with less unpleasant impurities.

Whether or not straws were used, my results of ORA applied to drinking vessels recovered at the Late Bronze Age site of Khani Masi confirmed that beer was drunk from a large range of individualized vessels. No indication of other beverages, through ORA or through the remains of grapes for instance, has been recovered. Furthermore, no chemical evidence of beer has been recovered in the few large vats discovered on site.
Having showed evidence that a change in beer consumption practices took place over time with a progressive increase of singular vessel use and disappearance of large communal vessels, this study moves on to discuss how this change could have impacted sociability and the overall experience of drinking in community at Khani Masi.

6.2.2 Individualised vessels and sociability

Drinking is far more than a simple biological and natural act. Cultural and social categories and statuses are very clearly marked and embodied by drinking practices. Drinking, like eating, is a learned and transmitted "technique du corps" (Mauss, 1979) and is "socially and culturally encoded" (Bourdieu, 1984). Drinking is also a social act and a communal activity. Thus, it is important to consider change in consumption practices, as studies have shown that the explanations behind eating and drinking a certain way are not solely practical but are also often connected to symbolic ones.

In his work on Guinean immigrants in Lisbon (Portugal) from the late 1990s to the early 2000s, Johnson has shown that while Guinean informants "may have chosen different eating styles based first on their convenience or practicality, they were always statements about identity and sociability" as they were eating from a common bowl (Johnson, 2016). Eating from the same bowl is a "powerful expression of kinship" (Janson, 2014: 144).

Drinking beer communally from a large jar using straws is a practice still very much alive in some villages of contemporary Africa (Karp, 1980) such as the village of Bupigu in Tanzania (Kubo, 2014) and the village of Luo in Kenya (Dietler and Herbich, 2006: 395–40). Karp describes beer drinking practices in the village of Iteso in Kenya which involves, as previously mentioned, sipping through straws from a common pot as a "sign of sociability" (Karp, 1980). With this consumption practice, the community is the focus, as people interact closely. Johnson even describes sharing food and drink from a common vessel as an "intimate act that demands a sense of trust" (Johnson, 2016, 242). In addition, drinking from shared vessels reinforces family hierarchy and gender differences and maintains social order, since participants are drinking beer from straws in a predetermined order (Dietler and Herbich, 2006; Hames, 2012: 87). We can speculate that people drinking at the same time from the common vessel, as is the case in certain representation from the 4th and 3rd millennium BCE Mesopotamia, would have been considered and would have considered themselves of equal status. Little or no social status is acquired (or lost) during the event. The participants, as Ivan Karp states, "recapitulate their experience of the social order" (Karp, 1980: 113) by displaying the fixed hierarchy among them, thus enabling them to reinforce the social within the self.

At least from the Late Bronze Age, we have evidence of another practice in the consumption of beer from smaller individualised vessels, although iconographic sources suggest this process most likely began already in the third millennium. Beer could either be drunk through straws like at Tell Bazi (Otto, 2014) or without straws like we hypothesis at Khani Masi. But drinking was still very much a communal activity evidenced by the presence of a large number of drinking vessels in specific areas of the monumental compound at Khani Masi (Glatz *et al* 2019). As previously explored in the Introduction, consumption practices enable people to assert their individual and group identity and to express and

sometimes even negotiate their status. Would the use of plain pottery and individualised vessels at Khani Masi provide a way for the participants to express and negotiate their status and identity, in contrast to the use of communal vessels?

In their work on "Pottery, Cuisine and Community in the Neolithic of North Greece", Urem-Kotsou and Kotsakis (Urem-Kotsou and Kotsakis, 2007) postulate that the use of plain pottery vessels with no apparent decoration or surface treatment would not allow individuals to stand out from the rest of the participants and would not have been actively used in social and economic status communication and negotiation or cultural group affiliation. However, other scholars have argued that in some cases the use of plain pottery could also be socially and culturally charged (Glatz, 2015a: 24–25) albeit in a different way to decorated and non-ceramic vessels.

I would argue that the exclusive use of these cups and goblets in communal drinking contexts suggests that they were of some social importance, demonstrated during consumption events. The fact that the vessels were produced locally (as evidenced by the discovery of a large kiln in trench V85) and for the same activity (i.e. drinking beer) supports this inference. The use of plain vessels with seemingly similar appearance might have created a sense of community at Khani Masi (Glatz, 2015b: 204).

It should also be noted that, while the drinking vessels discovered at Khani Masi are typically found in contemporaneous sites previously mentioned, almost every individualised vessel presented small variations amongst its general type (Glatz and Casana, 2016). These variations both technological (fabric) and stylistic (form, size) are rarely mentioned when describing Kassite-Babylonian ceramic assemblages, which are usually presented as highly standardized (Armstrong, 2017). For instance, the size of the Kassite goblets at Khani Masi varies. It is generally around 25cm; however, it can also reach the size of ca. 40cm. These impractically tall goblets could have been used for another purpose (i.e. serving) or another drinking practice, like sharing of drinks and passing the vessel between partakers.

Furthermore, the drinking vessels discovered at Khani Masi presented several variations between and within each type. For instance, the fabric of Kassite goblets is generally thick and heavily tempered, while that of cups is generally

more fine-grained (Glatz *et al.*, 2019). The vessels' importance could be further theorized by the evidence for repairs made to the bases. Cracks at the base can form during the drying process during production (Armstrong and Gasche, 2014: 38) and application of petroleum, as evidenced through organic residue analysis, either to mend the vessels after being broken or to enable them to hold liquids.

Plain pottery vessels at Khani Masi would have had the potential to differentiate participants. As previously mentioned, the individual goblets and cups recovered at Khani Masi presented different sizes and forms. Status distinctions may have been communicated by who gets how much (quantity) or which type of drinking vessels people would have used for what kind of beer (quality), but also, as we saw with collective vessels, the order in which individuals were served or the seating arrangements used while eating and drinking (Dietler, 1990). Individualised vessels could have thus offered a certain freedom for participants to negotiate their personal identities and status as well as to assert themselves effectively in the community.

And as stated by Mintz and du Bois (2002), like any archaeological artefact, food and consumption practices can "set groups apart" but also "solidify group membership". A shift in consumption practices and vessels could thus highlight the drawing of new boundaries, distinctions between social and cultural groups but also the re-definition of a sense of belonging.

It would be difficult to determine based solely on archaeological material whether a change in drinking practices, from communal to individualised vessels, indicates new forms of sociability. However, the use of singular vessels would have had the power to assert people's identities as different from others or/and belonging to a community.

Furthermore, we can propose that the use of singular vessels to drink would certainly have had a different impact on the overall drinking experience. It could have actually heightened senses and appreciation of the preferred beverage at Khani Masi: beer.

In the following **section 6.3** I will attempt to recreate the sensory experience of drinking at Khani Masi based on the results of ORA and drinking practices highlighted above.

6.3 Beer, senses and unity

Preference is the expression of choices; choices in beverages at Khani Masi that we listed in the first section of this Chapter. These choices are based on criteria that are both 1) subjective and more or less conscious, and 2) objective, clearly stated and conscious.

One major determinant in beverage preferences is sensory perception (Zajonc and Markus, 1982). Senses help us identify and appreciate the smell, taste and texture of food and develop our personal preferences. However, while sensory experiences are inextricably linked with subjectivity and the individual, it is now widely accepted within sociology that bodily process is not purely a product of biology (Bourdieu, 1977; 1984; Lupton, 1996, 1; Geurts, 2002; Classen, Howes and Synnott, 2003; Skeates, 2010; Hamilakis, 2014). Senses are culturally and socially conditioned and can be altered, both positively and negatively. They can be affected by multiple factors: a person's surroundings and upbringing (education and status), cultural background, religious beliefs, etc. (Acharya, Blackwell and Sen, 2018). For Rancière, what is and what is not allowed to be sensed and experienced, as well as appreciated, is imposed by consensus (Ranciere, 2004).

Based on the results of ORA presented in this thesis, I will attempt to recreate the sensory experience of drinking at Khani Masi in **section 6.3.1**.
Food and beverages were not experienced alone but in community and consumers will not passively perceive this experience (Højlund, 2015). The cognitive and brain mechanisms involved in the appraisal of relevant stimuli will elicit memories and emotions which in turn will have an impact on their social behaviour, emulating a sense of belonging. It is particularly the case when alcoholic beverages are consumed because, as explained in **section 2.3**, alcohol can lower inhibitions and enhance emotions. This argument will be explored in a second section on senses and social-bonding.

6.3.1 Recreating senses and sensibility

Of all behaviours, eating and drinking are surely the most intimate and personal because it involves the incorporation into the body (Korsmeyer and Sutton, 2011).
Eating and drinking are sensory 'experiences' that use all five senses (taste, smell, touch, sound, and sight) interconnected to each other.

6.3.1.1 A multi-sensorial experience

We do not know what Mesopotamian beer tasted like, although, following ancient recipes such as the ancient Sumerian poem honouring Ninkasi, professional brewers and academics have tried to recreate it. A team of experts from Ohio's Great Lakes Brewing Company, along with archaeologists like Tate Paulette from the University of Chicago, have replicated 5500-year-old beer from Mesopotamia using clay vessels, a wooden spoon, and an ancient recipe. The final product was a beer with a very strong vinegar flavour. Recently, a team of Israeli researchers created from ancient yeast a beer with 6% alcohol content, and a mead (honey-wine) with 14% strength using modern instruments. Based on ancient texts, their recipe consisted of a mix of grains and water, baked and left to ferment in the sun and fruit concentrates as well as modern ingredients, like hops (not available in ancient times).
Given the limited knowledge we have about the ancient brewing process, some scholars have suggested the possibility that Mesopotamian beer may have been in fact alcohol-free (Damerow, 2012). However, according to the poem "Inanna & the God of Wisdom", Enki (God of Wisdom) became so drunk on beer that he gave away the sacred meh (laws of civilization) to Inanna (Goddess of Creation) (Wolkstein and Kramer, 1983: 12–27).

Our residue analysis results provide us with several indications on the composition and taste of beer consumed at Khani Masi. First, the results indicate the presence of fermentation compounds as well as yeast consistent with alcoholic drinks (Perruchini *et al.*, 2018). Beer at Khani Masi would thus have been at least slightly alcoholic.

Our results point to a beer made principally of barley, consistent with ancient texts and archaeological evidence (**Section 3.1**). They also prove that different types of beers were consumed at Khani Masi with evidence for the addition of adjuncts, specifically of seasonings and spices. Seasonings and spices are unique in the realm of food. Besides giving a slight boost in metabolic rate, they have little to no nutritional value. However, they have other essential properties: their potential to preserve or alter the taste, smell and colour of food and drinks ingested by the individual (Le Guérer, 1998: 85).

Spices in the realm of flavour cannot be classified within one of the four basic types of flavours (salty, sweet, sour, and bitter). However, they generally have strong and distinctive flavours, as well as a rich and warm colour that will have an impact on the food or beverages they are in contact with (Korsmeyer, 2005: 37). Nutmeg is a carminative agent. The spice is made from the seed covering (aril) also known as mace. The aril is of a bright crimson red colour when fresh and yellow-brown when dry. Studies have shown the important psychological impact of food colour on the perception of food flavour and could even, in some cases, intensify it (Spence, 2015).

Crude oils have also been chemically identified in four of our cups, which we established usually contained beer based on the analysis results of 45 drinking other drinking vessels. It is possible that those four vessels would have been used or reused for another purpose. However, if we think that these cups would have served their original purpose, crude oils, when applied inside these ceramic vessels to enable them to hold their contents, would have had most probably an impact, even if unintentional, on the overall flavour of beer they would have contained. Crude oils are classified according to two parameters: its sulfur content and its API gravity (**Section 5.3.3**). Crude oils with greater concentrations of sulfur and metals are qualified as heavy oils and as such have a thicker/viscous texture. For instance, bitumen is qualified as extra heavy. Crude oil also is categorized as “sweet” or “sour” depending on the level of sulfur. Petroleum that has few metals or sulfur tends to be lighter and nearly clear in colour. The term ‘sweet’ originates from the fact that a low level of sulfur provides the oil with a mildly sweet taste and pleasant smell. By contrast, the high concentration of sulfur in sour crude caused it to smell like rotten eggs (e.g. Forbes, 1985: 95). Thus, different crude oils will have distinct tastes and smells. Usually, evidence of bitumen in Mesopotamian has been observed thanks

to the identification of a visible viscous black residue (Schwartz and Hollander, 2016). Our results present the possibility that another type of petroleum with a different texture and lighter colour and thus sweeter flavour would have been used. This theory is reasonable as we have seen in **section 5.3.3** that natural sources of light sweet crude oil exist in the Kurdish region.

Finally, our results highlighted the fact that beer was drunk from individual drinking vessels, possibly without the use of straws. I argue that by drinking directly from the vessels rather than with the aid of a straw, beer would have been experienced differently and maybe more intensely. Indeed, scholars have postulated that clay vessels convey a certain flavour to the food and drink they contained (Arnold, 1985: 138–139). First, we can hypothesize that by drinking directly from a cup or goblet, the individual's face would have to come closer to the content than with the use of a straw, and thus would probably have been more affected by smell, colours and textures of the beer. Furthermore, the composition (clay and inclusions) as well as the shape and the feel of the ceramic vessel would have had an influence on the perception of the flavour of the contents.
The clay of the drinking vessels would have contributed to the flavor of the beer (Rice, 1987: 465). Moreover, the porous body of the ceramic would have enabled part of the water content of the beer to evaporate, thus helping to keep the vessel and the beer it contained cool (Bourriau, Smith and Nicholson, 2000: 143). The shape of the vessel would have had an impact on the flow of the liquid across the tongue (Spence and Van Doorn, 2017). Similarly, the appearance of beer would have been affected by the vessel. The sense of touch would have also been affected by the act of holding and bringing the cup or goblet to your mouth (Hamilakis, 2014: 88-89). Pottery would thus affect the flavor as well as the tactile and the visual experience of drinking beer.

6.3.1.2 An emotional experience

However, the senses involved in eating and drinking are not only biological mechanisms that help us to experience food, they also stir and evoke emotional responses. The taste, smell and texture of food can serve to trigger memories of previous food events and experiences around the food. Preparing and consuming

a meal may evoke memories of past events when that meal was prepared and eaten, conjuring up the emotions felt at that time, thus adding to the anticipation of the emotional outcome, a phenomenon which is often called 'food nostalgia' (Sutton, 2001; Sutton, 2005; Perry, 2017). There is thus a strong link between food, senses and the memories and emotions they encapsulate. This linkage may take place at a subconscious or unconscious level, at which certain tastes and smells of food may evoke emotional responses derived from previous experiences without that connection being consciously recognised.

Beer was a common item in the diet of the region and period. The tastes, smells and textures experienced during its production and consumption would have thus been comforting and pleasurable (Gordon, 1959: 264, Proverb 2.123) as it is conveyed by the Sumerian greeting "*My sister, your grain - its beer is tasty, my comfort*" (Hornsey, 2003: 108).

Smells in particular have the potential to call to the imagination and trigger the memory of the individual. This is why for Sperber (1975: 118) odours are "*symboles par excellence*", a "code" (Douglas, 1978). In addition, while ingestion is a voluntary act, olfaction is often done without will or conscious control. Furthermore, odours are imposed on and breathed by everyone independently of their age, sex, social status, cultural background, etc. (Le Guérer, 1998: 185-186). Wengrow, in his work on meat preparation, explained that the choice of using a certain cooking method is possibly linked to sensory reasons as "roasting meat – as opposed to cooking it in a closed container – produces aromas and fumes that rise into the air, forming a point of mediation between mortals and distant or invisible gods" (Wengrow, 2013: 292).

In his introductory paper on food, culture and identity in the Neolithic and Early Bronze Age, Parker-Pearson (2003) highlights the potential significance of smell and taste as a source of evocative symbolism and memories, in contexts ranging from funerary rituals to feasts to mundane meals, with diverse examples such as ritual purifications and incense, decomposing and cremating corpses, roasting meat (Parker Pearson, 2003). The contexts, practices and table manners associated with specific food and drink items structure and manage those emotions, and sometimes even strengthen them (Korsmeyer, 2005).

For instance, spices and other aromatic plants have strong smells and have often been associated with the ability to purify the environment. This is why they were used in the past for mundane tasks such as their application on clothes to hide bad smells (Le Guérer, 1998: 85; Milburn, 2016). However, it is significant to note that they have been an integral part of ritualistic and religious activities in the past and still are today. For instance, incense is often used as part of a purification ritual in different religions and parts of the world (e.g. Phuntsok and Rikey, 1991; Carroll, Siler and Siler, 2003; Coulon, 2016; Milburn, 2016). Frankincense and myrrh were also used in Ancient Egypt as part of funerary rituals alongside bitumen and other aromatic resinous substances used in embalmment practices necessary for mummification process (Le Guérer, 1998: 88–89; Abdel-Maksoud and El-Amin, 2011; Brettell *et al.*, 2015; Clark, Ikram and Evershed, 2016), partly for their colour but most probably to hide the odour of decomposition (Brettell *et al.*, 2015). However, philosophers, like Schopenhauer, and writers like Beaudelaire and Proust, have mentioned the capacity of humans to recall long-dormant memories and emotions, triggered when tasting or smelling something from one's past (Le Guérer, 1998: 192, 198–199, 202–203; Waskul, Vannini and Wilson, 2009; Verbeek and van Campen, 2013). The strong smells would have led to the recollection of the emotions and the memories associated with rituals and memories of the deceased.

Nutmeg is strongly aromatic and colorful, thus it is interesting to note that our evidence of nutmeg spice in beer has been discovered associated with ritualistic material (i.e. offering sets). It is thus possible that even if the aromatic beer was not consumed but used as offerings, the smell and the colour of aromatics and spices (like nutmeg) would have an impact on the individual experience of the ritual. Furthermore, specific smells could have been used at distinctive moments of the ritual thus used to mark ritual and social order. It is entirely possible that the smells of the combination of nutmeg and beer would have marked a specific part of the service for the participants.

6.3.1.3 An entheogenic experience

We know from ancient texts that beer was recognized for its nutritional and medicinal (Biggs, 2005; Scurlock, 2014) as well as euphoric, intoxicating and psychoactive properties (Jennings *et al.*, 2005: 275).

Beer as an alcohol had disinhibitory effects on behaviour as evidenced by texts mentioning beer effect on mood and the iconography depicting consumption of beer in scenes of sexual nature (see **section 6.2.1**).

In addition, some aromatic plants have psychoactive and medicinal effects. Some aromatic plants have medicinal virtues that arise only in their fragrance (Le Guérer, 1998: 116-118). Nutmeg, for instance, has a number of healthy properties. It is a stimulant that has been shown to help with digestion issues and insomnia, as it is a proven muscle relaxant (Pole, 2013: 235). In addition, it is important to reiterate that modern analyses have shown that some species of the *Myristicaceae* family, in particular nutmeg, have medicinal properties (Sharangi, 2018: 81). We know that, culturally, medical concepts were inextricably linked to the religious sphere in Ancient Mesopotamia (Teall, 2014) and that medicinal properties did not work only on the body but treat also the *spiritus* and the soul. Furthermore, nutmeg has been shown to have the capacity to act as an aphrodisiac (Tajuddin *et al.*, 2005; Sharangi, 2018: 81) and, in a sufficiently high dosage, also has powerful psychoactive effects, so much so that it is reported to be a hallucinogen (Weiss, 1960; Williams and West, 1968; Sangalli and Chiang, 2000). For instance, in 2010, hospital and schools in Florida, Miami and in the town of Kiruna, Sweden reported the use of nutmeg as an intoxicant by young people[8]. Regarding the psychoactive effects of nutmeg, it is impossible to quantify the amount of nutmeg used at Khani Masi. However, the fact that identifiable traces of nutmeg survived inside five vessels suggests that a good amount of nutmeg would have been incorporated.

Mixing nutmeg with beer would probably have intensified the intoxicating effect of the spiced beer. The fact that evidence of spiced beer has so far been discovered strictly associated within a ritual context at Khani Masi attests to its importance to the overall experience of the ritual and points to its entheogenic significance. The term "entheogen," as defined by Fitzpatrick and Merlin (2018, 2), encompasses diverse types of psychoactive substances that induce any type of spiritual experience. Although alcoholic beverages have their own psychoactive properties that would have affected the ritual experience (e.g. Carod-Artal, 2015; Seinfeld, 2018), the addition of other intoxicating substances

[8] https://abcnews.go.com/Health/large-doses-nutmeg-hallucinogenic-high/story?id=12347815 https://sverigesradio.se/sida/artikel.aspx?programid=2054&artikel=3698505

would have created a powerful alcohol-based entheogenic experience (e.g. Loughmiller-Cardinal, 2018).

We stated that alcohol acted as social lubricant (**Section 2.4**). Beer taken in enough quantities is assumed to have a direct physiological effect upon the body of the individual, inspiring exhilaration and dulled senses. Beer as an alcoholic beverage is an intoxicating substance, capable of inducing "altered states of consciousness" (Rudgley, 1993: 3) that would have been enhanced by the addition of aromatic plants known for their psychoactive properties, such as nutmeg. Consequently, the effects of this beverage are inextricably linked to sociability and will have an important effect on social behaviours when consumed within a communal setting (Hamilakis, 2014: 135). It would have been an important part in the facilitation of social interaction and social bonding (Sayette *et al.*, 2012).

6.3.2 Sense of community

All sensory faculties would have been activated in unison by the beer, aromatic plants and the drinking vessels, as well as the space where the drinking took place, the activities associated with it, and the people attending. Community belongingness through the consumption of specific food items is associated and accentuated by the communal activity of sharing a meal with people in the same room, i.e. commensality. Commensality is not only eating and drinking in a group. Seremetakis defines commensality as "the exchange of sensory memories and emotions, and of substances and objects incarnating remembrance and feeling" (Seremetakis, 1994: 37). This multi-sensorial and emotional experience of commensality would have played a fundamental role in defining personal and group identities and the creation of sociability, helping the participants to be incorporated into the collective body of the community (Hamilakis, 2014: 135).

6.3.2.2 A Communal taste, a Communal identity

We established that what we regard as pleasant or unpleasant taste and smell is subjective. Taste is strongly associated with individual preferences. Yet, preferences are also socially and culturally biased and conditioned (Le Guérer, 1998: 180; Korsmeyer, 2005: 7) and are thus subject to social pressures. Food is

not merely chosen by an individual for themselves, according to their own sense of perception, but also according to certain general custom or habits believed to be valid for others (Kant, 2005: 210-212). Bourdieu in his social critique of consumption practices in 20th century France introduced the concept of "Habitus" in the vocabulary of consumption theory (Bourdieu, 1977; 1984). The individual is not really making choices, it is the social group around the individual which determined norms of consumption and the individual learns appropriate tastes and consumer behaviour within the parameters of their respective cultures (Bourke and Hillier, 2002: 5). Tastes are thus embedded in social relations. Bourdieu was particularly concerned with showing that consumption behaviours are an expression of class position and differences in terms of their distinctive social practices and their capacities, reflexively, to appreciate those differences (Bourdieu, 1984: 170). He established that consumption behaviour is a means whereby social classes display their cultural and economic capital (Bourdieu, 1984: 174-175). Moreover, cultural traditions lead people to accustom themselves to a specific range of foods and beverages (Korsmeyer, 2005: 3).

Beer, as we established, was a quintessential part of the Mesopotamian diet (**Sections 3.1 and 3.3**). Beer was consumed at least from the 4th millennium BCE in a wide variety of contexts in Mesopotamia – at feasts, festivals, and ritual ceremonies, for example, but also in the everyday life in households and taverns. Therefore, beer could be qualified as a traditional food. The nature and meaning of "traditional food" is often subjected to heated debates. First, the main criterion of a traditional food is that it has to be a well-established customary item made with specific ingredients, materials and techniques familiar to a cultural cluster of individuals from the smallest groups (e.g. families) to the largest populations (e.g. cities, countries, ethnicities, religious groups) (Warde, 1997: 64; Cayot, 2007). Traditional foods also reflect a sense of longevity and cultural inheritance (Cayot, 2007; Warde, 1997: 64). Finally, when employing the term 'traditional' to describe food, we give an aura of authenticity not only to the food itself, but also to the community eating it (Warde, 1997: 64). At Khani Masi, by consuming beer - what we define here as a "traditional food"- an individual and the social group 'authenticated' themselves as belonging to a certain cultural community (Warde, 1997: 66-67; Loveland,

Smeesters and Mandel, 2010), “a cocoon of identity” (Hastorf, 2016d: 69). The taste of beer could have triggered group and collective memories (Seremetakis, 1994; Sutton, 2001; Holtzman, 2006) and consequently would have created a sense of belonging.

Behind the senses there is thus an historical consciousness and a social knowledge created, replicated and remembered that connects people during commensal activities. Sensorial experience of food is also linked to the knowledge of the commodities (are they local or exotic? What are the skills required to prepare them?), which is socially acquired and transmitted (Seremetakis, 1994; Sutton, 2001). We previously stated that beer brewing was not an easy process. In his study of beer consumption by ethnic groups from Northern Cameroon, de Garine (2011) states that beer, while commonly drunk, entails an element of mystery. Fermentation particularly would have been a mysterious process and the brewing procedure would not have been completely under control (de Garine, 2011). And while wine is seen as a relatively higher-status drink in relation to other alcoholic beverages (Lutz, 1922; Dietler, 1990), it does not mean that beer was not a valuable item. Firstly, beer represented a common cultural marker. Secondly, as evidenced by texts and iconography, it was also a significant commodity of reciprocity, hospitality and communality, and could represent a payment of tribute to kings or an offering to dead ancestors and gods. The production and consumption of beer pervaded many cultural acts as it held a central role in many ceremonial and religious activities (e.g. Heffron, 2014; Brown, 2018). As such, it possessed great social, economic and political value (Arthur, 2003). Its significance was dual: it was both a dietary staple and a ‘significant’ food. We observe that beer was produced locally and consumed in high quantity at Khani Masi. Abundance is frequently seen as an expression of wealth (VanDerwarker, Scarry and Eastman, 2007). Thus the abundance of beer at Khani Masi could have been a statement of the participants’ higher economic status.

The consumption of beer and its abundance would have carried social weight and would have been the expression of the group’s cultural and social identity, helping to create a sense of cohesion. Furthermore, by manipulating traditional beer through the addition of aromatics, a new taste was created, which could

have been strictly experienced by "knowledgeable or influential social groups" (Warde, 1997: 97). It is particularly true when we think about the addition of nutmeg. Adding alien foods to beer, a familiar base, would have produced and enhanced a complex sensorial experience (Schivelbusch, 1992) that could become strong cultural and social identity signifiers. In his "Theory of the Leisure Class", the American economist Thorstein Veblen identified consumption and display of very expensive goods as a mode of status-seeking (Veblen, 1953). These food items could have been "awkward to resource, difficult to cook, hard to appreciate, perhaps even distasteful for some," but they would have been the expression of social superiority (Warde, 1997: 67-68).
Spices were precious materials in the Middle Ages (Korsmeyer: 2005, 124). Some of these spices can produce a strong and distinctive flavour, as well as a rich and warm colour to food and beverages (Korsmeyer: 2005, 37). Some of the spices have specific biological value, physiological effects as well as medicinal benefits. However, as Korsmeyer states, this is not the only explanation as to why spices were so sought after. They were a means of defining and distinguishing a cultural group from others (in-group behaviour) as well as defining an individual as part of a specific social group (Korsmeyer, 2005: 35-37).

As previously mentioned, until modern cultivation techniques were introduced in the 19th century CE, nutmeg was successfully cultivated exclusively on the remote Banda Islands located 1200km east of Java in modern Indonesia (Freedman, 2008). Any evidence for nutmeg in the Middle East and Europe prior to the 19th century CE, thus, would be evidence for long-distance trade in aromatics with Southeast Asia and thus would emphasise that nutmeg was highly valued. Literature from the Middle Ages presents spices as a "taste of Paradise". The symbolic meaning of spices' mystery and the actual physical taste of spices were closely intertwined. Social connections, power, wealth and prestige were "tasted" (Korsmeyer, 2005: 125). Furthermore, literature from 16th century AD Europe, when nutmeg was extremely popular, indicates how its origin still remained a mystery to most people involved in the trade (Milton, 1999). Both the immense distances travelled and their enigmatic provenience would have added further dimensions to their value (Helms, 2013). Contrary to dietary tradition, dietary innovation, like the addition of exotic items, put at risk the body accustomed to local food and beverages prepared in the traditional way

(Shapin, 2014). The addition of exotic items might indeed have medicinal, ritual and magical reasons behind it; however, while they could nourish and cure, they could also harm the populations that were not used to them. The fear of the unknown and the uncommon taste would have enhanced the social and cultural significance of nutmeg in beer.

6.3.2.2 Seeing others in oneself and oneself in others: senses, kinaesthesia and empathy

The sensory experience of belongingness from the consumption of highly socially and culturally charged items at Khani Masi would have been enhanced by the fact that these items would have been shared communally.

Ewart has noted that social activity, such as eating and drinking, simultaneously involves "seeing and being seen" (Ewart, 2008). Eating and drinking with others awakes self-awareness and awareness of the body (i.e. Kinaesthesia). It also affirms the participant's place within the community physically and emotionally and would have heightened the sensory experience of each participant. Indeed, commensality includes not only bodies' interaction with objects (vessels, food, beverages, etc.) and the sensations they provoke. Sociality resides also in the interaction with the other participants: seeing, hearing, talking, and smelling them, as well as tactile interactions (Hsu, 2008; Sutton, 2000).

In addition to bringing self-awareness to the participants, a sense of unity would have also arisen from this joint experience. Seeing others drinking traditional beer, using the same specific vessels and gestures, would have instilled a strong sense of place and belonging in the participants (Sutton, 2000; Hsu, 2008). This social bond between the participants is not only strengthened by eating and drinking together but also by the fact that the participants are drinking the same beer in a shared space and thus "belong together" (Hamilakis, 2008).

Philosophers like Hegel (1770 – 1831) (Berenson, 1982; Russon, 2011) and Sartre (1905–1980) (Sartre, 1943) have long theorized on the important role of the Other in the formation of the Self. To put it another way, one becomes aware of oneself by seeing oneself through the eyes of another. It also means that we recognize ourselves in the Other and we have the capacity to empathise. Imagining the other participants tasting and experiencing the same drinks -

maybe in a different way – (e.g. Mann, 2018), as well as the simultaneously felt emotions would have reinforced group unity.

Furthermore, empathy (the ability to sense other people's emotions, coupled with the ability to imagine what someone else might be thinking or feeling) and in particular kinaesthetic empathy (ability to experience empathy merely by observing the movements of another human being) may have enhanced the individual sensations and emotions. The term of kinaesthetic empathy has only been employed to dance studies so far, as dance communicates "emotional experiences through movement" (Reason and Reynolds, 2010). However, I would argue that commensality is also a highly kinaesthetic activity, involving senses, spatial closeness, tactile interactions and specific gestures. Each participant is both an actor and a spectator. Seeing a neighbouring participant eating and drinking may trigger a kinaesthetic response from the other participants whom "may perceive emotional behaviour in others and immediately experience it within their own bodies" (Reason and Reynolds, 2010).

The shared sensual and kinaesthetic experience and "state of relatedness" (Fernandez, 1986: 191; Sutton, 2000) created during commensal events is crucial in instilling a sense of belongingness in the individual, but it is also crucial in building and maintaining the community, especially in context of commensality rituals, as it is the case at Khani Masi. These intense moments of synchronicity between the participants would have made "the social group physically real, engendering vitality in the group as whole" (Hsu, 2008).

6.3.2.3 Spicing up rituals: collective memory, performance and community building

During rituals, sharing meals became an important cultural connector, reminding the participants who they are, their faith as well as their place in the history and within the community. As Kim-Cragg states that ritualistic "meal-sharing viscerally teaches […] the importance of community and fellowship; they are not alone" (Kim-Cragg, 2017: 38). In *Ritual, Politics and Power*, Kertzer (1988) presents rituals as central to the organisation and unity of social groups due to their highly standardized and repetitive actions. Kertzer defines ritual as "culturally standardized, repetitive activity, primarily symbolic in character, aimed at influencing human affairs" and as action "that follows highly

structured, standardized sequences and is often enacted at certain places and times that are themselves endowed with special symbolic meaning" (Kertzer, 1988: 8-9). Kertzer stresses that rituals are also an important means of channeling emotions, guiding cognition, moulding perceptions and organising belief and social groups (Kertzer, 1988: 8-9 and 86), in sum creating community.

At Khani Masi, we observe that rituals associated with an important consumption of beer took place in the central part of the complex building signalling that the historical meaning of this part of the building was acknowledged by the community. Furthermore, spiced beer has been identified in five vessels associated with specific ritual practices at the site: two offering sets consisting of a bowl, a juglet, a gold earring, two identical drinking cups and two faience buckets (Glatz *et al.*, 2019). The use of specific food and drink in ceremonies and rituals is probably one of the most common ways that foods and their flavours achieve meaning and social significance (Korsmeyer, 2005: 145). As highly valued and prestigious food items, spices are unlikely to have been wasted and have often been reserved for special occasions and contexts. For instance, remains of peppercorns (also originated from South India) have been found in funerary contexts, in the case of the mummy of pharaoh Ramses II (ca. 1279-1217 BCE) (Fuller *et al.*, 2015: 5). A similar trend of consuming special food during special events seems to have taken place at Khani Masi.

The spiced beer may have provided comfort and would have also inspired nostalgia and memory of the community, its history and heritage. As we have seen, food and the sensory experience it creates can evoke nostalgia and memories (Sutton, 2001) and enable "social actors to connect more intimately to the past" (Low, 2015: 68). More than personal nostalgia, "sensory experiences of food contain within them both personal and collective memories, emotions, histories, spaces and moments in time, providing referential in points between then and now, and here and there" (Abdullah, 2010: 172). By displaying and incorporating the spiced beer into the ritual performance at Khani Masi, the unique sensory experience it would have provoked would have contributed to the formation or perpetuation of communal memory (Sutton, 2000; 2001; 2005; Chesson, 2001). This is also referred to as "palate memory" by Ortíz Cuadra (2013: 51) to express how the sensory and emotional aspects of food create an "intimate bond" that reflects remembrance of vital experiences of a social and

cultural communion, through which a form of historical consciousness is created (Sutton, 2001).

Indeed, commensality, the food and beverages consumed and the practices involved are *polytemporal* (Korsmeyer and Sutton, 2011; Knight, 2014; Abarca and Colby, 2016). Memories of food and beverages, particularly during their consumption, simultaneously place us in the past, the present and often even in the future, which Sutton calls "prospective memory" (Sutton, 2001; Hamilakis, 2008). This polytemporality and "palate memory" is fed and shaped through repetition and the re-enactment of the performative acts of eating, drinking, serving, offering, and sharing foods in quotidian or ritual settings (Abarca and Colby, 2016) such as the ones which took place at Khani Masi.

In sum, the sensory and emotionally charged experience of commensality taking place in a ritual setting at Khani Masi would have created conditions to help the participants remember their belongingness. Moreover, the participants would have themselves constituted a community and contributed to its longevity and unity by perpetuating traditions through the performative enactment and re-enactment of the shared experience of drinking spiced beer (Hodder and Cessford, 2004; Pollock, 2012; 2015).

To summarize, in order to create a novel approach to illuminate food behaviour as expression of social relationships through the study or archaeological material, I investigated the sensual, emotional and kinaesthetic experience of drinking at Khani Masi.

Food and drink choices at Khani Masi exhibited both traditional and more peculiar features. Regarding beverages, beer, a common item in Mesopotamian diet was in some instances mixed with seasonings like nutmeg, an exotic item less accessible. Seasonings are conscious additions of flavours but we also presented evidence of practices that would have indirectly modified the flavours of beer. Petroleum, identified through organic residue analysis, would have been applied to vessels primarily for mending purpose but would have had an impact on the taste and smell of beer.

The results of this study provide us with the opportunity to shed a new light on beer consumption practices in the Kassite-Middle Babylonian period. Beer drinking was still very much a communal activity; however, it involved the use of

individualised vessels with different sizes, shapes and fabrics. Drinking from plain pottery vessels that we know were characteristic of Kassite-Babylonia and neighbouring regions might have created a sense of community between the inhabitants of Khani Masi as well as a cultural link with the rest of the region. However, by drinking directly from individual vessels rather than drinking from communal vessels, we have proposed that the overall experience of drinking beer would have been enhanced, with senses of touch, smell and taste more involved in the activity.

Beer is a quintessential part of the Mesopotamian diet and a culturally traditional food. The sensory experience of beer would have invoked a sense of security and comfort and would have been emotionally gratifying. Moreover, consuming beer would have been the expression of strong regional cultural tradition and a sense of belonging to a community. Its psychoactive properties would have also contributed to the creation of social bonds. The inordinate quantity of beer and its local production would have been a reinforcement of identity through a focus on “normal” and traditional foods but also would have acted as a display of wealth and a powerful expression of difference in economic status. We also discovered evidence of nutmeg at Khani Masi, and nutmeg would have conveyed prestige, high-standing and social superiority as it implies long-distance trade, social connections, power, and wealth. By consuming spiced beer in a very specific ritualistic context would have provided comfort and inspired a strong sense of unity as well, instilling nostalgia and shared memories. The depth of meaning, comfort, memory, sensorial experience associated with beer drinking at Khani Masi would have worked as “social glue”, forming and strengthening bonds between and within the community.

7 Nourishing Knowledge: Conclusions, reflections and new directions

This thesis has sought to reveal new narratives on social drinking and community identity building in Late Bronze Age Mesopotamia and beyond, by moving away from common approaches that focus on food access and social diversity. Instead it considers the ways in which food and, in particular, alcoholic beverages can evoke sensorial and emotional responses that could have strengthened bonds between individuals at Khani Masi. By incorporating multiple sources of evidence, especially strong qualitative and quantitative chemical evidence in concert with textual, iconographic and archaeological information, as well as a theoretical framework that draws on a range of discipline's approaches to food, senses and identity, I hope to have mapped out a pathway towards new research trajectories for ORA in archaeology.

This final chapter briefly summarises and reflects on the original contributions made by this thesis to the understanding of social organisation and community identity at the Late Bronze Age site of Khani Masi by returning to the research questions raised in my introduction. It also discusses the implications of the application of this new interdisciplinary approach to the study of other archaeological projects interested in incorporating ORA as well as projects investigating food, socio-economic organisation and identity in ancient societies. Finally, potential directions for future research are suggested.

7.1 How can the archaeological identification of beverages and their ingredients in a consumption context such as at Khani Masi be improved?

The first contribution of this study is the creation of a multi-disciplinary methodology allowing for the secure identification of beverages and their ingredients in a consumption context.

7.1.1 A novel improved ORA protocol

As part of this study, I presented a novel ORA methodology enabling the secure identification of archaeologically significant compounds in face of contamination; this new methodology allows us to characterise the contents of ceramic vessels designed for consumption.

Organic residue analysis in archaeology has made great strides since its introduction in the 1970s; today, the discipline encompasses a vast range of materials, periods, contexts and research questions. The discipline has opened up a new world of possibilities for archaeological research to elucidate crucial aspects of ancient lives, information that often could not have been discovered without using scientific techniques of analysis. While it seems that organic residue analysis is an established discipline today, several questions and challenges in the field of organic residue analysis still remain unresolved today. For instance, in seeking to characterize organic material from the past analysts are faced with the problem of trying to identify traces of significant compounds despite degradation and contamination within an environment full of similar compounds with different origins. Over the lifetime of an organic residue recovered from archaeological material, several possible sources of contamination could have an impact on its analysis. The most obvious source of degradation and contamination is of course the burial environment. Another source of contamination is the air introduced in the laboratory during the preparation and analysis of organic material.

Yet, one of the most challenging questions facing organic residue researchers is the secure identification of ancient fatty material from modern contamination which may have come into contact with the material during or directly after the exhumation of the ceramic vessel. During the post-excavation process, which includes handling, washing and storage, the chances that you will contaminate your material increase tenfold and thus could have a big impact on the identification of the compounds and thus the interpretation of your results. Unfortunately, little has been published about contamination and organic residues, but a basic knowledge of potential contaminants and the “do’s and don’ts” is crucial when seeking to interpret the results of residue analysis. In the results, the importance of the sampling strategy and protocol is often understated. In addition, the various instruments used to perform the analysis

are often seen by the archaeologist as infallible and the data is believed to be easily interpretable. Projects using organic residue analysis are cautioned to acknowledge all potential sources of contamination. It is imperative to engage in rigorous control to assess possible contaminants, and include primary control data in final project publications.

Hence, a major part of my PhD work was dedicated to the creation of an organic residue analysis protocol that aims to reduce and assess contamination. This protocol includes a very cautious sampling regime applied directly on site with the use of clean material, as well as the use of control and reference samples.

Due to the sampling regime specifically designed here for residue analysis, organic residues were well-preserved with only small amounts of modern contamination such as plasticizers (i.e. phthalates and phenols) compared to other compounds for most of my results. Comparisons were made with soil residues, laboratory blanks and residues extracted from the outer and inner vessel surfaces to ensure that identified compounds were of archaeological significance and not the results of contamination. The majority of the compounds that were associated with the burial soils and identified in the vessels' outer surfaces were not considered in the results.

The identification of compounds and thus the substance origin has not only been possible through comparison with the National Institute of Standards and Technology or NIST mass spectra library providing over 100 000 reference mass spectra for GC-MS and LC-MS/MS, but also through the creation of food reference material and literature research. The compound list created will be accessible for any future projects (**http://dx.doi.org/10.5525/gla.researchdata.875**).

The creation of a new sampling strategy and ORA protocol, based on trial and error, are presented in this thesis. They give us the confidence that we can securely identify archaeologically significant compounds in our samples, allowing us to present a more grounded and reliable interpretation of our results, the basis of our reflection on beverages consumption at Khani Masi.

7.1.2 Beer and ingredients identification in consumption vessels

This study presents the first identification of beer through the analysis of absorbed residues and the creation of reference samples.

The first step was to apply this new ORA protocol to identify compounds characteristic of beverages; this was not only applied to ceramic vessels that can be clearly classified based on their projected functions and suitability (shape, capacity, stability, etc.) as drinking vessels (i.e. 'Kassite' goblets and cups), but also to other types of ceramics vessels found on site (i.e. bowls, *namzitu* and other large vessels) used as comparative material. Most of the 'Kassite' goblets and cups analysed have similar chromatographic profiles and show a co-occurrence of chemical compounds which, considered together, point to the presence of a cereal-derived fermented beverage, i.e. beer (Perruchini *et al.* 2018). The same compounds were identified in the *namzitu,* the vessel used in beer production, discovered nearby. In contrast, a completely different chromatographic profile has been observed for the bowls and larger vessels. The second step was to create modern reference samples. A similar set of compounds was also discovered in the reference samples of barley and modern beers, which further supports my identification of beer in the archaeological samples.

This study also offers the chemical identification of ingredients used in the preparation of beer, for which we only had rare evidence.

The results of organic residue analysis, the analysis of a reference sample of barley and the discovery of charred grains on site, indicate that beer was made with barley and not wheat. Furthermore, results of organic residue analysis reveal that different types of beer were produced and consumed at Khani Masi. In addition to the co-occurring compounds indicative of barley beer mentioned above (Perruchini *et al.*, 2018), the lipid extracts from a small group of vessels presented compounds which represent the adjuncts of aromatics.

Notably regarding flavour added to beer, our results of ORA unveiled the possible addition of a very specific ingredient: the seed oil of plants of the Myristicaceae or nutmeg family (Leray, 2012, 20), evergreen trees notable for their blood-red sap and for their aromatic smell. The most well-known member of the Myristicaceae family is *Myristica fragrans Houtt.*, the common nutmeg tree native to the Moluccas (Spice Islands) (Nybe *et al.*, 2007). Similar compounds were observed in a reference sample of nutmeg, further supporting my interpretation.

7.2 How can organic residue analysis reveal new insights into vessels and practices used in beverage consumption in the Late Bronze Age Mesopotamia?

This study, thanks to the novel ORA protocol, presents the identification of beer in consumption vessels discovered in situ, previously only identified in production and storage vessels. It allowed me to provide new insights into consumption practices in the Late Bronze Age.

In this thesis, I presented archaeological data relating to the consumption of alcohol, from the site of Khani Masi. The ceramic assemblage particularly from two trenches (Y88/89) and ensuing ORA results show that the community who used/lived in the complex building were avid consumers of beer. This evidence – fits within the context of the documented history of the region (**Sections 3.1 and 3.3**). However, it does reinterpret what we knew of beer consumption practices, which were previously seen as "common"; we now have a clearer vision of the significance of beer consumption and its place in ritual and community building events.

Firstly, our analytical results allow us, for the first time and with confidence, to ascribe a diverse range of drinking equipment to the consumption of beer, in particular the 'Kassite' goblet, which represents a key element of the Kassite ceramic assemblage.

Secondly, this work demonstrates that, at Khani Masi, beer was consumed from individualised vessels of different sizes and forms. The disappearance in the Middle Babylonian ceramic assemblage of communal vessels usually associated with beer consumption (according to evidence from iconography and texts) as well as the increasing number of individualised ceramic vessels from the Old Babylonian period onwards, indicate a growing trend toward an individualized beer consumption experience. This could mean that new brewing practices were adopted at that time. Whatever the practical reason behind it, the consumption of beer from various sizes and forms of individualised drinking vessels, from tall to medium-sized solid-footed goblets and small drinking cups, would have had an impact on sociability and on the overall experience of drinking.

Finally, I was able to map the consumption of different types of beer in specific settings. Beer was used for multiple purposes and events as seen in texts (**Section 3.3**). For instance, during the Late Kassite period, a letter from Nippur dated back from either the latter part of the reign of Kurigalzu II or more probably the reign of his successor reports sweet beer as part of the offerings and rites of the temple (Biggs, 1965). However, those texts do not give us any details on what type of beer was consumed during those rituals. My study presents evidence for a unique type of beer, which includes the adjunct nutmeg discovered exclusively in vessels recovered from the room used for ritual activities, as evidenced by the two offering sets.

While we do not know the role of the monumental complex discovered at Khani Masi in the political landscape of the period, it seems to have been an important centre for communal events during which feasting, drinking and powerful sensorial experiences took place. These events would have played out an important part in the creation of social and cultural identities. Having access to this information on the food and beverages consumed at Khani Masi provides us with the opportunity to explore its sensorial experiences.

7.3 What evidence can allow us to recreate certain elements of the sensory experience of social drinking in the past?

This study demonstrates that, through the combination of archaeological, textual and iconographic evidence, considered alongside ethnographical, biological and psychological studies, it is possible to recreate certain elements of the sensory experience of drinking in the past, or at least a verbal representation of it.

With the identification of beer and ingredients such as nutmeg, based on strong chemical data, I was able to start thinking about their sensory aspects, their strong taste and smell, and the emotions, the nostalgia and the comfort they can evoke in the individual based on philosophical and ethnographical literature.

As indicated by the chemical presence of fermentation compounds, we can certify that beer at Khani Masi was at least slightly alcoholic and thus had

psychoactive properties. Beer would have had physiological effects on the body and impact on the mood, a hypothesis supported by textual evidence and iconography. In a similar way, nutmeg also has powerful psychoactive effects and is reported to be a hallucinogen. Mixing nutmeg with beer would probably have intensified the intoxicating effect of the spiced beer.

This study also highlights that other factors, supported by archaeological findings, would have added to the sensory experience of drinking. Drinking directly from individualised ceramic vessels, for instance, would certainly have had an influence on the perception of the flavour of the beer. While drinking, all sensory faculties would have been activated in unison and intensified by the consumption settings, i.e. the space and the people attending (**Section 6.3.2**).

7.4 What new perspectives on social organisation and community identity in Late Bronze Age Mesopotamia can the recreation of sensorial and emotional experience bring us?

Contrary to previous studies that focus on food as a marker of social distinction, this thesis brings new narratives on social organisation and community identity in Late Bronze Age Mesopotamia.

First, I argue that the multi-sensorial and emotional experience of commensality, in particular social drinking, at Khani Masi would have played a fundamental role in helping the participants to be incorporated into the collective body of the community. I stressed the fact that food preferences and taste are socially and culturally conditioned, shaped by an historical consciousness and a social knowledge. Thus, by consuming certain food items, an individual and the social group 'authenticated' themselves as belonging to a certain cultural community. For instance, the taste of beer, as a 'traditional' food item of the region, would have triggered a sense of cultural belongingness. In a similar way, the taste and smell of nutmeg, a valuable item, would have reminded the participants that they belonged to a certain socio-economic status.

Moreover, I propose that the sensory experience of consuming these socially and culturally charged items would have been central in strengthening social bonds. A sense of unity would have arisen from the joint experience of drinking the same beverage from similar drinking vessels. Imagining the other participants tasting and experiencing the same drinks, as well as the simultaneously felt emotions, would have not only heightened the sensory experience of each participant but would also have reinforced the group unity.

Finally, this study is going one step further by suggesting that these intense moments of synchronicity between the participants, especially in the context of commensality rituals in the case of Khani Masi, would have helped build and maintain the community identity. Indeed, rituals, and their highly standardized and repetitive actions, are central to the organisation and unity of social groups. For instance, at Khani Masi, we observe that rituals associated with an important consumption of beer took place in the central part of the building complex and the addition of nutmeg in beer was exclusively found in this setting. The flavouring of beer may have been used as an agent of memory in mortuary rituals to trigger recollections of previous rituals. This unique sensory experience would have connected participants to the past and contributed to the formation and/or perpetuation of communal memory.

7.5 Avenues for further and future research

This research has highlighted the rich insights that can be gained by integrating multiple approaches and crossing trans-disciplinary boundaries in the analysis and interpretation of archaeological datasets.
Moreover, the approaches and interpretations presented in this thesis have allowed me to consider useful routes for potential future research into commensality and food-related practices, in general.

More research is needed into the recreation of sensory experience of drinking beer at Khani Masi. Indeed, this study was only able to recreate certain elements of what could have been experienced by the participants based on strong chemical evidence and comparative literature studies. However, one way that I could improve the interpretation of the taste and smell of beer at Khani Masi

would be to recreate the ancient beer, or at least as close an approximation as possible, through experimental archaeology. This could be achieved by incorporating what we discovered of the ingredients and vessels at Khani Masi, with the information from ancient texts and other beer recreation projects (e.g. the works of Patrick E. McGovern, Tate Paulette or more recently Aren Maeir). This idea was developed by Dr. Claudia Glatz at the University of Glasgow, in the course "Feasting like the Ancients: An Inter-Disciplinary Approach to Early Food and Drink," during which beer was brewed with the students using ingredients and replicas of ancient vessels. Preliminary results show that the beer recreated contains similar compounds as in the archaeological samples (**Appendix E, Figure 276**). Thanks to the use of a replica of *namzitu*, the colour of the beer was clear brown. The beer smelled a bit like vinegar (but not unpleasant) and tasted sour. New experiments are needed to explore the taste and smell of ancient beer.

More research is also needed into food consumption in the Kassite period.
Most of the archival sources dated to the Kassite period have been recovered in cities at the centre of the Kingdom with the little information on the socio-economic organisation of Kassite Babylonia coming mainly from excavations at Nippur (Zettler, 1993).
It appears that the Kassite Babylonian kingdom was in contact with a lot of different communities and was part of large trade networks and cultural exchanges (Vermaak, 2007; Miller, 2017). Kassite wealth and control of resources was such that the ruler Kurigalzu Ist ruled a territorial state that stretched as far south as Dilmun (modern Bahrain) in the Persian Gulf, and he and his descendants were in regular contact with rulers in Mitanni and then Hatti and Assyria in northern Mesopotamia as well as Anatolia, Egypt and Elam in Iran as witnessed in texts and letters such as the Amarna letters (**Section 3.3**). A number of "exotic" food items could have thus entered the Kassite kingdom territory through these exchanges. This study presents the first evidence of nutmeg from this period and thus the existence of a long-distance trade with Southeast Asia during the Kassite period. The fact that Khani Masi is located near the exit from the Zagros mountains of two branches of the later Silk Routes, corroborates the plausibility of the existence of a land-route for the movement of exotic food items during the Kassite period. However, this theory certainly

needs to be verified through systematic analysis of food residues in future excavations of sites dated to the Kassite period and earlier periods. It would help us understand if the observations highlighted in this study are restricted to Khani Masi or if we could see the same trend of food consumption in other sites of the Kassite period. We could also determine if the choices in beverages, practices and vessels involved in drink consumption identified in this study are a trait of the Kassite period or if they were already established in earlier periods. Furthermore, as discussed in **Sections 2.1 and 3.3**, consumption practices in domestic settings have *hitherto* been largely overlooked in comparison to more ritualistic and elite settings. It would be interesting to compare and map food consumption practices in both settings across different social contexts.

While the ORA evidence of food consumption at Khani Masi has been scarce so far, new residue analyses could be applied. For instance, one of the bowls (**BECS 1772 - Appendix C, Figure 70**) presented a very distinct chromatographic profile with series of compounds that could indicate that the bowl would have contained some sort of stew, a mix of meat and vegetables. The use of GC-IRMS (Gas chromatography coupled with an Isotope Ratio Mass Spectrometer) and isotope analysis could help us characterise the animal and vegetal sources of those compounds (Evershed *et al.*, 2002; Hemingway *et al.*, 2016).

One discovery during my study that needs further research is the identification of the unmistakable compound composition that indicates the presence of crude oils in ceramic production during the Kassite period. While, visible archaeological traces of bitumen – a specific type of crude oil – have been discovered in sites dated as far back as the 4th millennium BCE, it is interesting to note that our samples did not present any visible dark viscous material. We know that naturally occurring petroleum can have different textures and colours in part due to their sulfur content. Iraq, and in particular the Kurdistan region, is an oil-rich area (Connan, 1999; Mohialdeen and Hakimi, 2013) and some reserves present petroleum with relatively low sulfur content. However, non-local sources of petroleum could have also been used. It would thus be interested to pinpoint the nature(s) and origin(s) of petroleum used at Khani Masi as it would give us new information on ceramic production techniques, as well as movements of communities, and its cultural significance. Further research and

data using stable carbon isotopes and molecular organic geochemical analyses to identify the sources geographically are needed to answer those questions.

While many more questions remain on the study of ancient life in Mesopotamia during the Kassite period, one feature is clear: the study of food consumption and practices offer a powerful avenue for archaeologists to investigate identities, cultural exchanges and social organisation.

Furthermore, a new avenue that could be opened and explored further is how the use of ORA and the recreation of sensorial experience of food from the past could be incorporated in public outreach projects (Patania and Jaffe, 2018). Public engagement is becoming increasingly important in archaeological projects. It requires interests that will motivate and engage a large public. In **Chapter 2,** I mentioned the sensory and experiential power of food. This is why it will make the subject of food immediately relevant to people's lives. Furthermore, I presented how food enables people to come together, independently of their age and nationality, making it the perfect subject to attract public attention. The public could explore archaeology through the recreation of past consumption practices (replica of vessels and ancient food), experience what could have been tasted, smelled and emotionally felt by the people of the past. With the help of immersive virtual reality (VR), it is also possible to reconstruct sites and space that could add to the overall experience of the past by the public. The public personal experience could be followed by a discussion with researchers and archaeologists to learn more about the archaeological research.

Finally, this thesis demonstrates the necessity to not just analyse ancient texts and iconography but also the application of more consistently combined approaches of archaeology and a range of disciplines. Through the application of such novel approaches that bridge both the sciences and humanities, we may hope to better understand significant identity-forming periods in human history which would lead to the world we know today, where past, identity and image are still - and maybe even more relevant issues.

8 Bibliography

Abarca, M. E. and Colby, J. R. (2016) 'Food memories seasoning the narratives of our lives', *Food and Foodways*. 24(1–2), 1–8. doi: 10.1080/07409710.2016.1150101.

Abdel-Aal, E. I., Haroon, A. M. and Mofeed, J. (2015) 'Successive solvent extraction and GC–MS analysis for the evaluation of the phytochemical constituents of the filamentous green alga Spirogyra longata', *The Egyptian Journal of Aquatic Research*. 41(3), 233–246. doi: 10.1016/J.EJAR.2015.06.001.

Abdel-Maksoud, G. and El-Amin, A.-R. (2011) 'A review on the materials used during the mummification processes in ancient Egypt', *Mediterranean Archaeology and Archaeometry*. 11(2), 129-150. Available at: http://maajournal.com/Issues/2011/pdf/Maksoud.pdf.

Abdullah, N. (2010) 'Comfort Food, Memory, and "Home": Senses in Transnational Contexts', in Kalekin-Fishman, D. and Low, K. E. Y. (eds.) *Everyday Life in Asia: Social Perspectives on the Senses*. Surrey: Ashgate Publishing Limited, pp. 157–176. doi: 10.4324/9781315581309-15.

Acharya, A., Blackwell, M. and Sen, M. (2018) 'Explaining Preferences from Behavior: A Cognitive Dissonance Approach', *The Journal of Politics*. 80(2), 400–411. doi: 10.1086/694541.

Alba-Lois, L. and Segal-Kischinevzky, C. (2010) 'Yeast Fermentation and the Making of Beer and Wine', *Nature Education*. 3(9), 17.

Albenda, P. (1974) 'Grapevines in Ashurbanipal's Garden', *Bulletin of the American Schools of Oriental Research*. 215, 5–17. doi: 10.2307/1356313.

Algaze, G. (2001) 'Initial Social Complexity in Southwestern Asia', *Current Anthropology*. 42(2), 199–233. doi: 10.1086/320005.

Allred, L. (2011) 'The Kitchen at Garšana', in Owen, D. I. (ed.) *Garšana Studies (CUSAS 6)*. Bethesda: CDL Press, pp. 11-29.

Allred, L. (2006) 'Cooks and Kitchens: Centralized Food Production in Late Third Millennium Mesopotamia', PhD diss., Johns Hopkins University.

Amigues, S. (2005) 'Végétaux et aromates de l'Orient dans le monde antique', *Topoi*. 15, 75–125.

Amri, I. *et al*. (2012) 'Chemical composition and biological activities of the essential oils from three Melaleuca species grown in Tunisia', *International journal of molecular sciences*. 13(12), 16580–91. doi: 10.3390/ijms131216580.

Antonisamy, P., Duraipandiyan, V. and Ignacimuthu, S. (2011) 'Anti-inflammatory, analgesic and antipyretic effects of friedelin isolated from *Azima tetracantha Lam*. in mouse and rat models', *Journal of Pharmacy and Pharmacology*. 63(8), 1070–1077. doi: 10.1111/j.2042-7158.2011.01300.x.

Aouizerat, T. *et al.* (2019) 'Isolation and Characterization of Live Yeast Cells from Ancient Vessels as a Tool in Bio-Archaeology', *mBio*. 10(2), e00388-19. doi: 10.1128/mBio.00388-19.

Armstrong, J. A. (1993) 'Pottery', in Zettler, R. (ed.) *Nippur III: Kassite Buildings in Area WC-1*. Chicago: Oriental Institute of the University of Chicago, pp. 67–78.

Armstrong, J. A. (2017) 'Babylonian Pottery in the Kassite Period', in Sternitzke, K., Bartelmus, A., and Roaf, M. (eds) *Kar-duniaš: Babylonien in der Kassitenzeit. The Proceedings of the Symposium held in Munich 30 June to 2 July 2011, vol. 2*. Berlin: De Gruyter, pp. 437–478.

Armstrong, J. A. and Gasche, H. (2014) *Mesopotamian Pottery: A Guide to the Babylonian Tradition in the Second Millennium B.C.* Chicago: Ghent.

Arnold, B. (1999) '"Drinking the Feast": Alcohol and the Legitimation of Power in Celtic Europe', *Cambridge Archaeological Journal*. 9(1), 71–93. doi: 10.1017/S0959774300015213.

Arnold, D. E. (1985) *Ceramic Theory and Cultural Process*. Cambridge: Cambridge University Press.

Arthur, J. W. (2003) 'Brewing beer: Status, wealth and ceramic use alteration among the Gamo of south-western Ethiopia', *World Archaeology*. 34(3), 516–528. doi: 10.1080/0043824021000026486.

van As, A. and Jacobs, L. (1987) 'Second millennium BC goblet bases from Tell ed-Deir—the relationship between form and technique', *Newsletter Department of Pottery Technology (Leiden)*. 5, 39–53.

Ashton, K. *et al.* (2017) 'Do emotions related to alcohol consumption differ by alcohol type? An international cross-sectional survey of emotions associated with alcohol consumption and influence on drink choice in different settings.', *British Medical Journal open*. 7(10), e016089. doi: 10.1136/bmjopen-2017-016089.

Asuman, K. (2015) 'Characterization of the Fatty Acid and Mineral Compositions of Selected Cereal Cultivars from Turkey', *Record of Natural Product*. 9(1), 124–134.

Atalay, S. and Hastorf, C. A. (2006) 'Food, meals and daily activities: food habitus at Çatalhöyük', *American Antiquity*. 71, 283–319.

Auberger, J. and Goupil, S. (2010) 'Les "mangeurs de céréales" et les autres', *Phoenix*. 64, 52–79.

Aurora, P. and Klanecky, A. K. (2016) 'Drinking motives mediate emotion regulation difficulties and problem drinking in college students', *The American Journal of Drug and Alcohol Abuse*. 42(3), 341–350. doi: 10.3109/00952990.2015.1133633.

Azzazy, M. F. (2018) 'Exploratory palynological studies at the Tell el-Daba'a-Avaris archaeological site', *PLOS ONE*. 13(2), e0180770. doi: 10.1371/journal.pone.0180770.

Badler, V. (2008) 'Winemaking and Viticulture in the Ancient Near East and

Egypt', in Selin, H. (ed.) *Encyclopaedia of the History of Science, Technology, and Medicine in Non-Western Cultures*. Dordrecht: Springer Netherlands, pp. 2285–2286. doi: 10.1007/978-1-4020-4425-0_8943.

Badler, V., McGovern, P. E. and Glusker, D. (1996) 'Chemical evidence for a wine residue from Warka (Uruk) inside a late Uruk period spouted jar', *Baghdader Mitteilungen*. 27, 39–43.

Baeten, J. *et al*. (2013) 'Molecular evidence for the mixing of Meat, Fish and Vegetables in Anglo-Saxon coarseware from Hamwic, UK', *Archaeometry*. 55(6), 1150–1174. doi: 10.1111/j.1475-4754.2012.00731.x.

Bahrani, Z. (2001) *Women of Babylon: Gender and Representation in Mesopotamia*. Londres-New York: Routledge.

Ball, T. *et al*. (2016) 'Phytoliths as a tool for investigations of agricultural origins and dispersals around the world', *Journal of Archaeological Science*. 68, 32–45. doi: 10.1016/J.JAS.2015.08.010.

Balossi Restelli, F. (2010) 'Extended Families and Nuclear Families. Daily Life and the use of Domestic Space in the Ubaid and Post-Ubaid Communities: the Case of the Malatya Plain (Eastern Turkey)', *Origini*. XXXII(4), 189–201.

Balossi Restelli, F. (2012) 'Eating at Home and "Dining" Out?: Commensalities in the Neolithic and Late Chalcolithic in the Near East', in Pollock, S. (ed.) *Commensality Between Feasts and Daily Meals. Towards and Archaeology of Commensal Spaces*. eTopoi Journal of Ancient Studies, Special Volume 2, pp. 75–95.

Bamforth, C. W. (2004) *Beer: Health and Nutrition*. Oxford: Blackwell Science Ltd. Available at: http://www2.udec.cl/~erhetz/Beer_-_Health_and_Nutrition.pdf.

Barba, L. (2007) 'Chemical residues in lime-plastered archaeological floors', *Geoarchaeology*. 22(4), 439–452. doi: 10.1002/gea.20160.

Barjamovic, G. (2011) *A historical geography of Anatolia in the Old Assyrian colony period*. Carsten Niebuhr Institute Publications xviii, Copenhagen: Museum Tusculanum Press.

Barnard, H. *et al*. (2011) 'Chemical evidence for wine production around 4000 BCE in the Late Chalcolithic Near Eastern highlands', *Journal of Archaeological Science*. 38(5), 977–984. doi: 10.1016/j.jas.2010.11.012.

Barry-Ryan, C., Devereux, M. and Lonchamp, J. (2009) 'Identification of volatile quality markers of ready-to-use lettuce and cabbage', *Food Research International*, 42, 1077-1086.

Barthes, R. (2008) 'Toward a Psychosociology of Contemporary Food Consumption'', in Counihan, C. and Van Esterik, P. (eds) *Food and Culture*. New York: Routledge, pp. 28–36.

Bayliss, G. S. (1968) 'The formation of pristane, phytane and related isoprenoid hydrocarbons by the thermal degradation of chlorophyll', *155th American Chemical Society National Meeting San Francisco, California March 31-*

April 5. Preprint F.117-131. Available at: https://web.anl.gov/PCS/acsfuel/preprint archive/Files/12_1_SAN FRANCISCO_03-68_0117.pdf.

Bayliss, M. (1973) 'The Cult of Dead Kin in Assyria and Babylonia', *Iraq*. 35(2), 115-125. doi: 10.2307/4199959.

Beagan, B. L., Power, E. M. and Chapman, G. E. (2015) '"Eating isn't just swallowing food": Food practices in the context of social class trajectory', *Canadian Food Studies / La Revue canadienne des études sur l'alimentation*. 2(1), 75–98. doi: 10.15353/cfs-rcea.v2i1.50.

Becuţ, A. G. and Puerto, K. L. i (2017) 'Introduction. Food history and identity: Food and eating practices as elements of cultural heritage, identity and social creativity', *International Review of Social Research*. 7(1), 1–4. doi: 10.1515/irsr-2017-0001.

Bedale, C. L. (1915) *Sumerian tablets from Umma in the John Rylands Library*. Manchester: Manchester University Press.

Bedigian, D. (2004) 'History and lore of sesame in Southwest Asia', *Economic Botany*. 58(3), 329–353. doi: 10.1663/0013-0001(2004)058[0329:ar]2.0.co;2.

Bedigian, D. (2010) *Sesame : the genus Sesamum*. Boca Raton: Taylor & Francis.

Bedigian, D. and Harlan, J. R. (1986) 'Evidence for Cultivation of Sesame in the Ancient World', *Economic Botany*. 40, 137–154. doi: 10.1007/BF02859136.

Ben-Amos, I. K. (2000) 'Gifts and Favors: Informal Support in Early Modern England', *Journal of Modern History*. 72(2), 295–338.

Ben-Amos, I. K. (2008) *The Culture of Giving : Informal Support and Gift Exchange in Early Modern England*. Cambridge: Cambridge University Press.

Berenson, F. (1982) 'Hegel on Others and the Self', *Philosophy*. 57(219), 77–90.

Besbes, S. *et al*. (2004) 'Date seeds: chemical composition and characteristic profiles of the lipid fraction', *Food Chemistry*. 84, 577–584.

Beyer, D. (1982) *Meskéné - Emar : dix ans de travaux 1972-1982*. Paris: Editions Recherche sur les civilisations (ERC).

Bhuiyan, M. N. I. *et al*. (2009) 'Constituents of Peel and Leaf Essential Oils of *Citrus Medica L*', *Journal of Scientific Research*. 1(2), 387–392. doi: 10.3329/jsr.v1i2.1760.

Bieniada, M. E. (2009) 'Habur Ware: Where are the Stylistic and Functional Sources of the Painted Pottery of the Second Millennium BCE Habur River Basin?', *Ancient Near Eastern Studies*. 46, 160–211. doi: 10.2143/ANES.46.0.2040716.

Biers, W. R. and McGovern, P. E. (1990) *Organic contents of ancient vessels : materials analysis and archaeological investigation*. MASCA Research Papers in Science and Archaeology 7, Philadelphia: University of Pennsylvania.

Biggs, R. D. (1965) ‘A Letter from Kassite Nippur’, *Journal of Cuneiform Studies*. 19(4), 95–102. doi: 10.2307/1359113.

Biggs, R. D. (2005) ‘Medicine , Surgery , and Public Health in ancient Mesopotamia’, *Journal of Assyrian academic studies*. 19(1), 1–19.

Binford, L. R. (1967) ‘Smudge Pits and Hide Smoking: the Use of Anology In Archaeological Reasoning’, *American Antiquity*. 32(1), 1–12.

Bisogni, C. A. *et al*. (2002) ‘Who We Are and How We Eat: A Qualitative Study of Identities in Food Choice’, *Journal of Nutrition Education and Behavior*. 34(3), 128–139. doi: 10.1016/S1499-4046(06)60082-1.

Blagovic, B. *et al*. (2001) ‘Lipid composition of brewer’s yeast’, *Food Technology and Biotechnology*. 39(3), 175–181.

Boëda, E. *et al*. (2008) ‘New Evidence for Significant Use of Bitumen in Middle Palaeolithic Technical Systems at Umm el Tlel (Syria) around 70,000 BP’, *Paléorient*. 34(2), 67–83. doi: 10.3406/paleo.2008.5257.

Boehmer, R. M. and Dämmer, H.-W. (1985) *Tell Imlihiye, Tell Zubeidi, Tell Abbas*. Baghdader Forschungen 7, Mainz: Philipp von Zabern.

Boenke, N. (2007) ‘Human Excrement from a Prehistoric Saltmine as a Mirror of Daily Life?’, in Twiss, K. C. (ed.) *The Archaeology of Food and Identity*, Center for Archaeological Investigations Occasional Paper No. 34. Carbondale: Southern Illinois University, pp. 69–84.

Bogaard, A. (2017) ‘The archaeology of food surplus’, *World Archaeology*. 49(1), 1–7. doi: 10.1080/00438243.2017.1294105.

Boivin, N., Blench, R. and Fuller, D. Q. (2009) ‘Archaeological, linguistic and historical sources on ancient seafaring: a multidisciplinary approach to the study of early maritime contact and exchange in the Arabian Peninsula’, in Petraglia, M. D. and Rose, J. I. (eds) *The Evolution of Human Populations in Arabia*. Dodrecht: Springer, pp. 251–78.

Bokulich, N. A. (2017) *Brewing Microbiology*. Norfolk: Caister Academic Press.

Bordes, L. *et al*. (2018) ‘Raman spectroscopy of lipid micro-residues on Middle Palaeolithic stone tools from Denisova Cave, Siberia’, *Journal of Archaeological Science*. 95, 52–63. doi: 10.1016/j.jas.2018.05.001.

Bottéro, J. (1995) *Textes culinaires mésopotamiens*. Winona Lake, Indiana: Eisenbrauns.

Bottéro, J. (2004) *The oldest cuisine in the world : cooking in Mesopotamia*. Chicago: University of Chicago Press.

Boulton, N. and Heron, C. (2000) ‘Chemical detection of ancient wine’, in Nicholson, P. T. and Shaw, I. (eds) *Ancient Egyptian materials and technology*. Cambridge: Cambridge University, pp. 599–603.

Bourdieu, P. (1977) *Outline of a Theory of Practice*. Cambridge: Cambridge University Press.

Bourdieu, P. (1979) *La Distinction*. Paris: Editions de minuit.

Bourdieu, P. (1984) *Distinction : A Social Critique of the Judgement of Taste*, *Distinction : A Social Critique of the Judgement of Taste*. Cambridge: Harvard University Press.

Bourke, D. and Hillier, J. (2002) 'Habitus: Introduction', in Hillier, J. and Rooksby, E. (eds) *Habitus: a sense of place*. Aldershot: Ashgate Publishing Limited, pp. 3–25.

Bourriau, J., Smith, L. M. V. and Nicholson, P. T. (2000) *New Kingdom Pottery Fabrics: Nile clay and Mixed Nile/Marl Clay Fabrics from Memphis and Amarna*. Occasional Publication 14, London: Egypt Exploration Society.

Boz, H. (2015) 'p-Coumaric acid in cereals: presence, antioxidant and antimicrobial effects', *International Journal of Food Science & Technology*, 50(11), 2323–2328. doi: 10.1111/ijfs.12898.

Braidwood, R. J. *et al*. (1953) 'Symposium : Did Man Once Live by Beer Alone ? *American Anthropologist*. New series, 55(4), 515–526.

Bray, T. (2003) 'The Commensal Politics of Early States and Empires New York', in Bray, T. (ed.) *The Archaeology of Politics of Food and Feasting in Early States and Empires*. New York: Kluwer Academic/Plenum Publishers, pp. 1–13.

Breniquet, C. (2009) 'Boire de la bière en Mésopotamie', in Faivre, X., Lion, B., and Michel, C. (eds.) *Et il y eut un esprit dans l'Homme. Jean Bottéro et la Mésopotamie*. Paris: De Boccard, pp. 183–196.

Brettell, R. C. *et al*. (2015) '"Choicest unguents": molecular evidence for the use of resinous plant exudates in late Roman mortuary rites in Britain', *Journal of Archaeological Science*. 53, 639–648. doi: 10.1016/J.JAS.2014.11.006.

Briggs, D. E. (1978) *Barley*. London: Chapman & Hall.

Briggs, D. E. *et al*. (2004) *Brewing: Science and Practice*. Cambridge: Woodhead Publishing.

Brinkman, J. A. (1976) *Materials and studies for Kassite history*. Chicago: Oriental Institute of the University of Chicago.

Broshi, M. (2007) 'Date Beer and Date Wine in Antiquity', *Palestine Exploration Quarterly*. 139(1), 55–59. doi: 10.1179/003103207x163013.

Brown, M. (2018) 'Biological perspectives on Hittite brewing', *Journal of Archaeological Science: Reports*. 20, 596–601. doi: 10.1016/J.JASREP.2018.06.007.

Brück, J. (2005) 'Experiencing the past? The development of a phenomenological archaeology in British prehistory', *Archaeological Dialogues*. 12(1), 45–72.

Brumfiel, E. M. (1987) 'Elite and Utilitarian Crafts in the Aztec State', in Brumfiel, E. M. and Earle, T. K. (eds.) *Specialization, Exchange, and Complex Societies*. Cambridge: Cambridge University Press, pp. 102–118.

Brumfiel, E. M. (2005) *Production and Power at Postclassic Xaltocan*. Pittsburgh: University of Pittsburgh Press.

Buckingham, J. (1993) *Dictionary of Natural Products*. London: Taylor & Francis Ltd/CRC Press.

Buonasera, T. (2005) 'Fatty acid analysis of prehistoric burned rocks: A case study from central California', *Journal of Archaeological Science*. 32(6), 957–965. doi: 10.1016/j.jas.2005.01.012.

Buonasera, T. (2007) 'Investigating the presence of ancient absorbed organic residues in groundstone using GC-MS and other analytical techniques: a residue study of several prehistoric milling tools from central California', *Journal of Archaeological Science*. 34(9), 1379–1390. doi: 10.1016/j.jas.2006.10.028.

Burger, P. *et al*. (2016) 'Identification, Geochemical Characterisation and Significance of Bitumen among the Grave Goods of the 7th Century Mound 1 Ship-Burial at Sutton Hoo (Suffolk, UK)', *PLoS ONE*. 11(12), 1–19. doi: 10.1371/journal.pone.0166276.

Butler, J. (1993) *Bodies that Matter: On the Discursive Limits of "Sex"*. London: Routledge.

Calderbank, D. (2018) *Moulding Clay to Model Sealand Society: Pottery Production and Function at Tell Khaiber, Southern Iraq*. PhD diss., University of Manchester.

Campbell, C. (1995) 'The sociology of consumption', in Miller, D. (ed.) *Acknowledging Consumption: A Review of New Studies*. London: Routledge, pp. 96–126.

do Canto-Pereira, L. H. M. *et al*. (2007) 'Effects of acute alcohol intoxication on visuospatial attention', *Human & Experimental Toxicology*. 26(4), 311–319. doi: 10.1177/0960327106070490.

Caplan, P. (1997) *Food, health, and identity*. London: Psychology Press.

Carlin, M. (2008) '"What say you to a piece of beef and mustard?": The Evolution of Public Dining in Medieval and Tudor London', *Huntington Library Quarterly*. 71(1), 199–217. doi: 10.1525/hlq.2008.71.1.199.

Carod-Artal, F. J. (2015) 'Hallucinogenic drugs in pre-Columbian Mesoamerican cultures', *Neurología (English Edition)*. 30(1), 42–49. doi: 10.1016/J.NRLENG.2011.07.010.

Carroll, J. L., Siler, E. M. and Siler, E. M. " (2003) 'Let My Prayer Be Set Before Thee: The Burning of Incense in the Temple Cult of Ancient Israel', *Studia Antiqua*. 2(2), 17-32.

Casana, J. and Glatz, C. (2017) 'The land behind the land behind Baghdad: archaeological landscapes of the Upper Diyala (Sirwan) River Valley', *Iraq*. 79, 47–69. doi: 10.1017/irq.2017.3.

Caton, S. J., Marks, J. E. and Hetherington, M. M. (2005) 'Pleasure and alcohol: manipulating pleasantness and the acute effects of alcohol on food intake', *Physiology & Behavior*. 84(3), 371–377. doi: 10.1016/J.PHYSBEH.2004.12.013.

Cayot, N. (2007) 'Sensory quality of traditional foods', *Food Chemistry*. 102(2),

445–453. doi: 10.1016/j.foodchem.2006.10.016.

Celant, A. and Fiorentino, G. (2017) 'Macroremains of citrus fruit in Italy', in Zech-Matterne, V. and Fiorentino, G. (eds.) *AGRUMED: Archaeology and history of citrus fruit in the Mediterranean*. Naples: Publications du Centre Jean Bérard, pp. 130–138.

de Certeau, M., Giard, L. and Mayol, P. (1998) *The practice of everyday life, volume 2, Living and cooking*. Minneapolis and London: University of Minnesota Press.

Chambon, G. (2011) 'Boire du vin à Mari', *Journal Asiatique*. 299, 495–503. doi: 10.2143/JA.299.2.2141880.

Chandler, R. F. and Hooper, S. N. (1979) 'Friedelin and associated triterpenoids', *Phytochemistry*. 18(5), 711–724. doi: 10.1016/0031-9422(79)80002-3.

Charles, N. and Kerr, M. (1988) *Women, Food and Families*. Manchester: Manchester University Press.

Charles, M., Pessin, H. and Hald, M. M. (2010) 'Tolerating change at Late Chalcolithic Tell Brak: responses of an early urban society to an uncertain climate', *Environmental Archaeology*. 15(2), 183–198.

Charters, S., Evershed, R. P., Goad, L. J., Heron, C., *et al*. (1993a) 'Identification of an adhesive used to repair a roman jar', *Archaeometry*. 35, 91–101.

Charters, S., Evershed, R. P., Goad, L. J., Leyden, A., *et al*. (1993b) 'Quantification and Distribution of Lipid in Archaeological Ceramics: Implications for Sampling Potsherds for Organic Residue Analysis and the Classification of Vessel Use', *Archaeometry*. 35(2), 211–223. doi: 10.1111/j.1475-4754.1993.tb01036.x.

Charters, S. *et al*. (1995) 'Evidence for the Mixing of Fats and Waxes in Archaeological Ceramics', *Archaeometry*. 37(1), 113–127. doi: 10.1111/j.1475-4754.1995.tb00730.x.

Chesson, M. S. (ed.) (2001) *Social memory, identity, and death : Anthropological perspectives on mortuary rituals*. Archeological Papers of the American Anthropological Association 10, Arlington: American Anthropological Association.

Civil, M. (1964) 'A Hymn to the Beer Goddess and a Drinking Song', in Biggs, R. D. and Brinkman, A. *Studies Presented to A. Leo Oppenheim* (eds.). Chicago: The Oriental Institute of the University of Chicago.

Civitello, L. (2011) *Cuisine and Culture: A History of Food and People,* 3rd Edition. Hoboken: John Wiley & Sons.

Clark, K A, Ikram, S. and Evershed, R. P. (2016) 'The significance of petroleum bitumen in ancient Egyptian mummies', *Philosophical transactions. Series A, Mathematical, physical, and engineering sciences*. 374(2079), 20160229. doi: 10.1098/rsta.2016.0229.

Clark, P. (1983) *The English alehouse : a social history, 1200-1830*. London:

Longman.

Classen, C., Howes, D. and Synnott, A. (2003) *Aroma: The cultural history of smell*. London and New York: Routledge.

Clayden, T. (1998) 'Faience buckets', *Baghdader Mitteilungen*, 29, 47–79.

Clayden, T. (2014) 'Kassite housing at Ur: the dates of the EM, YC, XNCF, AH and KPS Houses', *Iraq*. 76, 19–64. doi: 10.1017/irq.2014.3.

Cohen, A. C. (2005) *Death rituals, ideology, and the development of early Mesopotamian kingship : toward a new understanding of Iraq's royal cemetery of Ur*. Leiden and Boston: Brill Academic Publishers.

Colombini, M. P. *et al*. (2005) 'Characterisation of organic residues in pottery vessels of the Roman age from Antinoe (Egypt)', *Microchemical Journal*. 79(1–2), 83–90. doi: 10.1016/j.microc.2004.05.004.

Colombini, M. P. and Modugno, F. (2009) 'Organic Materials in Art and Archaeology', in Colombini, M. P. and Modugno, F. (eds.) *Organic Mass Spectrometry in Art and Archaeology*. Chichester: Wiley, pp. 1–36.

Colombini, M. P., Modugno, F. and Ribechini, E. (2005) 'Organic mass spectrometry in archaeology: evidence for Brassicaceae seed oil in Egyptian ceramic lamps', *Journal of Mass Spectrometry*. 40(7), 890–898. doi: 10.1002/jms.865.

Colonese, A. C. *et al*. (2017) 'New criteria for the molecular identification of cereal grains associated with archaeological artefacts', *Scientific Reports*. 7(1), 6633. doi: 10.1038/s41598-017-06390-x.

Condamin, J. *et al*. (1976) 'The application of gas chromatography to the tracing of oil in ancient amphorae', *Archaeometry*. 18, 195–201.

Connan, J. (1999) 'Use and trade of bitumen in antiquity and prehistory: molecular archaeology reveals secrets of past civilizations', *Philosophical Transactions of the Royal Society B: Biological Sciences*. 354(1379), 33–50. doi: 10.1098/rstb.1999.0358.

Connolly, R. M. and Waltham, N. J. (2015) 'Spatial analysis of carbon isotopes reveals seagrass contribution to fishery food web', *Ecosphere*. 6(9), art148. doi: 10.1890/ES14-00243.1.

Cooper, M. L. *et al*. (1995) 'Drinking to regulate positive and negative emotions: a motivational model of alcohol use', *Journal of personality and social psychology*, 69(5), 990–1005.

Copeland, L. and Hardy, K. (2018) 'Archaeological Starch', *Agronomy*. 8(4), 1–12. doi: 10.3390/agronomy8010004.

Copley, M. S., Rose, P. J., Clapham, A., Edwards, D. N., *et al*. (2001a) 'Detection of palm fruit lipids in archaeological pottery from Qasr Ibrim, Egyptian Nubia', *Proceedings of the Royal Society of London B*. 268, 593–7.

Copley, M. S., Rose, P. J., Clapham, A., Edwards, D. N., *et al*. (2001b) 'Processing palm fruits in the Nile Valley: biomolecular evidence from

Qasr Ibrim', *Antiquity*. 75, 538–42.

Copley, M. S. *et al.* (2003) 'Direct chemical evidence for widespread dairying in prehistoric Britain', *Proceedings of the National Academy of Sciences of the United States of America*. 100, 1524–9.

Copley, M. S. *et al.* (2005) 'Dairying in antiquity. I. Evidence from absorbed lipid residues dating to the British Iron Age', *Journal of Archaeological Science*. 32(4), 485–503. doi: 10.1016/j.jas.2004.07.004.

Correa-Ascencio, M. and Evershed, R. P. (2014) 'High throughput screening of organic residues in archaeological potsherds using direct acidified methanol extraction', *Analytical Methods*. 6(5), 1330. doi: 10.1039/c3ay41678j.

Coulon, J. (2016) 'Fumigations et rituels magiques', *Bulletin d'études orientales*. LXIV, 179–248. doi: 10.4000/beo.4679.

Cox, W. M. *et al.* (2006) 'Motives for drinking, alcohol consumption, and alcohol-related problems among British secondary-school and university students', *Addictive Behaviors*. 31(12), 2147–2157. doi: 10.1016/J.ADDBEH.2006.02.023.

Craig, O. (2002) 'The development of dairying in Europe: potential evidence from food residues on ceramics', *Documenta Praehistorica*. 9, 97–107.

Craig, O. *et al.* (2007) 'Molecular and isotopic characterisation of the processing of aquatic products in northern European prehistoric pottery', *Archaeometry*. 49(1), 135–52.

Craig, O. *et al.* (2011) 'Ancient lipids reveal continuity in culinary practices across the transition to agriculture in Northern Europe', *Proceedings of the National Academy of Sciences*. 108(44), 17910–17915. doi: 10.1073/pnas.1107202108.

Cramp, L. J. E. *et al.* (2014) 'Immediate replacement of fishing with dairying by the earliest farmers of the northeast Atlantic archipelagos', *Proceedings of the Royal Society B: Biological Sciences*. 281(1780), 20132372–20132372. doi: 10.1098/rspb.2013.2372.

Crawford, H. (1973) 'Mesopotamia's Invisible Exports in the Third Millennium B.C.', *World Archaeology*. 5, 231–241.

Crawford, H. (2013) 'Trade in the Sumerian World', in Crawford, H. (ed.) *The Sumerian World*. London and New-York: Routledge, pp. 447–461.

Cuéllar, A. M. (2013) 'The Archaeology of Food and Social Inequality in the Andes', *Journal of Archaeological Research*. 21(2), 123–74.

Cummings, V. (2002) 'Experiencing texture and touch in the British Neolithic', *Oxford Journal of Archaeology*. 21, 249–61.

Curtin, D. (1992) 'Food/body/person', in Curtin, D. and Heldke, L. (eds.) *Cooking, Eating, Thinking: Transformative Philosophies of Food*. Bloomington, Indiana: Indiana University Press, pp. 3–22.

Curtis, J. (2008) 'Observations on selected metal objects from the Nimrud

tombs', in Curtis, J. E. *et al*. (eds.) *New Light on Nimrud. Proceedings of the Nimrud, Conference 11-13 March 2002*. London: British Museum, pp. 243–252.

Curtis, M. (2013) 'Archaeological Evidence for the Emergence of Food Production in the Horn of Africa', in Mitchell, P. and Lane, P. J. (eds.) *The Oxford Handbook of African Archaeology*. Oxford: Oxford University Press, pp. 571–584.

Curtis, R. I. (2001) *Ancient Food Technology*. Boston: Brill.

D'Anna, M. B. (2010) 'The Ceramic Containers of Period VI A. Food Control at the Time of Centralisation', in Frangipane, M. (ed.) *Economic Centralisation in Formative States. The Archaeological Reconstruction of the Economic System in 4th Millennium Arslantepe,* Studi di Preistoria Orientale 3., Rome: Rome University 'la Sapienza', pp. 167–192.

D'Anna, M. B. (2012) 'Between Inclusion and Exclusion: Feasting and Redistribution of Meals at Late Chalcolithic Arslantepe (Malatya, Turkey)', in Pollock, S. (ed.) *Between Feasts and Daily Meals. Towards an Archaeology of Commensal Spaces, Special Volume 2*. eTopoi, Journal for Ancient Studies, pp. 97–123.

D'Anna, M. B. and Guarino, P. (2010) 'Continuity and Change in the Elite Food Management during the 4th Millennium B.C. Arslantepe Periods VII and VIA: a Comparison', in Frangipane, M. (ed.) *Economic Centralisation in Formative States. The Archaeological Reconstruction of the Economic System in 4th Millennium Arslantepe*. Rome: Rome University 'la Sapienza', pp. 193–204.

D'Anna, M. B. and Guarino, P. (2012) 'Pottery Production and Use at Arslantepe between Periods VII and VIA. Evidence for Social and Economic Change', *Origini*. New Series, 34, 49–68.

Dal Corso, M. *et al*. (2018) 'Where are the cereals? Contribution of phytolith analysis to the study of subsistence economy at the Trypillia site Maidanetske (ca. 3900-3650 BCE), central Ukraine', *Journal of Arid Environments*. 157, 137–148. doi: 10.1016/J.JARIDENV.2018.06.009.

Damerow, P. (2012) 'Sumerian Beer: The Origins of Brewing Technology in Ancient Mesopotamia', *Cuneiform Digital Library Initiative*, 002. Available at: https://cdli.ucla.edu/pubs/cdlj/2012/cdlj2012_002.html.

Day, J. (2013) 'Botany meets archaeology: people and plants in the past', *Journal of Experimental Botany*. 64(18), 5805–5816. doi: 10.1093/jxb/ert068.

Day, J. (2017) 'Scents of Place and Colours of Smell: Fragranced Entertainment in Ancient Rome', in Betts, E. (ed.) *Senses of the Empire: Multisensory Approaches to Roman Culture*. London, New York: Routledge, pp. 176–192.

Debono Spiteri, C. (2012) *Pottery use at the transition to agriculture in the western Mediterranean: evidence from biomolecular and isotopic characterisation of organic residues in Impressed/Cardial Ware vessels*. PhD diss., University of York.

Debono Spiteri, C. *et al*. (2016) 'Regional asynchronicity in dairy production and processing in early farming communities of the northern Mediterranean.', *Proceedings of the National Academy of Sciences of the United States of America*. 113(48), 13594–13599. doi: 10.1073/pnas.1607810113.

Delougaz, P. (1952) *Pottery from the Diyala Region, vol. LXIII*. Chicago: The University of Chicago Press.

DeSoucey, M. (2016) *Contested tastes : foie gras and the politics of food*. Princeton: Princeton University Press.

Dickson, D. B. (2006) 'Public Transcripts Expressed in Theatres of Cruelty: the Royal Graves at Ur in Mesopotamia', *Cambridge Archaeological Journal*. 16(2), 123–144. doi: 10.1017/S0959774306000084.

Dietler, M. (1990) 'Driven by drink: The role of drinking in the political economy and the case of Early Iron Age France', *Journal of Anthropological Archaeology*. 9(4), 352-406. doi: 10.1016/0278-4165(90)90011-2.

Dietler, M. (2001) 'Theorizing the feast. Rituals of consumtion, commensal politics, and power in african contexts', in Dietler, M. and Hayden, B. (eds.) *Feasts. Archaeological and ethnographic perspectives on food, politics and power*. Washington: Smithsonian Institution Press, pp. 65–114.

Dietler, M. (2006) 'Alcohol: Anthropological/Archaeological Perspectives', *Annual Review of Anthropology*. 35(1), 229–249. doi: 10.1146/annurev.anthro.35.081705.123120.

Dietler, M. (2007) 'Culinary encounters: food, identity', in Twiss, K. (ed.) *The Archaeology of Food and Identity*. Carbondale: Center for Archaeological Investigations Press, pp. 218–242.

Dietler, M. and Herbich, I. (2006) 'Liquid material culture: following the flow of beer among the Luo of Kenya', in Wotzka, H.-P. (ed.) *Grundlegungen. Beiträge zur europäischen und afrikanischen Archäologie für Manfred K.H. Eggert*. Tübingen: Francke Verlag, pp. 395–408.

Dietrich, O. *et al*. (2012) 'The role of cult and feasting in the emergence of Neolithic communities. New evidence from Göbekli Tepe, south-eastern Turkey', *Antiquity*. 86(333), 674–695. doi: 10.1017/S0003598X00047840.

Dimitrakoudi, E. A. *et al*. (2011) 'Characterization by Gas Chromatography—Mass Spectrometry of Diterpenoid Resinous Materials in Roman-Age Amphorae from Northern Greece', *European Journal of Mass Spectrometry*. 17(6), 581–591. doi: 10.1255/ejms.1155.

Dixon, K. J. (2006) 'Saloons in the Wild West and Taverns in Ancient Mesopotamia: Explorations Along the Timeline of Public Drinking', in Archer, S. and Bartoy, K. (eds.) *Between Dirt and Discussion: Methods and Methodology in Historical Archaeology*. New York: Springer Academic Press, pp. 61–79.

Dornemann, R. H. (1977) 'Tell Hadidi: A Millennium of Bronze Age City Occupation', *Annual of the American Schools of Oriental Research*. 44, 113–150.

Dornemann, R. H. (1981) 'The Late Bronze Age Pottery Tradition at Tell Hadidi, Syria', *Bulletin of the American Schools of Oriental Research*. 241, 29–47.

Dossin, G. (1938) 'Les Archives épistolaires du Palais de Mari', *Syria: Archéologie, Art et histoire*, T. 19(Fasc 2), 105–126.

Douglas, M. (1975) 'Deciphering a Meal', in Douglas, M. (ed.) *Implicit Meanings: Essays in Anthropology*. London: Routledge & Kegan Paul, pp. 249–275.

Douglas, M. (1978) *Cultural bias*. London: Royal Anthropological Institute.

Douglas, M. (1984) *Food in the Social Order: Studies of Food and Festivities in Three American Communities*. New York: Russell Sage Foundation.

Douglas, M. (1997) 'Deciphering a meal', in Counihan, C. and Van Esterik, P. (eds.) *Food and Culture: A Reader*. New York: Routledge, pp. 36–54.

Douglas, M. and Isherwood, B. (1979) *The World of Goods*. New York: Basic Books.

Dubreuil, L. and Nadel, D. (2015) 'The development of plant food processing in the Levant: insights from use-wear analysis of Early Epipalaeolithic ground stone tools', *Philosophical Transactions of the Royal Society B: Biological Sciences*. 370(1682), 20140357. doi: 10.1098/rstb.2014.0357.

Dudd, S. N. and Evershed, R. P. (1998) 'Direct demonstration of milk as an element of archaeological economies', *Science*. 282, 1478–81.

Dugo, G. and Mondello, L. (2011) *Citrus oils : composition, advanced analytical techniques, contaminants, and biological activity*. Boca Raton: CRC Press.

Dunbabin, K. (1996) 'Convivial spaces: dining and entertainment in the Roman villa', *Journal of Roman Archaeology*. 9, 66–80.

Dunbabin, K. (1998) 'Ut graeco more bibitur: Greeks and Romans on the dining couch', in Nielsen, I. and Nielsen, H. (eds) *Meals in a Social Context: Aspects of the Communal Meal in the Hellenistic and Roman World*. Oxford: Oxford University Press, pp. 81–101.

Dunne, J. *et al.* (2012) 'First dairying in green Saharan Africa in the fifth millennium BC', *Nature*. 486, 390–394. doi: 10.1038/nature11186.

Dunne, J. *et al.* (2016) 'Earliest direct evidence of plant processing in prehistoric Saharan pottery', *Nature Plants*. 3(16194). doi: 10.1038/nplants.2016.194.

Duruz, J. (2007) 'Rich Pickings: Cultures and Histories of Taste', *The Senses and Society*. 2(3), 377–383. doi: 10.2752/174589307X233611.

Eerkens, J. (2007) 'Organic Residue Analysis and the Decomposition of Fatty Acids in Ancient Potsherds', in Barnard, H. and Eerkens, J. (eds.) *Theory and Practice in Archaeological Residue Analysis*. BAR International Series 1650, Oxford: Archaeopress, pp. 90–98.

Eiler, W. J. A. *et al.* (2015) 'The apéritif effect: Alcohol's effects on the brain's response to food aromas in women', *Obesity*. 23(7), 1386–1393. doi: 10.1002/oby.21109.

Elias, N. (1978) *The Civilizing Process: The History of Manners*. New York: Urizen Books.

Ellison, E. R. (1978) *A study of diet in Mesopotamia (c.3000-600 BC) and associated agricultural techniques and methods of food preparation*. PhD diss., University of London.

Ellison, E. R. (1981) 'Diet in Mesopotamia: The Evidence of the Barley Ration Texts (c. 3000-1400 B.C.)', *Iraq*. 43(1), 35–45.

Ellison, E. R. (1984) 'Methods of Food Preparation in Mesopotamia (c. 3000-600 BC)', *Journal of the Economic and Social History of the Orient*. 27(1), 89–98. doi: http://doi:10.2307/3631938.

Emberling, G. (2005) *The Archaeology of Ethnicity: Constructing Identities in the Past and Present*, *American Anthropologist*. doi: 10.1525/aa.1998.100.2.576.2.

Endevelt-Shapira, Y. *et al*. (2014) 'Disinhibition of olfaction: Human olfactory performance improves following low levels of alcohol', *Behavioural Brain Research*, 272, 66–74. doi: 10.1016/j.bbr.2014.06.024.

Engelen, B. (2017) 'A new definition of and role for preferences in positive economics', *Journal of Economic Methodology*. 24(3), 254–273. doi: 10.1080/1350178X.2017.1286026.

Ermidoro, S. (2015) *Commensality and Ceremonial Meals in the Neo-Assyrian Period,* Antichistica 8, Studi orientali 3. Venezia: Edizioni Ca' Foscari.

van Ess, M. (2014) 'Characteristics of Middle Babylonian Pottery Production as Mirrored on Old Babylonian Pottery - Continuity or Change?', in Luciani, M. and Hausleiter, A. (eds.) *Recent Trends in the Study of Late Bronze Age Ceramics in Syro-Mesopotamia and Neighbouring Regions: Proceedings of the International Workshop in Berlin, 2-5 November 2006*. Rahden: Leidorf, pp. 333–383.

Esteban, I. *et al*. (2018) 'Phytoliths as an indicator of early modern humans plant gathering strategies, fire fuel and site occupation intensity during the Middle Stone Age at Pinnacle Point 5-6 (south coast, South Africa)', *PLOS ONE*. e0198558. doi: 10.1371/journal.pone.0198558.

Evans, J. M. (2008) 'Kassite Babylonia', in Aruz, J., Benzel, K., and Evans, J. M. (eds) *Beyond Babylon: Art, Trade, and Diplomacy in the Second Millennium B.C*. New York: Metropolitan Museum of Art, pp. 200–205.

Evershed, R. P. (1993) 'Biomolecular Archaeology and Lipids', *World Archaeology*. 25(1), 74–93. doi: 10.2307/124755.

Evershed, R. P. *et al*. (1991) 'The Survival of Food Residues: New Methods of Analysis, Interpretation and Application', *Proceedings of the British Academy,* 77, 187-208.

Evershed, R. P. *et al*. (1995) 'Formation of long-chain ketones in ancient pottery vessels by pyrolysis of acyl lipids', *Tetrahedron Letters*. 36(48), 8875–8878.

Evershed, R. P. *et al*. (1997) 'New criteria for the identification of animal fats

preserved in archaeological pottery', *Naturwissenschaften*. 84, 402–406.

Evershed, R. P., *et al*. (2002) 'Chemistry of archaeological animal fats', *Accounts of Chemical Research*. 35(8), 660–668. doi: 10.1021/ar000200f.

Evershed, R. P. *et al*. (2003) 'New chemical evidence for the use of combed ware pottery vessels as beehives in ancient Greece', *Journal of Archaeological Science*, 30(1), pp. 1–12. doi: 10.1006/jasc.2001.0827.

Evershed, R. P. *et al*. (2004) 'Archaeology: formulation of a Roman cosmetic', *Nature*, 432(7013), pp. 35–6.

Evershed, R. P. *et al*. (2008) 'Earliest date for milk use in the Near East and southeastern Europe linked to cattle herding', *Nature*. 455(7212), 528–531. doi: 10.1038/nature07180.

Evershed, R. P. (2008) 'Organic residue analysis in archaeology: The archaeological biomarker revolution', *Archaeometry*. 50(6), 895–924. doi: 10.1111/j.1475-4754.2008.00446.x.

Evershed, R. P., Heron, C. and Goad, L. J. (1991) 'Epicuticular wax components preserved in potsherds as chemical indicators of leafy vegetables in ancient diets', *Antiquity*. 65, 540–4.

Ewart, E. (2008) 'Seeing, Hearing and Speaking: Morality and Sense among the Panará in Central Brazil', *Ethnos*. 73(4), 505–522. doi: 10.1080/00141840802563949.

Farrar, L. (2016) 'Gardens and gardeners of the ancient world : history, myth and archaeology' Oxford : Windgather Press.

Feigl, F. (1956) *Spot tests in organic analysis*. Amsterdam: Elsevier Publishing Co.

Fernandez, J. (1986) *Persuasions and Performances: The Play of Tropes in Culture*. Princeton: Princeton University Press.

Fieldhouse, P. (1995) 'Social functions of food', in Fieldhouse, P. (ed.) *Food and Nutrition: Customs and culture*. Boston: Springer US, pp. 78–105.

Fielding-Singh, P. (2017) 'A taste of inequality: Food's symbolic value across the socioeconomic spectrum', *Sociological Science*. 4, 424–448. doi: 10.15195/v4.a17.

Fischler, C. (1988) 'Food, self and identity', *Social Science Information*. 27(2), 275–292. doi: 10.1177/053901888027002005.

Fischler, C. (1990) *L'Homivore*. Paris: Odile Jacob.

Fitzpatrick, S. M. and Merlin, M. D. (2018) 'Introduction: Drugs from a deep time perspective', in Fitzpatrick, S. M. (ed.) *Ancient Psychoactive Substances*. Gainesville: University Press of Florida, pp. 1–19.

Flammer, P. G. *et al*. (2018) 'Molecular archaeoparasitology identifies cultural changes in the Medieval Hanseatic trading centre of Lübeck', *Proceedings of the Royal Society B: Biological Sciences*. 285. doi: 10.1098/rspb.2018.0991.

Forbes, R. J. (1936) *Bitumen and Petroleum in Antiquity*. Leiden: E. J. Brill.

Forbes, R. J. (1958) *Studies in Early Petroleum History*. Leiden: E. J. Brill.

Forshaw, R. (2015) 'Unlocking the past: The role of dental analysis in archaeology.', *Dental historian : Lindsay Club newsletter*. 60(2), 51–62.

Frangipane, M. (2010) 'The Political Economy of the Early Central Institutions at Arslantepe. Concluding Remarks', in Frangipane, M. (ed.) *Economic Centralisation in Formative States. The Archaeological Reconstruction of the Economic System in 4th Millennium Arslantepe*. Rome: Sapienza Università di Roma, pp. 289–307.

Frankfort, H. (1939) *Sculpture of the Third Millennium B.C. from Tell Asmar and Khafajah*. OIP 44, Chicago: University of Chicago Press.

Frankfort, H. (1955) *Stratified Cylinder Seals from the Diyala Region*. OIP 72, Chicago: University of Chicago Press.

Freedman, P. (2008) *Out of the East: Spices and the Medieval Imagination*. New Haven: Yale University Press.

Fuller, D. *et al*. (2015) 'The archaeobiology of Indian Ocean translocations: current outlines of cultural exchanges by proto-historic seafarers', in Tripati, S. (ed.) *Maritime Contacts of the Past: Deciphering connections amongst communities*. New Delhi: Delta Book World, pp. 1-23.

Fuller, D. (2003) 'Further evidence on the prehistory of sesame', *Asian Agri-History*. 7(2), 127–137.

de Garine, I. (1972) 'The socio-cultural aspects of nutrition', *Ecology of Food and Nutrition*. 1(2), 143–163. doi: 10.1080/03670244.1972.9990282.

de Garine, I. (2011) 'Beer, ritual and conviviality in northern Cameroon', in Schiefenhövel, W. and Macbeth, H. (eds.) *Liquid bread : beer and brewing in cross-culturel perspective*. Anthropology of Food and Nutrition, 7, New York: Berghahn Books, pp. 133–158.

Garnier, N. and Valamoti, S. M. (2016) 'Prehistoric wine-making at Dikili Tash (Northern Greece): Integrating residue analysis and archaeobotany', *Journal of Archaeological Science*. 74, 195–206. doi: 10.1016/J.JAS.2016.03.003.

Gates, M.-H. (1988) 'Dialogues between Ancient near Eastern Texts and the Archaeological Record: Test Cases from Bronze Age Syria', *Bulletin of the American Schools of Oriental Research*. 270, 63–91.

Gautschi, M. *et al*. (1997) 'Chemical Characterization of Diketopiperazines in Beer', *Journal of Agricultural and Food Chemistry*. 45, 3183–3189.

Gell, A. (1977) 'Magic, Perfume, Dream...', in Lewis, I. M. (ed.) *Symbols and Sentiments: Cross Cultural Studies in Symbolism*. London: Academic Press, pp. 25–38.

Geller, J. (1993) 'Bread and beer in fourth-millennium Egypt', *Food and Foodways*. 5 (3), 255–267.

George, A. R. (2003) *The Babylonian Gilgamesh Epic: Introduction, Critical Edition and Cuneiform Texts*. Oxford: Oxford University Press.

Ghassan, Y. T. (1995) *Old Babylonian Pottery from the Hamrin, Tell Halawa*. EDUBBA 4, London: NABU.

Ghisalberti, E. L. and Godfrey, I. M. (1998) 'Application of nuclear magnetic resonance spectroscopy to the analysis of organic archaeological materials', *Studies in Conservation*. 43(4), 215–230. doi: 10.1179/sic.1998.43.4.215.

Gibson, M. (1987-8) *Nippur, Annual Report of the Oriental Institute*. Chicago: University of Chicago Press.

Gilboa, A. and Namdar, D. (2015) 'On the Beginnings of South Asian Spice Trade with the Mediterranean Region: A Review', *Radiocarbon*. 57(2), 265–283. doi: 10.2458/azu_rc.57.18562.

Glatz, C. (2015a) 'Introduction: plain and simple? Another look at plain pottery traditions in early complex societies', in Glatz, C. (ed.) *Plain Pottery Traditions of the Eastern Mediterranean and Near East: Production, Use, and Social Significance*. Walnut Creek: Left Coast Press, pp. 13–37.

Glatz, C. (2015b) 'Plain pots, festivals and feasting in Late Bronze Age Anatolia', in Glatz, C. (ed.) *Plain Pottery Traditions of the Eastern Mediterranean and Near East Production, Use, and Social Significance*. Walnut Creek, CA: Left Coast Press, pp. 183–214.

Glatz, C. *et al*. (2019) 'Babylonian Encounters in the Upper Diyala River Valley: Contextualizing the Results of Regional Survey and the 2016–2017 Excavations at Khani Masi', *American Journal of Archaeology*. 123(3), 439–471. doi: 10.3764/aja.123.3.0439.

Glatz, C. and Casana, J. (2016) 'Of highland-lowland borderlands: Local societies and foreign power in the Zagros-Mesopotamian interface', *Journal of Anthropological Archaeology*. 44, 127–147. doi: 10.1016/J.JAA.2016.09.001.

González Carretero, L., Wollstonecroft, M. and Fuller, D. Q. (2017) 'A methodological approach to the study of archaeological cereal meals: a case study at Çatalhöyük East (Turkey)', *Vegetation history and archaeobotany*. 26(4), 415–432. doi: 10.1007/s00334-017-0602-6.

Goody, J. (1982) *Cooking, cuisine, and class : a study in comparative sociology*. Cambridge: Cambridge University Press.

Goody, J. and Goody, E. (1995) 'Food and Identities: Changing patterns of consumption in Ghana', *The Cambridge Journal of Anthropology*, 18(3), 1–14. doi: 10.2307/23818753.

Gordon, E. I. (1959) *Sumerian Proverbs: Glimpses of Everyday. Life in Ancient Mesopotamia*. Philadelphia: University of Pennsylvania.

Goulder, J. (2010) 'Administrators' bread: An experiment-based re-assessment of the functional and cultural role of the Uruk bevel-rim bowl', *Antiquity*. 84(324), 351–362. doi: 10.1017/S0003598X0006662X.

Grayson, A. K. (1991) *Assyrian Rulers of the Early First Millennium BC. 1: 1114-859 BC (RIMA 2)*. Toronto: University of Toronto Press.

Greenfield, T. L. (2015) 'The palace versus the home: social status and zooarchaeology at Tushan (Ziyaret Tepe), a Neo-Assyrian administrative provincial capital in southeastern Turkey', *Journal of Eastern Mediterranean Archaeology and Heritage Studies*. 3(1), 1–26.

Gregg, M. W. (2009) 'Organic Residue Analysis and the Earliest Uses of Pottery in the Ancient Middle East', *Europe*, p. 247. doi: 10.1017/CBO9781107415324.004.

Gregg, M. W. and Slater, G. F. (2010) 'A new method for extraction, isolation and transesterification of free fatty acids from archaeological pottery', *Archaeometry*. 52(5), 833–854. doi: 10.1111/j.1475-4754.2010.00518.x.

Guasch-Jané, M. R. *et al*. (2006) 'First evidence of white wine in ancient Egypt from Tutankhamun's tomb', *Journal of Archaeological Science*. 33(8), 1075–1080. doi: 10.1016/j.jas.2005.11.012.

Guay, F., Vallerand, R. J. and Blanchard, C. (2000) 'On the Assessment of Situational Intrinsic and Extrinsic Motivation: The Situational Motivation Scale (SIMS)', *Motivation and Emotion*. 24(3), 175–213.

Le Guérer, A. (1998) *Les pouvoirs de l'Odeur,* 2ème edition. Paris: Editions Odile Jacob.

Guerra-Doce, E. (2006) 'Exploring the significance of beaker pottery through residue analysis', *Oxford Journal of Archaeology*. 25(3), 247–259. doi: 10.1111/j.1468-0092.2006.00260.x.

Guerra-Doce, E. (2015) 'The Origins of Inebriation: Archaeological Evidence of the Consumption of Fermented Beverages and Drugs in Prehistoric Eurasia', *Journal of Archaeological Method and Theory*. 22(3), 751–782. doi: 10.1007/s10816-014-9205-z.

Gumerman, G. (1997) 'Food and complex societies', *Journal of Archaeological Method and Theory*. 4(2), 105–139. doi: 10.1007/BF02428056.

Gunkel, A. H. (2016) 'Food and Culture', in Burns, G. A. (ed.) *Companion to Popular Culture*. Malden: John Wiley and Sons Ltd., pp. 245–264.

Gunstone, F. D., Harwood, J. L. and Padley, F. B. (1994) *The Lipid Handbook: Second Edition*. London: Chapman and Hall.

Guzman, J. D. (2014) 'Natural cinnamic acids, synthetic derivatives and hybrids with antimicrobial activity', *Molecules*. 19(12), 19292–19349.

Hald, M.-M. and Charles, M. (2008) 'Storage of crops during the fourth and third millennia B.C. at the settlement mound of Tell Brak, northeast Syria', *Vegetation History and Archaeobotany*. 17, 35–41.

Hald, M. M. (2010) 'Distribution of crops at late Early Bronze Age Titriş Höyük, southeast Anatolia: towards a model for the identification of consumers of centrally organised food distribution', *Vegetation History and Archaeobotany*. 19(1), 69–77. doi: 10.1007/s00334-009-0223-9.

Hames, G. (2012) *Alcohol in World History*. London and New York: Routledge.

Hamilakis, Y. (1996) 'Wine, oil and the dialectics of power in Bronze Age Crete: A review of the evidence', *Oxford Journal of Archaeology*. 15(1), 1–32. doi: 10.1111/j.1468-0092.1996.tb00071.x.

Hamilakis, Y. (1998) 'Eating the dead: mortuary feasting and the politics of memory in the Aegean bronze age societies', in Branigan, K. (ed.) *Cemetery and society in the Aegean bronze age*. Sheffield: Sheffield Academic Press, pp. 115–132.

Hamilakis, Y. (1999) 'Food technologies / technologies of the body : The social context of wine and oil production and consumption in Bronze Age Crete', *World Archaeology*. 31(1), 38–54. doi: 10.1080/00438243.1999.9980431.

Hamilakis, Y. (2002) 'The past as oral history: towards an archaeology of the senses', in Hamilakis, Y., Pluciennik, M., and Tarlow, S. (eds.) *Thinking Through the Body: Archaeologies of Corporeality*. London: Kluwer Academic Press, pp. 121–36.

Hamilakis, Y. (2008) 'Time, performance and the production of a mnemonic record: from feasting to an archaeology of eating and drinking', in Hitchcock, L., Laffineur, R., and Crowley, J. (eds.) *Dais: The Aegean Feast, Aegaeum 29*. Liège and Austin: Université de Liège and University of Texas at Austin, pp. 3–17.

Hamilakis, Y. (2011) 'Archaeologies of the Senses', in Timothy, I. (ed.) *The Oxford Handbook of the Archaeology of Ritual and Religion*. New York: Oxford University Press, pp. 208–225.

Hamilakis, Y. (2014) *Archaeology and the Senses: Human Experience, Memory, and Affect*. New York: Cambridge University Press.

Hamilakis, Y. and Harris, K. (2011) 'The social zooarchaeology of feasting: the evidence from the "ritual" deposit at Nopigeia-Drapanias', in Kapsomenos, E. AndreadakiVlazaki, M. and Andrianakis, M. (eds.), *Proceedings of the 10th International Cretological Congress* A, Hania: Literary Society of Hania 'Chrysostomos', pp. 225-244.

Hamilakis, Y. and Sherratt, S. (2012) 'Feasting and the consuming body in Bronze Age Crete and Early Iron Age Cyprus', in Cadogan, G. *et al*. (eds.) *Parallel Lives: Ancient Island Societies in Crete and Cyprus*. London: British School at Athens, pp. 187–207.

Hamilton, S. *et al*. (2006) 'Phenomenology in practice: towards a methodology for a "subjective" approach', *European Journal of Archaeology*. 9(1), 31–71. doi: 10.1177/1461957107077704.

Hansen, D. P. (1980-83) 'Lagaš B Archäologisch', in *RIA VI*. Berlin, pp. 422–430.

Hanuš, L. O. and Ben-Yehoshua, S. (2013) 'Analysis of resinous material present on an alabaster lid excavated from Nabataean Moa in the Arava valley', *Arabian Archaeology and Epigraphy*. 24(2), 232–236. doi: 10.1111/aae.12028.

Harris, K. and Hamilakis, Y. (2008) 'A social zooarchaeology of feasting: the

evidence from the ritual deposit at Nopigeia, Crete', in Baker, S. *et al*. (eds.) *Food and drink in archaeology I: University of Nottingham Postgraduate Conference 2007*. Devon: Prospect Books, pp. 162–164.

Harris, M. (1985) *Good to eat: riddles of food and culture*. New York: Simon and Schuster.

Hartman, L. F. and Oppenheim, A. L. (1950) *On beer and brewing techniques in Ancient Mesopotamia: according to the XXIIIrd tablet of the Series HAR.ra = hubullu*. Supplement to the Journal of the American Oriental Society 10 Baltimore.

Hastorf, C. (1991) 'Gender, space and food in prehistory', in Gero, J. and Conkey, M. (eds) *Engendering Archaeology: Woman and Prehistory*. Oxford: Basil Blackwell, pp. 132–159.

Hastorf, C. A. (2016a) 'Food in the Construction of Group Identity', in Hastorf, C. A. (ed.) *The Social Archaeology of Food: Thinking about Eating from Prehistory to the Present*. Cambridge: Cambridge University Press, pp. 223–272.

Hastorf, C. A. (2016b) 'Food studies in Archaeology', in Hastorf, C. A. (ed.) *The Social Archaeology of Food*: *: Thinking about Eating from Prehistory to the Present*. Cambridge: Cambridge University Press, pp. 81–141.

Hastorf, C. A. (2016c) 'Introduction: The Social Life of Food', in Hastorf, C. A. (ed.) *The Social Archaeology of Food: Thinking about Eating from Prehistory to the Present*. Cambridge: Cambridge University Press, pp. 1–16.

Hastorf, C. A. (2016d) 'The Practices of a Meal in Society', in Hastorf, C. A. (ed.) *The Social Archaeology of Food: Thinking about Eating from Prehistory to the Present*. Cambridge: Cambridge University Press, pp. 55–80.

Hauck-Lawson, A. (2004) 'Introduction to Special Issue on the Food Voice', *Food, Culture and Society*. 7(1): 24–25. doi: 10.2752/155280104786578139.

Hawkes, G. (2001) 'An Archaeology of Food: A Case Study From Roman Britain', *Annual Theoretical Roman Archaeology Journal*, Conference London 2000, Oxford: Oxbow Books, pp. 94-103. doi: 10.16995/TRAC2000_94_103.

Hayashida, F. M. (2008) 'Ancient beer and modern brewers: Ethnoarchaeological observations of chicha production in two regions of the North Coast of Peru', *Journal of Anthropological Archaeology*. 27(2), 161–174. doi: https://doi.org/10.1016/J.JAA.2008.03.003.

Hayashida, F. M. (2015) 'Beer', in Bescherer Metheny, K. and Beaudry, M. C. (eds.) *Archaeology of Food*. London: Rowman and Littlefield, p. 47.

Hayden, B. (2001) 'Fabulous Feasts: A Prolegomenon to the Importance of Feasting', in Dietler, M. and Hayden, B. (eds.) *Feasts: Archaeological and Ethnographic Pespectives on Food, Politics, and Power*. Tuscaloosa, Alabama: University of Alabama Press, pp. 23–64.

Hayden, B. (2014) 'Before the Feast', in Hayden, B. (ed.) *The Power of Feasts*. New York: Cambridge University Press, pp. 1–24. doi:

10.1017/CBO9781107337688.

Hayden, B. and Villeneuve, S. (2011) 'A century of feasting studies', *Annual Review of Anthropology*. 40, 433–449.

Heffron, Y. (2014) 'The Material Culture of Hittite "God-drinking"', *Journal of Ancient Near Eastern Religions*. 14(2), 164–185. doi: 10.1163/15692124-12341261.

Helms M. W. (2013) *Craft and the Kingly Ideal: Art, Trade, and Power*. Austin: University of Texas Press.

Helwing, B. (2003) 'Feasts as a social dynamic in Prehistoric Western Asia - three case studies from Syria and Anatolia', *Paléorient*. 29, 63–85.

Hemingway, J. D. *et al.* (2016) 'Multiple plant-wax compounds record differential sources and ecosystem structure in large river catchments', *Geochimica et Cosmochimica Acta*. 184, 20–40. doi: 10.1016/j.gca.2016.04.003.

Hendy, J. *et al.* (2018) 'Ancient proteins from ceramic vessels at Çatalhöyük West reveal the hidden cuisine of early farmers', *Nature Communications*. 9(1), 4064. doi: 10.1038/s41467-018-06335-6.

Hernanz, D. *et al.* (2001) 'Hydrocinnamic acids and ferulic acid dehydrodimers in barley and processed barley', *Journal of Agricultural and Food Chemistry*. 49, 4884–4888.

Heron, C. and Evershed, R. P. (1993) 'The Analysis of Organic Residues and the Study of Pottery Use The Analysis of Organic Residues and the Study of Pottery Use', *Archaeological Method and Theory*. 5(1993), 247–284.

Heron, C., Evershed, R. P. and Goad, L. J. (1991) 'Effects of migration of soil lipids on organic residues associated with buried potsherds', *Journal of Archaeological Science*. 18, 641–659.

Hillman, G. C. (1984) 'Interpretation of archaeological plant remains: the application of ethnographic models from Turkey', in van Zeist, W. and Casparie, W. A. (eds.) *Plants and Ancient Man: Studies in Palaeoethnobotany*. Rotterdam: Balkema, pp. 1–41.

Hodder, I. and Cessford, C. (2004) 'Daily Practice and Social Memory at Çatalhöyük', *American Antiquity*. 69(1), 17–40. doi: 10.2307/4128346.

Hodges, H. (1992) *Technology in the ancient world*. New-York: Barnes & Noble Publishing.

Højlund, S. (2015) 'Taste as a social sense: rethinking taste as a cultural activity', *Flavour*. 4, 6. doi: 10.1186/2044-7248-4-6.

Hollows, J. *et al.* (2014) 'Making sense of urban food festivals: Cultural regeneration, disorder and hospitable cities', *Journal of Policy Research in Tourism, Leisure and Events*. 6(1), 1–14. doi: 10.1080/19407963.2013.774406.

Holtzman, J. D. (2006) 'Food and Memory', *Annual Review of Anthropology*. 35, 361–78. doi: 10.1146/annurev.anthro.35.081705.123220.

Hopwood, M. (2013) 'Sustenance, taste, and the practice of community in ancient Mesopotamia', in Day, J. (ed.) *Making senses of the past : toward a sensory archaeology*. Carbondale: Southern Illinois University Press, pp. 222–242.

Hornsey, I. S. (2003) *A history of beer and brewing*. Cambridge: Royal Society of Chemistry RSC Paperbacks.

Horsley, R. A. (2006) *Oral performance, popular tradition, and hidden transcript in Q*. Atlanta: Society of Biblical Literature.

Howes, D. (2006) 'Scent, Sound and Synesthesia: Intersensoriality and Material Culture Theory', in Tilley, C. et al. (eds.) *Handbook of Material Culture*. London: Sage, pp. 161–172.

Hsu, E. (2008) 'The Senses and the Social: An Introduction', *Ethnos*. 73(4), 433–443. doi: 10.1080/00141840802563907.

Hu, Q. *et al*. (2017) 'Rapeseed research and production in China', *The Crop Journal*. 5(2), 127–135. doi: 10.1016/J.CJ.2016.06.005.

Hubert, A. *et al*. (2000) 'High Extraction Efficiency for POPs in Real Contaminated Soil Samples Using Accelerated Solvent Extraction', *Analytical Chemistry*. 72(6), 1294–1300. doi: 10.1021/AC991005L.

Hughen, K. A., Eglinton, T. I. and Xu, L. (2004) 'Abrupt tropical vegetation response to rapid climate changes', *Science*. 304(5679), 1955–9.

Hunt, C. O. *et al*. (2001) 'Romano-Libyan Dryland Animal Husbandry and Landscape: Pollen and Palynofacies Analyses of Coprolites from a Farm in the Wadi el-Amud, Tripolitania', *Journal of Archaeological Science*. 28(4), 351–363. doi: 10.1006/JASC.2000.0572.

Hurcombe, L. (2007) 'A sense of materials and sensory perception in concepts of materiality', *World Archaeology*. 39(4), 532–545. doi: 10.1080/00438240701679346.

Ickes, C. M. and Cadwallader, K. R. (2017) 'Effects of Ethanol on Flavor Perception in Alcoholic Beverages', *Chemosensory Perception*. 10(4), 119–134. doi: 10.1007/s12078-017-9238-2.

Iguchi, K. *et al*. (2001) 'Myristoleic Acid, a Cytoxic Component in the Extract from Serenoa repens, induces Apoptosis and Necrosis in Human Prostatic LNCaP Cells', *The Prostate*. 47, 59–65.

Jaffe, Y., Wei, Q. and Zhao, Y. (2018) 'Foodways and the Archaeology of Colonial Contact: Rethinking the Western Zhou Expansion in Shandong', *American Anthropologist*. 120(1), 55–71. doi: 10.1111/aman.12971.

Jambrina-Enríquez, M., Herrera-Herrera, A. V. and Mallol, C. (2018) 'Wax lipids in fresh and charred anatomical parts of the Celtis australis tree: Insights on paleofire interpretation', *Organic Geochemistry*. 122, 147–160. doi: 10.1016/J.ORGGEOCHEM.2018.05.017.

Jansen, B. *et al*. (2006) 'The applicability of accelerated solvent extraction (ASE) to extract lipid biomarkers from soils', *Applied Geochemistry*. 21(6), 1006–1015. doi: 10.1016/J.APGEOCHEM.2006.02.021.

Janson, M. (2014) *Islam, Youth, andModernity in the Gambia: The Tablighi Jama'at*. London: International African Institute.

Jennings, J. *et al*. (2005) '"Drinking Beer in a Blissful Mood": Alcohol Production, Operational Chains, and Feasting in the Ancient World', *Current Anthropology*. 46(2), 275–303.

Jennings, J. and Valdez, L. (2018) 'Ingredients Matter: Maize vs. Molle Brewing in Ancient Andean Feasting', in Fitzpatrick, S. M. (ed.) *Ancient Psychoactive Substances*. Tallahasse: University Press of Florida, pp. 286–318.

Jerković, I. *et al*. (2011) 'Chemical Profile of the Organic Residue from Ancient Amphora Found in the Adriatic Sea Determined by Direct GC and GC-MS Analysis', *Molecules*. 16, 7936–7948. doi: 10.3390/molecules16097936.

Joffe, A. H. (1998) 'Alcohol and Social Complexity in Ancient Western Asia', *Current Anthropology*. 39(3), 297–322. doi: 10.1086/204736.

Johnson, M. C. (2016) '"Nothing is sweet in my mouth": Food, identity, and religion in African Lisbon', *Food and Foodways*. 24(3–4), 232–254. doi: 10.1080/07409710.2016.1210901.

Jones, A. M. (2001) 'Enduring images? Image production and memory in earlier Bronze Age Scotland', in Bruck, J. (ed.) *Bronze Age landscapes: tradition and transformation*. Oxford: Oxbow Books, pp. 217–228.

Jones, A. M. (2016) 'The results for the project', in Jones, A. M. (ed.) *Preserved in the Peat: an extraordinary Bronze Age burial on Whitehose Hill, Dartmoor, and its wider context*. Oxford and Philadelphia: Oxbow Books, pp. 196–256.

Jones, S. (2015) 'Eating identity: an exploration of Fijian foodways in the archaeological past', *Journal of Indo-pacific archaeology*. 37, 64–71.

Kahn, L. C. (2012) 'Beer and Brewing', in Silberman, N. A. (ed.) *The Oxford Companion to Archaeology,* Volume 1. Oxford: Oxford University Press, pp. 196–198.

Kaiser, P., Medicus, G. and Bruene M. (2011) 'Healthy or detrimental? Physiological, Psychiatric and Evolutionary Aspects of Drinking Beer' in Schiefenhövel, W. and Macbeth, H. (eds.) *Liquid Bread: Beer and Brewing in Cross-cultural Perspective*. New York and Oxford: Berghahn Publlcation, pp. 21-34.

Källmén, H. and Gustafson, R. (1998) 'Alcohol and Disinhibition', *European Addiction Research*. 4(4), 150–162. doi: 10.1159/000018948.

Kant, I. (2005) 'Objective and Subjective Senses: The Sense of Taste', in Korsmeyer, C. (ed.) *The Taste Culture Reader: Experiencing Food and Drink*. New York: Berg, pp. 209–214.

Karim, A. R., Khanaqa, P. and Shukur, D. A. (2017) 'Kurdistan crude oils as feedstock for production of aromatics', *Arabian Journal of Chemistry*. 10, S2601–S2607. doi: 10.1016/j.arabjc.2013.09.038.

Karp, Ivan (1980) 'Beer Drinking and Social Experience in an African Society: An

Essay in Formal Sociology', in Karp, I. and Bird, C. (eds.) *Explorations in African Systems of Thought*. Bloomington: Indiana University Press, pp. 83–119.

Katz, H. (2008) 'The Ship from Uluburun and the Ship from Tyre: An International Trade Network in the Ancient Near East', *Zeitschrift des Deutschen Palästina-Vereins*, 124(2), pp.128–142.

Katz, S. H. and Maytag, F. (1991) 'Brewing an ancient beer', *Archaeology*. 44, 24–33.

Katz, S. H. and Voigt, M. M. (1986) 'Bread and beer: The early use of cereals in the human diet', *Expedition*. 28(2), 23–34.

Keates, S. (2002) 'The flashing blade: copper, colour and luminosity in north Italian Copper Age society', in Jones, A. and MacGregor, G. (eds.) *Colouring the Past*. Oxford: Berg, pp. 109–27.

Kertzer, D. I. (1988) *Ritual, politics, and power*. New Haven and London: Yale University Press.

Khakimov, B., Bak, S. and Engelsen, S. B. (2014) 'High-throughput cereal metabolomics: current analytical technologies, challenges and perspectives', *Journal of Cereal Science*. 59, 393–418.

Kim-Cragg, H. (2017) 'Through Senses and Sharing: How Liturgy Meets Food', *Liturgy*. 32(2), 34–41. doi: 10.1080/0458063X.2017.1262642.

Kinnier Wilson, J. V. (1972) *The Nimrud Wine Lists. A study of men and administration at the Assyrian capital in the eighth century B. C. (Cuneiform Texts from Nimrud, I)*. London: British School of Archaeology in Iraq.

Kittler, P. G., Sucher, K. P. and Nahikian-Nelms, M. (2012) *Food and culture, 6th edition*. Belmont, CA: Wadsworth/Cengage Learning.

Klopper, W. J. *et al*. (1986) 'Organic acids and Glycerol in Beer', *Journal of the Institute of Brewing*. 92, 225–228.

Knight, D. M. (2014) 'Mushrooms, Knowledge Exchange and Polytemporality in Kalloni, Greek Macedonia', *Food, Culture & Society*. 17(2), 183–201. doi: 10.2752/175174414X13871910532105.

Koh, A. J. and Birney, K. J. (2017) 'Organic compounds and Cultural continuity: The Penn Museum Late Minoan IIIC stirrup jar from Tourloti', *Mediterranean Archaeology & Archaeometry*. 17(2), 19–33. doi: 10.5281/zenodo.581717.

Koh, A. J. and Birney, K. J. (2019) 'Ancient organic residues as cultural and environmental proxies: The value of legacy objects', *Sustainability (Switzerland)*. 11(3), 1–20. doi: 10.3390/su11030656.

Koh, A. J., Yasur-Landau, A. and Cline, E. H. (2014) 'Characterizing a middle bronze palatial wine cellar from Tel Kabri, Israel', *PLoS ONE*,. 9(8), e106406. doi: 10.1371/journal.pone.0106406.

Korsmeyer, C. (2005) *The taste culture reader : experiencing food and drink*.

Oxford and New York: Berg.

Korsmeyer, C. and Sutton, D. (2011) 'The Sensory Experience of Food', *Food, Culture & Society*. 14(4), 461–475. doi: 10.2752/175174411X13046092851316.

Kramer, S. N. (1949) 'Schooldays: A Sumerian Composition Relating to the Education of a Scribe', *Journal of the American Oriental Society*. 69(4), 199–215. doi: 10.2307/596246.

Kubo, R. (2014) 'Production of indigenous alcoholic beverages in a rural village of Tanzania', *Journal of the Institute of Brewing*. 120(2), 142–148. doi: 10.1002/jib.127.

Kuete, V. (2013) *Medicinal Plant Research in Africa: Pharmacology and Chemistry*. London: Elsevier.

Kümin, B. A. (2002) 'Public houses and their patrons in early modern Europe', in Kümin, B. and Tlusty, B. A. (eds.) *The world of the tavern : public houses in early modern Europe*. Aldershot, Burlington: Ashgate, pp. 44–62.

Kus, S. (1992) 'Toward an archaeology of body and soul', in Gardin, J. C. and Peebles, C. S. (eds.) *Representations in archaeology*. Bloomington, Indiana: Indiana University Press, pp. 168–177.

Langgut, D. (2015) 'Prestigious fruit trees in ancient Israel: first palynological evidence for growing Juglans regia and Citrus medica', *Israel Journal of Plant Sciences*. 62(1–2), 98–110. doi: 10.1080/07929978.2014.950067.

Langgut, D. (2017) 'The Citrus Route Revealed: From Southeast Asia into the Mediterranean', *HortScience*. 52(6), 814–822. doi: 10.21273/hortsci11023-16.

Lape, P. *et al*. (2018) 'New Data from an Open Neolithic Site in Eastern Indonesia', *Asian Perspectives*. 57(2), 222–243. doi: 10.1353/asi.2018.0015.

Larsson, M., Svensson, A. and Apel, J. (2019) 'Botanical evidence of malt for beer production in fifth–seventh century Uppåkra, Sweden', *Archaeological and Anthropological Sciences*. 11(5), 1961–1972. doi: 10.1007/s12520-018-0642-6.

Lee, C. (2007) *Feasting the Dead: Food and Drink in Anglo-Saxon Burial Rituals, Anglo-Saxon Studies 9*. Rochester: Boydell Press.

Leemans, W. F. (1960) *Foreign Trade in the Old Babylonian Period as Revealed by Texts from Southern Mesopotamia*. Leiden: E.J. Brill.

Lejay, M. *et al*. (2016) 'Organic signatures of fireplaces: Experimental references for archaeological interpretations', *Organic Geochemistry*. 99, 67–77. doi: 10.1016/j.orggeochem.2016.06.002.

Leray, C. (2012) *Introduction to Lipidomics: From Bacteria to Man*. New York: CRC Press.

Lev-Tov, J. and Mcgeough, K. (2007) 'Examing Feasting in Late Bronze Age Syro-Palestine Through Ancient Texts and Bones', in Twiss. K. (ed.) *We Were*

What We Ate: The Archaeology of Food and Identity, Occasional Paper, No.34, Carbondale: Center for Archaeological Investigations, pp. 85–111.

Lévi-Strauss, C. (1965) 'Le triangle culinaire', *L'Arc*. 26, 19–29.

Lévi-Strauss, C. (1968) *L'Origine des manières de table,* Mythologiques Tome 3. Paris: Plon.

Lévi-Strauss, C. (1969) *The Raw and the Cooked: Introduction to a Science of Mythology, Vol. I*. New York: Harper & Row.

Lindsay, H. (1998) 'Eating with the Dead: The Roman Funerary Banquet', in Nielsen, I. and Nielsen, H. S. (eds.) *Meals in a Social Context, Aarhus Studies in Mediterranean Antiquity 1*. Aarhus: Aarhus University Press, pp. 67–80.

Lion, B. (2013) 'Les cabarets à l'époque paléo-babylonienne', in Michel, C. (ed.) *Cahier des thèmes transversaux ArScAn XI, Theme 9. Habitudes alimentaires de l'acquisition à la consommation*. Nanterre: ArScAn, pp. 393–400.

Lion, B. and Michel, C. (2016) *The Role of Women in Work and Society in the Ancient Near East*. Berlin and Boston: De Gruyter.

Liu, L. *et al*. (2018) 'Fermented beverage and food storage in 13,000 y-old stone mortars at Raqefet Cave, Israel: Investigating Natufian ritual feasting', *Journal of Archaeological Science: Reports*. 21, 783–793. doi: 10.1016/j.jasrep.2018.08.008.

Liverani, M. (2001) *International Relations in the Ancient Near East, 1600-1100 BC*. Basingstoke and New York: Palgrave Macmillan.

Lloyd, P. S. (2015) *Food and identity in England, 1540-1640 : Eating to impress*. London and New-York: Bloomsbury Academic.

Logan, A. L., Hastorf, C. A. and Pearsall, D. M. (2012) '"Let's Drink Together": Early Ceremonial use of Maize in the Titicaca Basin', *Latin American Antiquity*. 23(3), 235–258. doi: 10.7183/1045-6635.23.3.235.

Lohaus, E., Bios, I. and Rüdiger, W. (1983) 'Carboxylic Acids in Wheat, Rye and Barley', *Zeitschrift für Naturforschung C*. 38, 524–530. Available at: https://www.degruyter.com/downloadpdf/j/znc.1983.38.issue-7-8/znc-1983-7-805/znc-1983-7-805.pdf.

Loughmiller-Cardinal, J. (2018) 'Mayan Ritual Beverage Production: Considering the Ceramics', in Fitzpatrick, S. M. (ed.) *Ancient Psychoactive Substances*. Gainesville: University Press of Florida, pp. 198–233.

Loveland, K. E., Smeesters, D. and Mandel, N. (2010) 'Still Preoccupied with 1995: The Need to Belong and Preference for Nostalgic Products', *Journal of Consumer Research*. 37(3), 393–408. doi: 10.1086/653043.

Low, K. E. Y. (2015) 'Tasting Memories, Cooking Heritage: A Sensuous Invitation to Remember', in Kong, L. and Sinha, V. (eds) *Food, Foodways and Foodscapes*. Singapore: World Scientific, pp. 61–82.

Luhtanen, R. K. and Crocker, J. (2005) 'Alcohol Use in College Students: Effects

of Level of Self-Esteem, Narcissism, and Contingencies of Self-Worth.', *Psychology of Addictive Behaviors*. 19(1), 99–103. doi: 10.1037/0893-164X.19.1.99.

Lupton, D. (1996) *Food, the body, and the self*. London: Sage Publications.

Lutz, H. F. (1922) *Viticulture and brewing in the ancient Orient*. New York: G. E. Stechert.

Maeir, A. M. and Garfinkel, Y. M. (1992) 'Bone and Metal Straw-Tip Beer-Strainers from the Ancient Near East', *Levant*. 24, 218–23.

Maisto, S. A. and Simons, J. S. (2016) 'Research on the Effects of Alcohol and Sexual Arousal on Sexual Risk in Men who have Sex with Men: Implications for HIV Prevention Interventions.', *AIDS and behavior*. 20 Suppl 1: S158-72. doi: 10.1007/s10461-015-1220-x.

Malainey, M. E. (2007) 'Fatty Acid Analysis of Archaeological Residues: Procedures and Possibilities', in Barnard, H. and Eerkens, J. (eds.) *Theory and Practice of Archaeological Residue Analysis*. Oxford, UK: British Archaeological Reports International Series 1650, pp. 77–89.

Mann, A. (2018) 'Ordering tasting in a restaurant: Experiencing, socializing, and processing food', *Senses and Society*. 13(2), 135–146. doi: 10.1080/17458927.2017.1376434.

Mannur, A. (2010) *Culinary fictions : food in South Asian diasporic culture*. Philadelphia, PA: Temple University Press.

Marmorstein, N. R. (2009) 'Longitudinal Associations Between Alcohol Problems and Depressive Symptoms: Early Adolescence Through Early Adulthood', *Alcoholism: Clinical and Experimental Research*. 33(1), 49–59. doi: 10.1111/j.1530-0277.2008.00810.x.

Marshall, L.-J. *et al*. (2008) 'Roman Diet and Trade : Evidence from Organic Residues on Pottery Sherds', *Brittania*. 39, 245–253.

Marti, L. (2011) 'Le banquet d'Aššurnaṣirpal II', *Journal Asiatique*. 299, 505–520.

Martin, H. P., Moon, J. and Postgate, J. N. (1985) *Graves 1 to 99, Abu Salabikh Excavations 2*. London: British School of Archaeology in Iraq.

Mata-Codesal, D. (2008) 'Rice & Coriander, Sensorial re-creations of home through food: Ecuadorians in a northern Spanish city', *Sussex Centre for Migration Research Working Paper*. 50, 1–21.

Mata-Codesal, D. (2010) 'Eating abroad, remembering (at) home. Three foodscapes of Ecuadorian migration in New York, London and Santander', *Anthropology of food*. 7.

Mauss, M. (1979) 'Body techniques', in Mauss, M. *Sociology and psychology: essays*. London: Routledge & Kegan Paul, pp. 97–123.

McCown, D. E., Haines, R. C. and Hansen, D. P. (1967) *Nippur I: Temple of Enlil, Scribal Quarter and Soundings. Excavations of the Joint Expedition to Nippur of the University Museum of Philadelphia and the Oriental Institute of the University of Chicago*. Oriental Institute Publication 78,

Chicago: University of Chicago Press.

McCracken, G. D. (1988) *Culture and consumption : new approaches to the symbolic character of consumer goods and activities*. Bloomington: Indiana University Press.

Mcgovern, P. E. *et al*. (1999) 'A funerary feast fit for King Midas: a royal banquet has been reconstructed from residues in pots found inside the tomb', *Nature*. 402, 863–4.

McGovern, P. E. *et al*. (1997) 'The Beginnings of Winemaking and Viniculture in the Ancient Near East and Egypt', *Expedition: The magazine of the University of Pennsylvania*. 39(1), 3–21.

McGovern, P. E. (1997) 'Wine of Egypt's golden age: an archaeochemical perspective', *Journal of Egyptian Archaeology*. 83, 69e108.

McGovern, P. E. (2003) *Ancient Wine: The Search for the Origins of Viniculture*. Princeton: Princeton University Press.

McGovern, P. E. *et al*. (2004) 'Fermented beverages of pre- and proto-historic China.', *Proceedings of the National Academy of Sciences of the United States of America*. National Academy of Sciences. 101(51), 17593–8. doi: 10.1073/pnas.0407921102.

McGovern, P. E. *et al*. (2005) 'Chemical Identification and Cultural Implications of a Mixed Fermented Beverage from Late Prehistoric China', *Asian Perspectives*. 44(2), 249–275. doi: 10.1353/asi.2005.0026.

McGovern, P. E. (2009) *Uncorking the Past: The Quest for Wine, Beer, and Other Alcoholic Beverages*. Berkeley and London: University of California Press.

McGovern, P. E. *et al*. (2017) 'Early Neolithic wine of Georgia in the South Caucasus', *Proceedings of the National Academy of Sciences*. 114(18), E10309-E10318. doi: 10.1073/pnas.1714728114.

McGovern, P. E., Fleming, S. J. and Katz, S. H. (1996) *The Origins and Ancient History of Wine*. Amsterdam: Gordon & Breach.

McGovern, P. E. and Hall, G. R. (2016) 'Charting a Future Course for Organic Residue Analysis in Archaeology', *Journal of Archaeological Method and Theory*. 23(2), 592–622. doi: 10.1007/s10816-015-9253-z.

McGovern, P. E., Hall, G. R. and Mirzoian, A. (2013) 'Danish Journal of Archaeology A biomolecular archaeological approach to "Nordic grog"', *Danish Journal of Archaeology*. 2(2), 112–131. doi: 10.1080/21662282.2013.867101.

McGovern, P. E., Mirzoian, A. and Hall, Gretchen R (2009) 'Ancient Egyptian herbal wines.', *Proceedings of the National Academy of Sciences of the United States of America*. National Academy of Sciences. 106(18), 7361–6. doi: 10.1073/pnas.0811578106.

McGovern, P. E., Mirzoian, A. and Hall, Gretchen R. (2009) 'Ancient Egyptian herbal wines', *Proceedings of the National Academy of Sciences*. 106(18), 7361-7366. doi: 10.1073/pnas.0811578106.

McIntosh, J. (2005) *Ancient Mesopotamia : new perspectives*. Santa Barbara, California: ABC-CLIO.

McMahon, A. *et al*. (2009) *Once There Was A Place: Settlement Archaeology at Chagar Bazar 1999-2002*. London: British Institute for the Study of Iraq.

Mennell, S. (1985) *All manners of food : eating and taste in England and France from the Middle Ages to the present*. Oxford: Basil Blackwell.

Mennell, S., Murcott, A. and van Otterloo, A. H. (1993) *The sociology of food : eating, diet, and culture*. London: Sage. Michalowski, P. (1978) *The neo-Sumerian silver ring texts*. Malibu, CA: Undena Publications.

Michalowski, P. (1994) 'The drinking gods: Alcohol in early Mesopotamian ritual and mythology', in Milano, L. (ed.) *Drinking in ancient socities: History and culture of drinks in the ancient Near East*. Padova: S.A.R.G.O.N., pp. 27–44.

Michel, C. (2012) 'L'alimentation au Proche-Orient ancien: les sources et leur exploitation', *Dialogues d'Histoire Ancienne*. 7, 17–45.

Michel, R. H., McGovern, P. E. and Badler, V. R. (1993) 'The first Wine & Beer: Chemical Detection of Ancient Fermented Beverages', *Analytical Chemistry*. 65(8), 408–413. doi: 10.1021/ac00056a002.

Middleditch, B. S. (1989) *Analytical Artifacts*. New York and Amsterdam: Elsevier.

Milburn, O. (2016) 'Aromas, scents, and spices: olfactory culture in China before the arrival of Buddhism', *The Journal of the American Oriental Society*. 136(3), 441.

Miller, J. (2017) 'Political Interactions between Kassite Babylonia and Assyria, Egypt and Ḫatti during the Amarna Age', in Bartelmus, A. and Sternitzke, K. (eds.) *Karduniaš. Babylonia under the Kassites, vol.1, Untersuchungen zur Assyriologie und vorderasiatischen Archäologie 11/1*. Berlin, Boston: De Gruyter, pp. 93–111.

Miller, N. F. and Wetterstrom, W. (2000) 'The Beginnings of Agriculture: The Ancient Near East and North Africa', in Kiple, K. F. and Ornelas, K. C. (eds.) *The Cambridge World History of Food*. Cambridge: University of Cambridge Press, pp. 1123–1239.

Milton, G. (1999) *Nathaniel's Nutmeg: How one man's courage changed the course of history*. London: Hodder & Stoughton.

Mintz, S. W. and Du Bois, C. M. (2002) 'The Anthropology of Food and Eating', *Annual Review of Anthropology*. 31(1), 99–119. doi: 10.1146/annurev.anthro.32.032702.131011.

Mitchell, C. W. (1959) 'Investigations into the soils and agriculture of the Lower Diyala area of eastern Iraq', *Geographical Journal*. 125, 390–7.

Mohialdeen, I. M. J. and Hakimi, M. H. (2013) 'Biomarker characteristics of certain crude oils and the oil-source rock correlation for the Kurdistan oilfields, Northern Iraq', *Arabian Journal of Geosciences*. 8(1), 507–523. doi: 10.1007/s12517-013-1228-3.

Molleson, T. (2007) ‘A method for the study of activity related skeletal morphologies The need to know’, *Bioarchaeology of the Near East*. 1, 5–33.

Monnier, G. F. *et al.* (2013) ‘A multi-analytical methodology of lithic residue analysis applied to Paleolithic tools from Hummal, Syria’, *Journal of Archaeological Science*. 40(10), 3722–3739. doi: 10.1016/j.jas.2013.03.018.

Moon, J. (1987) *Catalogue of Early Dynastic Pottery, Abu Salabikh Excavations 3*. London: British School of Archaeology in Iraq.

Moorey, P. R. S. (1980) ‘Metal wine sets in the Ancient Near East’, *Iranica Antiqua*. 15, 181–197.

Moran, W. L. (1992) *The Amarna Letters*. Baltimore: John Hopkins University Press.

Mukherjee, A. J., Gibson, A. M. and Evershed, R. P. (2008) ‘Trends in pig product processing at British Neolithic Grooved Ware sites traced through organic residues in potsherds’, *Journal of Archaeological Science*. 20, 1–15.

Müller-Karpe, V. (1999) ‘Untersuchungen in Kuşaklı 1998’, *Mitteilungen der Deutschen Orient-Gesellschaft*. 135, 57–113.

Müller-Karpe, V. (2006) ‘Tempelinventare in Kuşaklı und Boğazköy im Vergleich: Ein Beitrag zur hethitischen Chronologie’, in Mielke, D. P., Schoop, U.-D., and Seeher, J. (eds.) *Strukturierung und Datierung in der Hethitischen Archäologie, Byzas 4*. Istanbul: Ege Yayınları, pp. 241–242.

Murcott, A. (1988) ‘Sociological and social anthropological approaches to food and eating.’, *World review of nutrition and dietetics*. 55, 1–40.

Murcott, A. (2000) ‘Understanding life-style and food use: contributions from the social sciences’, *British Medical Bulletin*. 56(1), 121–132. doi: 10.1258/0007142001902833.

Murcott, Anne. (2013) ‘A burgeoning field: Introduction to The Handbook of Food Research’, in Murcott, A., Belasco, W., and Jackson, P. (eds.) *The Handbook of Food Research*. London, New York: Bloomsbury Publishing, pp. 1–25.

Murdoch, D. and Ross, D. (1990) ‘Alcohol and Crimes of Violence: Present Issues’, *International Journal of the Addictions*. 25(9), 1065–1081. doi: 10.3109/10826089009058873.

Murray, M. A. (2000a) ‘Fruits, vegetables, pulses and condiments’, in Nicholson, P. T. and Shaw, I. (eds.) *Ancient Egyptian Materials and Technology*. Cambridge: University of Cambridge Press, pp. 609–655.

Murray, M. A. (2000b) ‘Viticulture and Wine Production’, in Nicholson, P. T. and Shaw, I. (eds.) *Ancient Egyptian Materials and Technology*. Cambridge: CUP, pp. 577–608.

Myles, S. *et al.* (2011) ‘Genetic structure and domestication history of the grape.’, *Proceedings of the National Academy of Sciences of the United*

States of America. National Academy of Sciences. 108(9), 3530–5. doi: 10.1073/pnas.1009363108.

Namdar, D. *et al*. (2009) 'The contents of unusual cone-shaped vessels (cornets) from the Chalcolithic of the southern Levant', *Journal of Archaeological Science*. 36(3), 629–636. doi: 10.1016/J.JAS.2008.10.004.

Namdar, D. *et al*. (2013) 'Cinnamaldehyde in early iron age phoenician flasks raises the possibility of levantine trade with South East Asia', *Mediterranean Archaeology and Archaeometry*. 13(2), 1–19.

Namdar, D., Amrani, A. and Kletter, R. (2015) 'Cult and Trade in Yavneh through the study of organic residues', in Raz Kletter, Irit Ziffer, W. Z. (ed.) *Yavneh II The 'Temple Hill' Repository Pit*. Orbis Biblicus et Orientalis 36, Series Archaeologica, Fribourg: Fribourg Academic Press, pp. 214–223.

Namdar, D., Neumann, R. and Weiner, S. (2010) 'Residue Analysis of Chalices from the Repository Pit', in Kletter, R., Ziffer, I., and Zwickel, W. (eds.) *Yavneh I: The Excavation of the "Temple Hill" Repository Pit and the Cult Stands. Orbis biblicus et orientalis 30*. Fribourg: Fribourg Academic Press, pp. 167–73.

Naville, E. (1913) *The XIth Dynasty Temple at Deir el-Bahari (Vol. III). Memoir of the Egypt Exploration Fund, 32*. London: Egypt Exploration Fund.

Nelson, M. (2005) *The Barbarian's Beverage: A History of Beer in Ancient Europe*. Abingdon: Routledge.

Nemet-Nejat, K. R. (1998) *Daily life in ancient Mesopotamia*. Westport: Greenwood Press.

Neumann, H. (1994) 'Beer as a Means of Compensation for Work in Mesopotamia during the Ur III Period', *Drinking in Ancient Societies: History and Culture of Drinks in the Ancient Near East. Papers of a Symposium held in Rome, May 17-19, 1990*. History of the Acient Near East 6, pp. 321–331.

Neumann, K., Chevalier, A. and Vrydaghs, L. (2017) 'Phytoliths in archaeology: recent advances', *Vegetation History and Archaeobotany*. 26(1), 1–3. doi: 10.1007/s00334-016-0598-3.

Nieuwenhuyse, O. P. *et al*. (2015) 'Tracing pottery use and the emergence of secondary product exploitation through lipid residue analysis at Late Neolithic Tell Sabi Abyad (Syria)', *Journal of Archaeological Science*. 64, 54–66. doi: 10.1016/j.jas.2015.10.002.

Nissen, H. J. (1970) 'Grabung in den Planquadraten K/L XII in Uruk-Warka', *Baghdader Mitteilungen*. 5, 101–191.

Nollet, L. M. L. (2004) *Handbook of Food Analysis: Physical characterization*. New-York: Marcel Dekker.

Nowicki, S. (2014) 'Menu of the gods. Mesopotamian supernatural powers and their nourishment, with reference to selected literary sources', *Archiv Orientalni*. 82(2), 211–224.

Nybe, E. V., Mini Raj, N. and Peter, K. V. (2007) *Spices*. Horticulture science series 5, Pitam Pura: New India Publishing.

Nykänen, L. and Suomalainen, H. (1983) *Aroma of Beer, Wine and Distilled Alcoholic Beverages, Handbook of Aroma Research*. Berlin: Springer Science & Business Media.

O'Connor, K. (2015) *The never-ending feast : the anthropology and archaeology of feasting*. London and New York: Bloomsbury Publishing.

Ohnuki-Tierney, E. (1993) *Rice as self : Japanese identities through time*. Princeton, NJ: Princeton University Press.

Oppenheim, A. L. (1967) *Letters From Mesopotamia: Official, Business, and Private Letters on Clay Tablets from Two Millennia*. Chicago: University of Chicago Press.

Ortiz Cuadra, C. M. (2013) *Eating Puerto Rico : a history of food, culture, and identity, Trans. Russ Davidson*. Chapel Hill: University of North Carolina Press.

Oscar-Berman, M. and Marinković, K. (2007) 'Alcohol: Effects on Neurobehavioral Functions and the Brain', *Neuropsychology Review*. 17(3), 239–257. doi: 10.1007/s11065-007-9038-6.

Otto, A. (2012) 'Defining and Transgressing the Boundaries between Ritual Commensality and Daily Commensal Practices: The Case of Late Bronze Age Tall Bazi', in Pollock, S. (ed.) *Between Feasts and Daily Meals. Towards an Archaeology of Commensal Spaces, Special Volume 2*. eTopoi, Journal for Ancient Studies, pp. 179–195.

Otto, A. (2014) 'The Late Bronze Age pottery of the "Weststadt" of Tell Bazi (North Syria).', in Luciani, M. and Hausleitner, A. (eds.) *Recent trends in the study of Late Bronze Age ceramics in Syro-Mesopotamia and neighbouring regions. Proceedings of the International Workshop in Berlin, 2-5 November 2006*. Leidorf: Rahden/Westf., pp. 85–117.

Oudemans, T. F. M. (2007) 'Applying organic residue analysis in ceramic studies - a functional approach', *Leiden Journal of Pottery Studies*. 23, 5-20.

Özgüç, N. (1965) *Kültepe mühür baskılarında Anadolu grubu*. Ankara: Türk Tarih Kurumu Basimevi.

Pagnoux, C. *et al*. (2013) 'The introduction of Citrus to Italy, with reference to the identification problems of seed remains', *Vegetation History and Archaeobotany*. 22(5), 421–438. doi: 10.1007/s00334-012-0389-4.

Parker Pearson, M. (2003) 'Food, culture and identity: an introduction and overview', in Parker Pearson, M. (ed.) *Food, culture and identity in the Neolithic and Early Bronze Age*. BAR International Series (Book 1117), Oxford: Archaeopress, pp. 1-30.

Patania, I. and Jaffe, Y. (2018) 'Eating Archaeology: Experimenting with Food in Public Outreach', *Public Archaeology*. 17(1), 55–68. doi: 10.1080/14655187.2018.1510361.

Pearson, J. A. *et al*. (2013) 'Food and social complexity at çayÖnü Tepesi, southeastern Anatolia: Stable isotope evidence of differentiation in diet according to burial practice and sex in the early Neolithic', *Journal of*

Anthropological Archaeology. 32(2), 180–189. doi: 10.1016/j.jaa.2013.01.002.

Pearson, J. A. *et al*. (2015) 'Stable carbon and nitrogen isotope analysis at Neolithic Çatalhöyük: evidence for human and animal diet and their relationship to households', *Journal of Archaeological Science*. 57, 69–79. doi: 10.1016/J.JAS.2015.01.007.

Pecci, A. (2013) 'Almost ten years of plasters residue analysis in Italy: Activity areas and the function of structures', *Periodico di Mineralogia*. 82(3), 393–410. doi: 10.2451/2013PM0023.

Pecci, A. *et al*. (2013) 'Identifying wine markers in ceramics and plasters using gas chromatography-mass spectrometry. Experimental and archaeological materials', *Journal of Archaeological Science*. 40(1), 109–115. doi: 10.1016/j.jas.2012.05.001.

Pecci, A. *et al*. (2016) 'Organic residue analysis of experimental, medieval, and post-medieval glazed ceramics', *Archaeological and Anthropological Sciences*. 8(4), 879–890. doi: 10.1007/s12520-015-0262-3.

Pecci, A., Barba, L. and Ortiz, A. (2017) 'Chemical Residues as Anthropic Activity Markers. Ethnoarchaeology, Experimental Archaeology and Archaeology of Food Production and Consumption', *Environmental Archaeology*. 22(4), 343–353. doi: 10.1080/14614103.2017.1359354.

Perini, S. (2014) *Ceramic vessel production, use and distribution in Northern Mesopotamia and Syria during the Middle Bronze Age II (c. 1800-1600 BC) : a functional analysis of vessels from Tell Ahmar, North Syria*. PhD diss., University of Edinburgh.

Perruchini, E. *et al*. (2018) 'Revealing invisible brews: A new approach to the chemical identification of ancient beer', *Journal of Archaeological Science*. 100, pp. 176–190. doi: 10.1016/j.jas.2018.05.010.

Perry, M. S. (2017) 'Feasting on Culture and Identity: Food Functions in a Multicultural and Transcultural Malaysia', *3L The Southeast Asian Journal of English Language Studies*. 23(4), 184–199. doi: 10.17576/3L-2017-2304-14.

Phuntsok, C. T. and Rikey, T. K. (1991) 'The Deity Invocation Ritual and the Purification Rite of Incense Burning in Tibet', *The Tibet Journal*. 16(3), 3–27.

Pitts, M. (2015) 'The Archaeology of Food Consumption', in Wilkins, J. and Nadeau, R. (eds.) *A Companion to Food in the Ancient World*. Chichester, UK: John Wiley & Sons, Ltd, pp. 95–104.

Pole, S. (2013) *Ayurvedic medicine : the principles of traditional practice*. London: Singing Dragon.

Pollard, A. M. *et al*. (2007) *Analytical chemistry in archaeology*. Cambridge University Press.

Pollock, S. (2003) 'Feasts, Funerals, and Fast Food in Early Mesopotamian States', in Bray, T. (ed.) *The Archaeology and Politics of Food and*

Feasting in Early States and Empires. New York: Kluwer Academic/Plenum Publishers, pp. 17–38. doi: 10.1007/978-0-306-48246-5_2.

Pollock, S. (2012) 'Politics of Food in Early Mesopotamian Centralized Societies', *Origini*. 34, 146–153.

Pollock, S. (2013) 'Commensality, Public Spheres and Handlungsräume in Ancient Mesopotamia', in Robb, J. and Pauketat, T. (eds.) *Big Histories, Human Lives*. Santa Fe: School of Advanced Research, pp. 145–170.

Pollock, S. (2015) 'Towards an Archaeology of Commensal Spaces. An Introduction', in Pollock, S. (ed.) *Between Feasts and Daily Meals. Towards an Archaeology of Commensal Spaces*. Berlin: Edition Topoi, pp. 7–28.

Postgate, J. N. and Moorey, P. R. S. (1976) 'Excavations at Abu Salabikh, 1975', *Iraq*. 38, 133–169.

Poth, S. and Sauer, G. (2000) *The Spice Lilies: Eastern Secrets to Healing with Ginger, Turmeric, Cardamom, and Galangal*. Rochester, VT: Healing Arts Press.

Potts, D. (2002) *Feast of Dates*. Abu Dhabi: Trident Press in conjunction with the UAE Ministry of Information and Culture.

Potts, D. T. (1995) 'Distant shores: Ancient Near Eastern Trade with South Asia and Northeast Africa', in Sasson, J. M. (ed.) *Civilizations of the Ancient Near East: III, part 6 Economy and Trade*. New York: Hendrickson Publishers, pp. 1451–1463.

Potts, D. T. (1997) *Mesopotamian civilization : the material foundations*. Ithaca, New York: Cornell University Press.

Potts, D. T. (2012) 'Fish and Fishing', in Potts, D. T. (ed.) *A Companion to the Archaeology of the Ancient Near East*. Oxford, UK: Wiley-Blackwell, pp. 220–235. doi: 10.1002/9781444360790.

Potts, T. F. (1989) 'Foreign Stone Vessels of the Late Third Millennium BC from Southern Mesopotamia : Their Origins and Mechanisms of Exchange' *Iraq*. 51, 123–164.

Powell, M. A. (1996) 'Wine and Vine Mesopotamia: The Cuneiform Evidence', in McGovern, P. E., Fleming, S. J., and Katz, S. H. (eds.) *The Origins and Ancient History of Wine Food and Nutrition in History and Antropology*. Amsterdam: Gordon & Breach, pp. 97–122.

Price, R. (2018) 'Sniffing out the Gods: Archaeology with the Senses', *Journal of Ancient Egyptian Interconnections*. 17, 137–155.

Privat, K. L., O'connell, T. C. and Richards, M. P. (2002) 'Stable Isotope Analysis of Human and Faunal Remains from the Anglo-Saxon Cemetery at Berinsfield, Oxfordshire: Dietary and Social Implications', *Journal of Archaeological Science*. 29(7), 779–790. doi: 10.1006/jasc.2001.0785.

Proust, M. (1913) *Du côté de chez Swann (À la recherche du temps perdu)*. Paris: Grasset.

Pulak, C. (1998) 'The Uluburun shipwreck: an overview', *The International Journal of Nautical Archaeology*, 27 (3), 188–224.

Radner, K. (2014) 'Zagros Spice Mills: the Simurrean and the Hašimur grindstones', in Greco, A. *et al*. (eds.) *From Source to History: Studies on Ancient Near Eastern Worlds and Beyond Dedicated to Giovanni Battista Lanfranchi*. Münster, Germany: Ugarit-Verlag, pp. 573–580.

Ranciere, J. (2004) *The Politics of aesthetics: the distribution of the sensible*. London: Continuum.

Reason, M. and Reynolds, D. (2010) 'Kinesthesia, Empathy, and Related Pleasures: An Inquiry into Audience Experiences of Watching Dance', *Dance Research Journal*. 42(2), 49–75. doi: 10.1017/S0149767700001030.

Reber, E. A. (2014) 'Gas Chromatography-Mass Spectrometry (GC-MS): Applications in Archaeology', in *Encyclopedia of Global Archaeology*. New York: Springer New York, pp. 2953–2959. doi: 10.1007/978-1-4419-0465-2_340.

Regert, M. *et al*. (2001) 'Chemical Alteration and Use of Beeswax through Time: Acceler-ated Ageing Tests and Analysis of Archaeological Samples from Various Environmental Contexts', *Archaeometry*. 43(4), 549–569.

Ribechini, E. *et al*. (2008) 'An integrated analytical approach for characterizing an organic residue from an archaeological glass bottle recovered in Pompeii (Naples, Italy)', *Talanta*. 74(4), 555–561. doi: 10.1016/j.talanta.2007.06.026.

Rice, P. M. (1987) *Pottery analysis: A Source Book*. Chicago: University of Chicago Press.

Richards, M. (2002) 'A brief review of the archaeological evidence for Palaeolithic and Neolithic subsistence', *European Journal of Clinical Nutrition*. 56(12), 1270–1278. doi: 10.1038/sj.ejcn.1601646.

Richter, B. E. *et al*. (1996) 'Accelerated Solvent Extraction: A Technique for Sample Preparation', *Analytical Chemistry*. 68(6), 1033–1039. doi: 10.1021/ac9508199.

Roffet-Salque, M. *et al*. (2017) 'From the inside out: Upscaling organic residue analyses of archaeological ceramics', *Journal of Archaeological Science: Reports*. 16, 627–640. doi: 10.1016/j.jasrep.2016.04.005.

Rojo-Guerra, M. Á. *et al*. (2006) 'Beer and Bell Beakers: Drinking Rituals in Copper Age Inner Iberia.', *Proceedings of the Prehistoric Society*. Cambridge University Press 72, pp. 243–265. doi: 10.1017/S0079497X00000840.

Romano, L. (2015) 'Holding the Cup. Evolution of the Simposium and Banquet Scenes in the Early Dynastic Period', in Dittman, R. and Selz, G. J. (eds.) *It's a Long Way to a Historiography of the Early Dynastic Period(s), Altertumskunde des Vorderen Orients Archäologische Studien zur Kultur und Geschichte des Alten Orients, Band 15*. Münster: Ugarit-Verlag, pp. 289–301.

Romanus, K. (2008) *Residue analysis on organic remains in archaeological artefacts*. PhD diss., Katholieke Universiteit Leuven.

Rosengarten, F. J. (1969) *The Book of Spices*. New York: Jove Publication.

Ross, J. M. (2004) 'Phytoliths from a Norse Greenlandic Quern Stone: A Preliminary Investigation', *Environmental Archaeology*. 9(1), 99–106. doi: 10.1179/env.2004.9.1.99.

Roth, M. T. (1997) *Law Collections from Mesopotamia and Asia Minor*. Atlanta: Scholars Press.

Rothman M. S. (2002) *Tepe Gawra: the evolution of a small, prehistoric center in northern Iraq*. Philadelphia: University of Pennsylvania Press.

Rothman, M. S. and Badler, V. (2011) 'Contact and development in Godin VI', in Gopnik, H. and Rothman, M. (eds.) *On the High Road: The History of Godin Tepe, Iran*. Toronto: Royal Ontario Museum and Mazda Press, pp. 67–138.

Rozin, P. (1996) 'The socio-cultural context of eating and food choice', in Meiselman, H. L. and MacFie, H. J. H. (eds.) *Food Choice, Acceptance and Consumption*. Boston: Springer US, pp. 83–104. doi: 10.1007/978-1-4613-1221-5_2.

Rudgley, R. (1993) *Essential substances: A cultural history of intoxicants in society*. New York: Kodansha International.

Russon, J. (2011) 'Self and Other in Hegel's Phenomenology of Spirit', *Journal of Indian Council of Philosophical Research*. 18, 1–18.

Sadori, L., Mercuri, A. M. and Mariotti Lippi, M. (2010) 'Reconstructing past cultural landscape and human impact using pollen and plant macroremains', *Plant Biosystems*. 144(4), 940–951. doi: 10.1080/11263504.2010.491982.

Salameh, D. *et al*. (2008) 'Highlight on the problems generated by p-coumaric acid analysis in wine fermentations', *Food Chemistry*. 107(4), 1661–1667. doi: 10.1016/j.foodchem.2007.09.052.

Sallaberger, W. (2012) 'Home-made Bread, Municipal Mutton, Royal Wine. Establishing Social Relations during the Preparation and Consumption of Food in Religious Festivals at Late Bronze Age Emar', in Pollock, S. (ed.) *Between Feasts and Daily Meals. Towards an Archaeology of Commensal Spaces, Special Volume 2*. eTopoi, Journal for Ancient Studies, pp. 157–177.

Samuel, D. (1996a) 'Approaches to the archaeology of Food', *Petits propos culinaires*. 54, 12–21.

Samuel, D. (1996b) 'Archaeology Of Ancient Egyptian Beer', *Journal Of The American Society Of Brewing Chemists*, 54, 3-12.

Sandoval-Ramírez, B. A. *et al*. (2017) 'Beer Polyphenols and Menopause: Effects and Mechanisms-A Review of Current Knowledge.', *Oxidative medicine and cellular longevity*. 2017, 4749131. doi: 10.1155/2017/4749131.

Sangalli, B. C. and Chiang, W. (2000) 'Toxicology of Nutmeg Abuse', *Journal of Toxicology: Clinical Toxicology*. 38(6), 671–678. doi: 10.1081/CLT-100102020.

Sartre, J. P. (1943) *L'être et le néant: essai d'ontologie phénoménologique*. Paris: Gallimard.

Saul, H. *et al*. (2013) 'Phytoliths in Pottery Reveal the Use of Spice in European Prehistoric Cuisine', *PLoS ONE*. 8(8), e70583. doi: 10.1371/journal.pone.0070583.

Sayette, Michael A *et al*. (2012) 'Alcohol and group formation: a multimodal investigation of the effects of alcohol on emotion and social bonding.', *Psychological science*. 23(8), 869–78. doi: 10.1177/0956797611435134.

Sayette, Michael A. *et al*. (2012) 'Alcohol and Group Formation', *Psychological Science*. 23(8), 869–878. doi: 10.1177/0956797611435134.

Sayette, M. A. (2017) 'The effects of alcohol on emotion in social drinkers', *Behaviour Research and Therapy*. 88, 76–89. doi: 10.1016/j.brat.2016.06.005.

Schivelbusch, W. (1992) *Tastes of Paradise: A Social History of Spices, Stimulants and Intoxicants*. New York: Pantheon.

Schlumbaum, A., Tensen, M. and Jaenicke-Després, V. (2008) 'Ancient plant DNA in archaeobotany', *Vegetation History and Archaeobotany*. 17(2), 233–244. doi: 10.1007/s00334-007-0125-7.

Schmandt-Besserat, D. (2001) 'Feasting in the Ancient Near East', in Dietler, M. and Hayden, B. (eds.) *Feasts. Archaeological and ethnographic perspectives on food, politics and power*. Washington: Smithsonian Institution Press, pp. 391–403.

Schniedewind, W. and Hunt, J. H. (2007) *A Primer on Ugaritic: Language, Culture and Literature*. Cambridge: Cambridge University Press.

Schulting, R. (2018) 'Dietary Shifts at the Mesolithic–Neolithic Transition in Europe', in Lee-Thorp, J. and Katzenberg, M. A. (eds) *The Oxford Handbook of the Archaeology of Diet*. Oxford: Oxford University Press.

Schwartz, M. and Hollander, D. (2000) 'Annealing, distilling, reheating and recycling : bitumen processing in the Ancient Near East', *Paléorient*. 26(2), 83–91. doi: 10.3406/paleo.2000.4712.

Schwartz, M. and Hollander, D. (2016) 'The Uruk expansion as dynamic process: A reconstruction of Middle to Late Uruk exchange patterns from bulk stable isotope analyses of bitumen artifacts', *Journal of Archaeological Science: Reports*. 7, 884–899. doi: 10.1016/J.JASREP.2016.01.027.

Schwartz, M., Hollander, D. and Stein, G. J. (1999) 'Reconstructing Mesopotamian Exchange Networks in the 4th Millennium BC : Geochemical and Archaeological Analyses of Bitumen Artifacts from Hacinebi Tepe, Turkey', *Paléorient*. 25(1), 67–82. doi: 10.3406/paleo.1999.989.

Scott, J. C. (1990) *Domination and the Arts of Resistance*. New Haven: Yale University Press.

Scurlock, J. (2006) 'The Techniques of the Sacrifice of Animals in Ancient Israel and Ancient Mesopotamia: New Insights Through Comparison Part 1, *Andrews University Seminary Studies (AUSS)*, 44(1). Available at: https://digitalcommons.andrews.edu/auss/vol44/iss1/2.

Scurlock, J. (2014) *Sourcebook for Ancient Mesopotamian Medicine, Writings from the Ancient World*. Atlanta: Society of Biblical Literature.

Sealy, J. (2016) 'Intensification, Diet, and Group Boundaries among Later Stone Age Coastal Hunter-gatherers along the Western and Southern Coasts of South Africa', in Lee-Thorp, J. and Katzenberg, M. A. (eds.) *The Oxford Handbook of the Archaeology of Diet*. Oxford: Oxford University Press.

Seinfeld, D. M. (2018) 'Intoxication Rituals and Gender among the Ancient Maya', in Fitzpatrick, S. M. (ed.) *Ancient Psychoactive Substances*. Tallahasse: University Press of Florida, pp. 176–197.

Seremetakis, C. N. (1994) *The Senses Still: Perception and Memory as Material Culture in Modernity*. Boulder: Westview Press.

Seremetakis, C. N. (2004) 'The Memory of the Senses: Historical Perception, Commensal Exchange and Modernity', *Visual Anthropology Review*. 9(2), 2–18. doi: 10.1525/var.1993.9.2.2.

Serres, M. (1985) *Les cinq sens. Philosophie des corps mêlés I*. Paris: Grasset.

Shapin, S. (2014) '"You are what you eat": historical changes in ideas about food and identity*', *Historical Research*. 87(237), 377–392. doi: 10.1111/1468-2281.12059.

Sharangi, A. B. (ed.) (2018) *Indian Spices*. Cham: Springer International Publishing.

Sherratt, A. (1997) 'Cups That Cheered: The Introduction of Alcohol to Prehistoric Europe', in Sherratt, A. (ed.) *Economy and Society in Prehistoric Europe: Changing Perspectives*. Edinburgh: Edinburgh University Press, pp. 376–402.

Shillito, L. M. *et al*. (2009) 'The use of FT-IR as a screening technique for organic residue analysis of archaeological samples', *Spectrochimica Acta Part A: Molecular and Biomolecular Spectroscopy*. 72(1), 120–125. doi: 10.1016/j.saa.2008.08.016.

Simmel, G. (1998) 'The Sociology of the Meal', in Frisby, D. and Featherstone, M. (eds.) *Simmel on Culture: Selected Writings*. London: Sage, pp. 130-135.

Skeates, R. (2010) *An archaeology of the senses: prehistoric Malta*. Oxford: Oxford University Press.

Smith, M. E., Wharton, J. B. and Olson, J. M. (2003) 'Aztec Feasts Rituals and Markets' in Bray, T.L. (ed.) *The Archaeology and Politics of Food and Feasting in Early States and Empires*. Boston: Springer US, pp.235–268.

Soberl, L. *et al*. (2014) 'Neolithic and Eneolithic activities inferred from organic residue analysis of pottery from Mala Triglavca, Moverna vas and Ajdovska jama, Slovenia', *Documenta Praehistorica*. 41, 149–179. doi:

10.4312/dp.41.9.

Søe, M. J. *et al*. (2018) 'Ancient DNA from latrines in Northern Europe and the Middle East (500 BC-1700 AD) reveals past parasites and diet.', *PloS one*. 13(4), e0195481. doi: 10.1371/journal.pone.0195481.

Solazzo, C. *et al*. (2008) 'Identification of Protein Remains in Archaeological Potsherds by Proteomics', *Analytical Chemistry*. 80(12), 4590–4597. doi:10.1021/ac800515v.

Southerton, D. (2001) 'Consuming Kitchens: Taste, context and identity formation', *Journal of Consumer Culture*. 1(2), 179–203. doi: 10.1177/146954050100100202.

Spence, C. (2015) 'On the psychological impact of food colour', *Flavour*. 4, 21. doi: 10.1186/s13411-015-0031-3.

Spence, C. and Van Doorn, G. (2017) 'Does the Shape of the Drinking Receptacle Influence Taste/Flavour Perception? A Review', *Beverages*. 3(3), 33. doi: 10.3390/beverages3030033.

Sperber, D. (1975) *Rethinking Symbolism*. Cambridge: Cambridge University Press.

Spiteri, C., Heron, C. and Craig, O. E. (2011) 'Characterising surviving residues from archaeological ceramics: a biomolecular approach', in Scarcella, S. (ed.) *Archaeological Ceramics: A review of current research*. Oxford: Archaeopress, pp. 40–56.

Srogi, K. (2007) 'Monitoring of environmental exposure to polycyclic aromatic hydrocarbons: a review', *Environmental Chemistry Letters*. 5(4), 169–195. doi: 10.1007/s10311-007-0095-0.

Stajcic, N. (2013) 'Understanding Culture: Food as a Means of Communication', *Hemispheres. Studies on Cultures and Societies*. 28, 77–87.

Stappenbeck, C. A. and Fromme, K. (2014) 'The effects of alcohol, emotion regulation, and emotional arousal on the dating aggression intentions of men and women.', *Psychology of addictive behaviors : journal of the Society of Psychologists in Addictive Behaviors*. 28(1), 10–9. doi: 10.1037/a0032204.

Stashenko, E. and Martínez, J. R. (2014) 'Gas Chromatography-Mass Spectrometry', in Guo, X. (ed.) *Advances in Gas Chromatography*. IntechOpen, pp. 1–38. Available online at: https://www.intechopen.com/books/advances-in-gas-chromatography/gas-chromatography-mass-spectrometry.

Steel, L. (2004a) 'A Goodly Feast . . . A Cup of Mellow Wine: Feasting in Bronze Age Cyprus', *Hesperia*. 73(2), 281–300.

Steel, L. (2004b) 'Cyprus before history: From the earliest settlers to the end of the Bronze Age', London : Duckworth.

Steele, V. (2013) 'Organic Residues in Archaeology: The Highs and Lows of Recent Research', in Armitage, R. A. and Burton, J. (eds.) *Archaeological Chemistry VIII*. ACS Symposium Series, Washington: American Chemical

Society, pp. 89–108. doi: 10.1021/bk-2013-1147.ch005.

Stern, B. *et al*. (2000) 'A comparison of methods for establishing fatty acid concentration gradients across potsherds: a case study using Late Bronze Age Canaanite amphorae', *Archaeometry*. 42, 399–414. doi: 10.1111/j.1475-4754.2000.tb00890.x.

Stika, H.-P. (2011) 'Early Iron Age and Late Mediaeval malt finds from Germany—attempts at reconstruction of early Celtic brewing and the taste of Celtic beer', *Archaeological and Anthropological Sciences*. 3(1), 41–48. doi: 10.1007/s12520-010-0049-5.

Stol, M. (1994) 'Beer in Neo-Babylonian Times', in Milano, L. (ed.) *Drinking in Ancient Societies*. Padova: S.A.R.G.O.N., pp. 155–183.

Stol, M. (1995) 'Women in Mesopotamia', *Journal of the Economic and Social History of the Orient*. 38(2), pp. 123–144.

Stronach, D. (1995) 'The Imagery of the Wine Bowl: Wine in Assyria in the Early First Millennium B.C.', in McGovern, P. E., Fleming, S. J., and Katz, S. H. (eds.) *The Origins and Ancient History of Wine*. Luxembourg: Gordon and Breach, pp. 175–95.

Sutton, D. (2000) 'Whole Foods: Revitalization through Everyday Synesthetic Experience', *Anthropology and Humanism*. 25(2), 120–130. doi: 10.1525/ahu.2000.25.2.120.

Sutton, D. (2001) *Remembrance of Repasts: An Anthropology of Food and Memory*. Oxford: Berg.

Sutton, D. (2005) 'Synesthesia, Memory, and the Taste of Home', in Korsmeyer, C. (ed.) *The taste culture reader: experiencing food and drink*. Oxford: Berg, pp. 304–316.

Sutton, D. E. (2001) *Remembrance of Repasts: An Anthropology of Food and Memory*. Oxford: Berg.

Sutton, D. E. (2010) 'Food and the Senses', *Annual Review of Anthropology*. 39, 209–223. doi: 10.1146/annurev.anthro.012809.104957.

Tajuddin *et al*. (2005) 'An experimental study of sexual function improving effect of Myristica fragrans Houtt. (nutmeg).', *BMC complementary and alternative medicine*. 5, 16. doi: 10.1186/1472-6882-5-16.

Taylor, J. R. and Duodu Kwaku G. (2019) 'Traditional Sorghum and Millet Food and Beverage Products and Their Technologies', in Taylor, J. R. N. and Duodu, K. G. (eds.) *Sorghum and Millets, Chemistry, Technology and Nutritional Attributes 2nd edition*. Cambridge: AACC International Press, pp. 259–292.

Teall, E. K. (2014) 'Medicine and Doctoring in Ancient Mesopotamia', *Grand Valley Journal of History*. 3(1), 1–8.

Tekin, M., Martin, E., Ozek, T., Yilmaz G.and Baser K. H. C. (2018) 'Essential oil characterization of Cousinia sivasica Hub.-Mor. (Asteraceae)', *BioDiCon*. 651-0217.

Tengberg, M. (2012) 'Beginnings and early history of date palm garden cultivation in the Middle East', *Journal of Arid Environments*. 86, 139–147. doi: 10.1016/J.JARIDENV.2011.11.022.

Tilley, C. (1994) 'Space, place, landscape and perception: phenomenological perspectives', in Tilley, C. Y. (ed.) *A phenomenology of landscape: places, paths and monuments*. Oxford: Berg, pp. 7–34.

Tilley, C. (2004) *The Materiality of Stone: Explorations in Landscape Phenomenology*. Oxford and New York: Berg.

Tilley, C. (2016) *Interpreting Landscapes: Geologies, Topographies, Identities; Explorations in Landscape Phenomenology 3*. London and New York: Routledge.

Tivadar, B. and Luthar, B. (2005) 'Food, ethics and aesthetics', *Appetite*. 44(2), 215–233. doi: 10.1016/j.appet.2004.10.002.

Townshend, J. M. and Duka, T. (2005) 'Binge Drinking, Cognitive Performance and Mood in a Population of Young Social Drinkers', *Alcoholism: Clinical & Experimental Research*. 29(3), 317–325. doi: 10.1097/01.ALC.0000156453.05028.F5.

Trautvetter, S., Koelling-Speer, I. and Speer, K. (2009) 'Confirmation of phenolic acids and flavonoids in honeys by UPLC-MS. Apidologie', *Springer Verlag*. 40(2), 140–150.

Tringham, R. (2013) 'A Sense of Touch - the Full-Body Experience - in the Past and Present of Çatalhöyük, Turkey', in Day, J. (ed.) *Making Senses of the Past: Toward a Sensory Archaeology*. Carbondale: Center for Archaeological Investigations pp. 177–195.

Trümpelmann, L. (1981) 'Eine Kneipe in Susa', *Iranica Antiqua*. 16, pp. 35–44.

Tsartsidou, G. *et al*. (2008) 'Ethnoarchaeological study of phytolith assemblages from an agro-pastoral village in Northern Greece (Sarakini): development and application of a Phytolith Difference Index', *Journal of Archaeological Science*. 35(3), 600–613. doi: 10.1016/J.JAS.2007.05.008.

Tuan, Y. (1974) *Topophilia: A study of environmental perception, attitudes, and values*. Englewood Cliffs: Prentice-Hall.

Tucker, J. A., Vuchinich, R. E. and Sobell, M. B. (1982) 'Alcohol's Effects on Human Emotions: A Review of the Stimulation/Depression Hypothesis', *International Journal of the Addictions*. 17(1), 155–180. doi: 10.3109/10826088209054615.

Twiss, K. C. (2003) 'Food and Identity', *Anthropology News*. 44(8), 17. doi: 10.1111/an.2003.44.8.17

Twiss, K. C. (2007) 'We Are What We Eat', in Twiss, K. (ed.) *The Archaeology of food and identity*. Carbondale: Center of Archaeological Investigations, pp.1-15.

Twiss, K. C. (2008) 'Transformations in an early agricultural society: Feasting in the southern Levantine Pre-Pottery Neolithic', *Journal of Anthropological Archaeology*. 27(4), 418–442. doi: 10.1016/j.jaa.2008.06.002.

Twiss, K. C. (2012a) 'The Archaeology of Food and Social Diversity', *Journal of Archaeological Research*. 20(4), 357–395. doi: 10.1007/s10814-012-9058-5.

Twiss, K. C. (2012b) 'The Complexities of Home Cooking: Public Feasts and Private Meals Inside the Çatalhöyük House', in Pollock, S. (ed.) *Between Feasts and Daily Meals. Towards an Archaeology of Commensal Spaces, Special Volume 2*. eTopoi, Journal for Ancient Studies, pp. 53–73.

Twiss, K. C. (2015) 'Methodological and definitional issues in the archaeology of food', in Kerner, S., Chou, C., and Warmind, M. (eds.) *Commensality: from everyday food to feast*. London: Bloomsbury Publishing, pp. 89–98.

Tzedakis, Y., Martlew, H. and Jones, M. K. (2008) *Archaeology Meets Science: Biomolecular Investigations in Bronze Age Greece; The Primary Scientific Evidence, 1997–2003*. Oxford: Oxbow Books.

Urem-Kotsou, D. and Kotsakis, K. (2007) 'Pottery , Cuisine and Community in the Neolithic of North Greece', in Renard, J. and Mee, C. (eds.) *Cooking up the Past: Food and Culinary Practices in the Neolithic and Bronze Aegean*. Oxford and New York: Oxbow Books, pp. 225–246.

Vabø, M. and Hansen, H. (2014) 'The Relationship between Food Preferences and Food Choice: A Theoretical Discussion', *International Journal of Business and Social Science*. 5, 145–157.

Valtz, E. (2002-2003) 'La Ceramica dei Livelli II e I', in Bergamini, G., Gabutti, A., and Valtz, E. (eds) *La Ceramica di Tell Yelkhi. Mesopotamia 36-38*, pp. 265–320.

VanDerwarker, A. M., Scarry, C. M. and Eastman, J. M. (2007) 'Menus for Families and Feasts: Household and Community Consumption of Plants at Upper Saratown, North Carolina', in Twiss, K. (ed.) The *Archaeology Food and Identity*. Carbondale: Center of Archaeological Investigations, pp. 16–49.

Varlinskaya, E. I., Spear, L. P. and Spear, N. E. (2001) 'Acute effects of ethanol on behaviour of adolescent rats: role of social context', *Alcoholism: Clinical and Experimental Research*. 25, 377–385.

Veblen, T. (1953) *The theory of the leisure class*. New York: New American Library.

van der Veen, M. (2003) 'When is food a luxury?', *World Archaeology*. 34(3), 405–427. doi: 10.1080/0043824021000026422.

van der Veen, M. (2008) 'Food as embodied material culture: diversity and change in plant food consumption in Roman Britain', *Journal of Roman Archaeology*. 21, 83–109. doi: 10.1017/S1047759400004396.

Ventura, A. K. and Worobey, J. (2013) 'Early Influences on the Development of Food Preferences', *Current Biology*. 23(9), R401–R408. doi: 10.1016/j.cub.2013.02.037.

Verbeek, C. and van Campen, C. (2013) 'Inhaling Memories', *The Senses and Society*. 8(2), 133–148. doi: 10.2752/174589313X13589681980696.

Vermaak, P. S. (2007) 'Relations Between Babylonia And The Levant During The

Kassite Period', in Leick, G. (ed.) *The Babylonian World*. Abingdon: Routledge, pp. 515–526.

Wang, J. *et al*. (2016) 'Revealing a 5,000-y-old beer recipe in China.', *Proceedings of the National Academy of Sciences of the United States of America*. National Academy of Sciences, 113(23), 6444–8. doi: 10.1073/pnas.1601465113.

Wang, J. *et al*. (2017) 'Identifying ancient beer brewing through starch analysis: A methodology', *Journal of Archaeological Science: Reports*. 15, 150–160. doi: 10.1016/j.jasrep.2017.07.016.

Wapnish, P. and Hesse, B. (1988) 'Urbanization and the organization of animal production at Tell Jemmeh in the Middle Bronze Age Levant', *Journal of Near Eastern Studies*. 47(2), 81–94. doi: https://doi.org/10.1086/373259.

Warde, A. (1997) *Consumption, Food and Taste: Culinary Antinomies and Commodity Culture*. London: Sage.

Warinner, C. *et al*. (2015) 'Direct evidence of milk consumption from ancient human dental calculus', *Scientific Reports*. 4(1), 7104. doi: 10.1038/srep07104.

Waskul, D. D., Vannini, P. and Wilson, J. (2009) 'The Aroma of Recollection: Olfaction, Nostalgia, and the Shaping of the Sensuous Self', *The Senses and Society*. 4(1), 5–22. doi: 10.2752/174589309X388546.

Weatherill, L. (1993) 'The meaning of consumer behaviour in late-seventeenth and early-eighteenth century England', in Brewer, J. and Porter, R. (eds.) *Consumption and the World of Goods*. London: Routledge, pp. 206–227.

Webber, H. J., Reuther, W. and Lawton, H. W. (1967) 'History and development of the citrus industry', in Reuther, W., Webber, H. J., and Batchelor, L. D. (eds.) *The citrus industry 1. History, distribution, botany, and varieties*. Berkeley: University of California, pp. 1–39.

Weber, J. and Zettler, R. (1998) 'Metal vessels', in Zettler, R. and Horne, L. (eds.) *Treasures from the Royal Tombs of Ur*. Philadelphia: University of Pennsylvania Press, pp. 125–142.

Weiss, G. (1960) 'Hallucinogenic and narcotic-like effects of powdered Myristica (nutmeg).', *The Psychiatric quarterly*. 34, 346–56.

Wendrich, W. and Ryan, P. (2012) 'Phytoliths and Basketry Materials at Çatalhöyük (Turkey): Timelines of growth, harvest and objects life histories', *Paléorient*. 38(1), 55–63. doi: 10.3406/paleo.2012.5458.

Wengrow, D. (2013) 'Fleshpots of Egypt: rethinking temple economy in the ancient Near East', in Frood, E. and McDonald, A. (eds.) *Decorum and experience: essays in ancient culture for John Baines*. Oxford: Griffith Institute Press, pp. 291–298.

Weyrich, L. S. *et al*. (2017) 'Neanderthal behaviour, diet, and disease inferred from ancient DNA in dental calculus', *Nature*. 544(7650), 357–361. doi: 10.1038/nature21674.

Whelton, H. L. *et al*. (2018) 'Strong bias towards carcass product processing at

Neolithic settlements in northern Greece revealed through absorbed lipid residues of archaeological pottery', *Quaternary International*. 496, 127–139. doi: 10.1016/j.quaint.2017.12.018.

White, C. D. (2005) 'Gendered food behaviour among the Maya', *Journal of Social Archaeology*. 5(3), 356–382. doi: 10.1177/1469605305057572.

White, C. L. and Beaudry, M. C. (2009) 'Artifacts and Personal Identity', in Majewski, T. and Gaimster, D. (eds.) *The International Handbook of Historical Archaeology*. New York: Springer, pp. 209–225.

Williams, E. Y. and West, F. (1968) 'The use of nutmeg as a psychotrpic drug. Report of two cases.', *Journal of the National Medical Association*. 60(4), 289–90.

Wilson, G. T. and Niaura, R. (1984) 'Alcohol and the disinhibition of sexual responsiveness', *Journal of Studies on Alcohol*. 45(3), 219–224.

Wolkstein, D. and Kramer, S. N. (1983) *Inanna, Queen of Heaven and Earth. Her Stories and Hymns From Sumer*. New York: Harper & Row.

Wood, R. (1995) *The Sociology of the Meal*. Edinburgh: Edinburgh University Press.

Woodward, I. (2012) 'Consumption as cultural interpretation: Taste, performativity, and navigating the forest of objects', inAlexander, J. C. Jacobs, R. N. and Smith, P. *The Oxford Handbook of Cultural Sociology*. New York: Oxford University Press.

Wooley, C. L. (1955) *Alalakh, an account of the Excavations at Tell Atchana in the Hatay, 1937-1949*. London: Oxford University Press.

Woolley, L. (1934) *Ur Excavations II: The Royal Cemetery*. London: Oxford University Press.

Woolley, L. (1965) *Ur Excavations VIII. The Kassite Period and the period of the Assyrian Kings*. London: Oxford University Press.

Wright, J. L. (2010) 'Commensal politics in ancient Western Asia: The background to Nehemiah's feasting (continued, Part II)', *Zeitschrift fur die Alttestamentliche Wissenschaft*. 122(3), 333–352. doi: 10.1515/ZAW.2010.024.

Wright Jr, H. E. (1962) 'Pleistocene glaciation in Kurdistan', *Eiszeitalter und Gegenwart. Quaternary Science Journal*. 12, 131–164.

Wright, K. I. (2014) 'Domestication and inequality? Households, corporate groups and food processing tools at Neolithic Çatalhöyük', *Journal of Anthropological Archaeology*. 33(1), 1–33. doi: 10.1016/j.jaa.2013.09.007.

Wright, N. J. *et al*. (2015) 'Woodland modification in Bronze and Iron Age central Anatolia: an anthracological signature for the Hittite state?', *Journal of Archaeological Science*. 55, 219–230. doi: 10.1016/J.JAS.2014.12.021.

Wu, S., Zorn, H., Krings, U. and Berger, R.G. (2005) 'Characteristic volatiles from young and aged fruiting bodies of wild Polyporus sulfureus (Bull.:Fr.) Fr.',

Journal of Agricultural and Food Chemistry, 53, 4524-4528.

Zajonc, R. B. (1980) 'Feeling and thinking: Preferences need no inferences.', *American Psychologist*. 35(2), 151–175. doi: 10.1037/0003-066X.35.2.151.

Zajonc, R. B. and Markus, H. (1982) 'Affective and Cognitive Factors in Preferences', *Journal of Consumer Research*. 9(2), 123–131. doi: 10.1086/208905.

Zangani, F. (2016) 'Amarna and Uluburun: Reconsidering Patterns of Exchange in the Late Bronze Age', *Palestine Exploration Quarterly*, 148 (4), 230–244.

Zarnkow, M., Otto, A. and Berthold, E. (2011) 'Interdisciplinary investigations into the brewing technology of the ancient near east and the potential of the cold mashing process', in Schiefenhövel, W. and Macbeth, H. (eds.) *Liquid Bread: Beer and Brewing in Cross-Cultural Perspective*. New York: Berghahn Books, pp. 47–54.

Zeder, M. A. (1991) *Feeding Cities. Specialized Animal Economy in the Ancient Near East*. Washington and London: Smithsonian Institution Press.

Zeder, M. A. (2011) 'The Origins of Agriculture in the Near East', *Current Anthropology*. 52(S4), S221–S235. doi: 10.1086/659307.

van Zeist, W. and Bottema, S. (1977) 'Palynological investigations in western Iran', *Palaeohistoria Bussum*. 19, 19–85.

van Zeist, W. and Casparie, W. A. (1968) 'Wild einkorn wheat and barley from Tell Mureybit in Northern Syria', *Acta Botanica Neerlandica*. 17(1), 44–53. doi: 10.1111/j.1438-8677.1968.tb00064.x.

Zettler, R. L. (1993) *Nippur, III. The Excavations at Nippur: Kassite Buildings in Area WC-I*. Chicago: University of Chicago Press.

Zettler, R. L. and Miller, N. F. (1995) 'Searching for wine in the archaeological record of ancient Mesopotamia of the 3rd and 2nd millennia B.C.', in McGovern, P. E., Fleming, S. J., and Katz, S. H. (eds.) *The Origins and Ancient History of Wine*. Newark: Gordon and Breach, pp. 123–131.

Zohary, D. and Hopf, M. (2000) *Domestication of Plant in the Old World. The Origin and Spread of Cultivated Plants in West Asia, Europe and Nile Valley*. Oxford: Oxford University Press.

Zubr, J. (1997) 'Oil-seed crop: Camelina sativa', *Industrial Crops and Products*. 6(2), 113–119. doi: 10.1016/S0926-6690(96)00203-8.

TO BE CONSUMED WITHOUT MODERATION

A trans-disciplinary approach to drinking, senses and belongingness in Late Bronze Age Mesopotamia through the analysis of ancient organic residues

APPENDICES

Archaeology
School of Humanities
College of Arts
University of Glasgow

2019

APPENDIX A
SAMPLES LISTS

These lists contain information about each sample analysed and presented in this thesis:

- BECS laboratory identifier (BECS I.D.) and my own identifier (I.D.)
- the export number (Exp.),
- the trench (Tr.), Locus (L.) and lot (l.) where the samples were discovered,
- the type of sample – Pottery sherd (Sherd), soil associated (Soil), inner surface of the sherd (Inner) and outer surface of the sherd (Outer)
- The amount of powdered sample analysed (P.W.D) and lipid extracted (TLE)
- The GC-MS and Column used for the analysis
- The sample dilution (Dil.) and external standard (E.S.) and internal standard (I.S.) used for the analysis

BECS I.D.	I.D.	Type	PWD (g)	TLE (mg)	GC-MS	Col.	Dil.	E.S.
1237	SRP 46 S1	Sherd	9,4	0,25	Shimadzu - QP2010	SGE BP1	100	BECS MIX
1238	SRP 46 Soil a	soil	8,02	0,92	Shimadzu - QP2010	SGE BP1	150	BECS MIX
1245	SRP 46 S2	Sherd	9,66	0,64	Shimadzu - QP2010	SGE BP1	100	BECS MIX
1247	SRP 46 S3	Sherd	9,62	0,46	Shimadzu - QP2010	SGE BP1	100	BECS MIX
1248	SRP 46 S4	Sherd	9,43	22,64	Shimadzu - QP2010	SGE BP1	400	BECS MIX
1249	SRP 46 S5	Sherd	8,01	0,42	Shimadzu - QP2010	SGE BP1	200	BECS MIX
1250	SRP 117 S1	Sherd	10,15	0,4	Shimadzu - QP2010	SGE BP1	400	BECS MIX
1251	SRP 117 S2	Sherd	9,79	0,38	Shimadzu - QP2010	SGE BP1	400	BECS MIX
1253	SRP 117 S3	Sherd	11,57	0,32	Shimadzu - QP2010	SGE BP1	400	BECS MIX
1254	SRP 117 S4	Sherd	10,07	0,21	Shimadzu - QP2010	SGE BP1	100	BECS MIX
1255	SRP 117 Soila	soil	8,23	0,44	Shimadzu - QP2010	SGE BP1	150	BECS MIX
1256	SRP 117 S5	Sherd	10,69	0,38	Shimadzu - QP2010	SGE BP1	100	BECS MIX
1257	SRP 117 S6	Sherd	10,01	0,24	Shimadzu - QP2010	SGE BP1	100	BECS MIX
1258	SRP 117 S7	Sherd	9,76	0,31	Shimadzu - QP2010	SGE BP1	100	BECS MIX
1259	SRP 117 S8	Sherd	10,67	0,45	Shimadzu - QP2010	SGE BP1	100	BECS MIX
1260	SRP 117 S9	Sherd	9,59	0,67	Shimadzu - QP2010	SGE BP1	400	BECS MIX
1261	SRP 117 Soilb	soil	8,14	0,57	Shimadzu - QP2010	SGE BP1	150	BECS MIX
1263	SRP 117 TLB 155	Sherd	10,05	0,48	Shimadzu - QP2010	SGE BP1	100	BECS MIX
1264	SRP 117 TLB 123-1	Sherd	8,58	0,34	Shimadzu - QP2010	SGE BP1	100	BECS MIX
1265	SRP 117 TLB 123-2	Sherd	9,25	0,56	Shimadzu - QP2010	SGE BP1	400	BECS MIX
1266	SRP 36 LB 23-1	Sherd	10,32	0,42	Shimadzu - QP2010	SGE BP1	100	BECS MIX
1267	SRP 117 TLB 167-1	Sherd	5,04	0,32	Shimadzu - QP2010	SGE BP1	100	BECS MIX
1268	SRP 117 TLB 167-2	Sherd	4,68	0,35	Shimadzu - QP2010	SGE BP1	100	BECS MIX
1269	SRP 117 TLB 156	Sherd	9,22	0,2	Shimadzu - QP2010	SGE BP1	100	BECS MIX
1270	SRP 36 LB 23-2	Sherd	9,1	1,73	Shimadzu - QP2010	SGE BP1	100	BECS MIX
1402	SRP 18 D1	Sherd	6,07	3,42	Shimadzu - QP2010	SGE BP1	100	BECS MIX

1403	SRP 18 D2	Sherd	11,07	7,6	Shimadzu - QP2010	SGE BP1	500	BECS MIX
1404	SRP 18 D3	Sherd	10,56	0,55	Shimadzu - QP2010	SGE BP1	100	BECS MIX
1405	SRP 19 B1	Sherd	12,29	1,31	Shimadzu - QP2010	SGE BP1	400	BECS MIX
1406	SRP 19 B2	Sherd	8,49	1,03	Shimadzu - QP2010	SGE BP1	400	BECS MIX
1407	SRP 18 C1	Sherd	11,56	0,69	Shimadzu - QP2010	SGE BP1	200	BECS MIX
1415	SRP 18 C2	Sherd	12,62	5,45	Shimadzu - QP2010	SGE BP1	500	BECS MIX
1416	SRP 18 C3	Sherd	12,77	1,61	Shimadzu - QP2010	SGE BP1	300	BECS MIX
1417	SRP 18 C4	Sherd	7,83	0,88	Shimadzu - QP2010	SGE BP1	500	BECS MIX
1418	SRP 19 B3	Sherd	8,79	1,01	Shimadzu - QP2010	SGE BP1	200	BECS MIX
1419	SRP 19 B4	Sherd	11,97	0,87	Shimadzu - QP2010	SGE BP1	500	BECS MIX

Table A.1: List of samples analysed for the Pilot study (year 2015)

Exp.	Tr.	L.	l.	Type	I.D.	BECS I.D.	PWD (g)	TLE (mg)	GC-MS	Col.	Dil.	E.S.
78	Y88	2	4	Sherd	KM1 2	1760	2,79	0,28	Shimadzu -QP2010	SGE BP1	100	BECS MIX
79	Y88	2	4	Soil		1761	9,65	4,87	Shimadzu -QP2010	SGE BP1	100	BECS MIX
83	Y88	2	4	Sherd	KM2 4	1750	5,45	0,35	Shimadzu -QP2010	SGE BP1	100	BECS MIX
83	Y88	2	4	Inner	KM2 4	1751	0,51	0,06	Shimadzu -QP2010	SGE BP1	100	BECS MIX
83	Y88	2	4	Outer	KM2 4	1752	0,36	0,12	Shimadzu -QP2010	SGE BP1	100	BECS MIX
151	Y88	1	1	Sherd	KM 30 1	2218	9,98	0,43	Agilent 5977a	Restek Rtx-1	100	BECS MIX
151	Y88	1	1	Inner	KM 30 1	2219	0,1	0,21	Agilent 5977a	Restek Rtx-1	100	BECS MIX
151	Y88	1	1	Outer	KM 30 1	2220	0,36	0,27	Agilent 5977a	Restek Rtx-1	100	BECS MIX
167	Y88	1	1	Sherd	KM41 1	2223	9,78	0,37	Agilent 5977a	Restek Rtx-1	100	BECS MIX
167	Y88	1	1	Inner	KM41 1	2224	0,2	0,47	Agilent 5977a	Restek Rtx-1	100	BECS MIX
167	Y88	1	1	Outer	KM41 1	2225	0,25	0,23	Agilent 5977a	Restek Rtx-1	100	BECS MIX
168	Y88	1	1	Sherd	KM 42 1	2215	9,9	0,33	Agilent 5977a	Restek Rtx-1	100	BECS MIX
168	Y88	1	1	Inner	KM 42 1	2216	0,34	0,28	Agilent 5977a	Restek Rtx-1	100	BECS MIX

168	Y88	1	1	Outer	KM 42 1	2217	0,19	0,31	Agilent 5977a	Restek Rtx-1	100	BECS MIX
82	Y88	1	1	Soil		1762	4,72	0,41	Shimadzu -QP2010	SGE BP1	100	BECS MIX
131	L80C	2	1	Sherd	KM 22 2	1922	5,27	0,17	Agilent 5977a	Restek Rtx-1	100	BECS MIX
131	L80C	2	1	Inner	KM 22 2	1923	0,05	0,09	Agilent 5977a	Restek Rtx-1	100	BECS MIX
131	L80C	2	1	Outer	KM 22 2	1924	0,12	0,08	Agilent 5977a	Restek Rtx-1	100	BECS MIX
82	L80C	2	1	Soil		1763	10,32	1,56	Shimadzu -QP2010	SGE BP1	100	BECS MIX
101	Y88	3	10	Sherd	KM11 2	1910	7,95	0,76	Agilent 5977a	Restek Rtx-1	100	BECS MIX
101	Y88	3	10	Inner	KM11 2	1911	0,17	0,48	Agilent 5977a	Restek Rtx-1	100	BECS MIX
101	Y88	3	10	Outer	KM11 2	1912	0,11	0,62	Agilent 5977a	Restek Rtx-1	100	BECS MIX
119	Y88	3	10	Sherd	KM 17 2	1777	11,16	0,79	Shimadzu -QP2010	SGE BP1	100	BECS MIX
119	Y88	3	10	Inner	KM 17 2	1779	0,16	0,09	Shimadzu -QP2010	SGE BP1	100	BECS MIX
119	Y88	3	10	Outer	KM 17 2	1780	0,24	0,11	Shimadzu -QP2010	SGE BP1	100	BECS MIX
126	Y88	3	8	Sherd	KM20 2	1774	9,77	0,8	Shimadzu -QP2010	SGE BP1	100	BECS MIX
126	Y88	3	8	Inner	KM20 2	1775	0,12	0,08	Shimadzu -QP2010	SGE BP1	100	BECS MIX
126	Y88	3	8	Outer	KM20 2	1776	0,14	0,03	Shimadzu -QP2010	SGE BP1	100	BECS MIX
100	Y88	3	10	Soil		1913	8,94	0,69	Agilent 5977a	Restek Rtx-1	100	BECS MIX
124	Y88	3	9	Sherd	KM19 2	1772	8,56	1,6	Shimadzu -QP2010	SGE BP1	100	BECS MIX
124	Y88	3	9	Outer	KM19 2	1773	0,64	0,1	Shimadzu -QP2010	SGE BP1	100	BECS MIX
119	Y88	3	10	Soil		1778	8,03	0,99	Shimadzu -QP2010	SGE BP1	100	BECS MIX
175	Y88	20	35	Sherd	KM 49 1	1747	10,88	0,34	Shimadzu -QP2010	SGE BP1	100	BECS MIX
175	Y88	20	35	Inner	KM 49 1	1748	0,22	0,14	Shimadzu -QP2010	SGE BP1	100	BECS MIX
175	Y88	20	35	Outer	KM 49 1	1749	0,19	0,09	Shimadzu -QP2010	SGE BP1	100	BECS MIX
182	Y88	20	35	Sherd	KM 55 1	1757	10,11	0,23	Shimadzu -QP2010	SGE BP1	100	BECS MIX
182	Y88	20	35	Inner	KM 55 1	1758	1,01	0,09	Shimadzu -QP2010	SGE BP1	100	BECS MIX
182	Y88	20	35	Outer	KM 55 1	1759	0,78	0,17	Shimadzu -QP2010	SGE BP1	100	BECS MIX
185	Y88	20	35	Sherd	KM 56 2	1756	4,08	0,16	Shimadzu -QP2010	SGE BP1	100	BECS MIX
184	Y88	20	35	Inner	KM 56 1	1754	0,37	0,18	Shimadzu -QP2010	SGE BP1	100	BECS MIX
184	Y88	20	35	Outer	KM 56 1	1755	0,48	0,13	Shimadzu -QP2010	SGE BP1	100	BECS MIX
174	Y88	20	35	Sherd	KM 48 1	2018	10,1	0,13	Agilent 5977a	Restek Rtx-1	100	BECS MIX

174	Y88	20	35	Inner	KM 48 1	2019	1,65	0,36	Agilent 5977a	Restek Rtx-1	100	BECS MIX
174	Y88	20	35	Outer	KM 48 1	2020	0,15	0,07	Agilent 5977a	Restek Rtx-1	100	BECS MIX
177	Y88	20	35	Sherd	KM 51 1	2015	8,8	0,48	Agilent 5977a	Restek Rtx-1	100	BECS MIX
177	Y88	20	35	Inner	KM 51 1	2016	1,51	0,16	Agilent 5977a	Restek Rtx-1	100	BECS MIX
177	Y88	20	35	Outer	KM 51 1	2017	0,15	0,1	Agilent 5977a	Restek Rtx-1	100	BECS MIX
181	Y88	35	113	Sherd	KM 54 2	1935	9,32	0,23	Agilent 5977a	Restek Rtx-1	100	BECS MIX
181	Y88	35	113	Inner	KM 54 2	1936	0,7	0,27	Agilent 5977a	Restek Rtx-1	100	BECS MIX
181	Y88	35	113	Outer	KM 54 2	1937	0,23	0,18	Agilent 5977a	Restek Rtx-1	100	BECS MIX
192	Y88	20	35	Soil		1765	10,93	0,76	Shimadzu -QP2010	SGE BP1	150	BECS MIX
157	Y88	17	22	Sherd	KM 34 1	1766	9,32	0,36	Shimadzu -QP2010	SGE BP1	100	BECS MIX
157	Y88	17	22	Inner	KM 34 1	1767	0,15	0,26	Shimadzu -QP2010	SGE BP1	100	BECS MIX
157	Y88	17	22	Outer	KM 34 1	1768	0,46	0,26	Shimadzu -QP2010	SGE BP1	100	BECS MIX
162	Y88	21	34	Sherd	KM 38 1	1769	10,45	0,23	Shimadzu -QP2010	SGE BP1	100	BECS MIX
162	Y88	21	34	Inner	KM 38 1	1770	0,11	0,26	Shimadzu -QP2010	SGE BP1	100	BECS MIX
162	Y88	21	34	Outer	KM 38 1	1771	0,26	0,32	Shimadzu -QP2010	SGE BP1	100	BECS MIX
196	Y88	40	46	Sherd	KM 66 1	1915	11,36	0,05	Agilent 5977a	Restek Rtx-1	100	BECS MIX
196	Y88	40	46	Inner	KM 66 1	1916	0,09	0,2	Agilent 5977a	Restek Rtx-1	100	BECS MIX
196	Y88	40	46	Outer	KM 66 1	1917	0,12	0,14	Agilent 5977a	Restek Rtx-1	100	BECS MIX
201	Y88	36	41	Sherd	KM 70 2	1938	10,24	0,68	Agilent 5977a	Restek Rtx-1	100	BECS MIX
201	Y88	36	41	Inner	KM 70 2	1939	2,17	0,35	Agilent 5977a	Restek Rtx-1	100	BECS MIX
201	Y88	36	41	Outer	KM 70 2	1940	0,37	0,34	Agilent 5977a	Restek Rtx-1	100	BECS MIX
201	Y88	36	41	Soil		1941	9,17	0,74	Agilent 5977a	Restek Rtx-1	100	BECS MIX
122	Y88	14	19	Sherd	KM18 2	1918	10,29	0,23	Agilent 5977a	Restek Rtx-1	100	BECS MIX
122	Y88	14	19	Inner	KM18 2	1919	0,92	0,11	Agilent 5977a	Restek Rtx-1	100	BECS MIX
122	Y88	14	19	Outer	KM18 2	1920	0,27	0,2	Agilent 5977a	Restek Rtx-1	100	BECS MIX
150	Y88	15	23	Sherd	KM 29 2	1781	10,16	0,48	Shimadzu -QP2010	SGE BP1	100	BECS MIX
150	Y88	15	23	Inner	KM 29 2	1782	1,15	0,15	Shimadzu -QP2010	SGE BP1	100	BECS MIX
150	Y88	15	23	Outer	KM 29 2	1783	0,66	0,16	Shimadzu -QP2010	SGE BP1	100	BECS MIX

Table A.2: List of samples analysed for this thesis (years 2016-2017)

Exp.	Tr.	L.	l.	Type	BECS I.D.	PWD (g)	TLE (mg)	GC-MS	Col.	Dil.	I.S. (µg/ml)
172	Y89	6	1	Sherd	2807	10,34	0,23	Agilent 5977a	Restek Rtx-1	80	C22 - 9,12
172	Y89	6	1	Inner	2808	0,14	0,27	Agilent 5977a	Restek Rtx-1	100	C22 - 10,24
172	Y89	6	1	Outer	2809	0,13	0,19	Agilent 5977a	Restek Rtx-1	100	C22 - 9,12
152	Y89	5	2	Soil	2546	10,15	0,17	Agilent 5977a	Restek Rtx-1	80	C22 - 9,12
280	Y89	6	1	Sherd	2752	11,34	0,38	Agilent 5977a	Restek Rtx-1	80	C22 - 9,12
280	Y89	6	1	Inner	2753	0,76	0,22	Agilent 5977a	Restek Rtx-1	80	C22 - 9,12
280	Y89	6	1	Outer	2754	0,63	0,12	Agilent 5977a	Restek Rtx-1	80	C22 - 9,12
274	Y89	6	1	Soil	2820	9,8	0,52	Agilent 5977a	Restek Rtx-1	80	C22 - 10,24
281	Y89	6	1	Sherd	2761	11,46	0,21	Agilent 5977a	Restek Rtx-1	80	C22 - 10,24
281	Y89	6	1	Inner	2762	0,19	0,17	Agilent 5977a	Restek Rtx-1	80	C22 - 10,24
281	Y89	6	1	Outer	2763	0,27	0,41	Agilent 5977a	Restek Rtx-1	80	C22 - 10,24
170	Y89	6	1	Sherd	2810	11,13	0,13	Agilent 5977a	Restek Rtx-1	80	C22 - 10,24
170	Y89	6	1	Inner	2811	1,23	0,22	Agilent 5977a	Restek Rtx-1	80	C22 - 10,24
170	Y89	6	1	Outer	2812	0,61	0,25	Agilent 5977a	Restek Rtx-1	80	C22 - 10,24
126	Y89	6	1	Soil	2745	10,41	0,72	Agilent 5977a	Restek Rtx-1	80	C22 - 9,12
178	K136D	4	2	Sherd	2736	10,26	0,26	Agilent 5977a	Restek Rtx-1	80	C22 - 9,12
178	K136D	4	2	Inner	2737	0,14	0,3	Agilent 5977a	Restek Rtx-1	80	C22 - 9,12
178	K136D	4	2	Outer	2738	0,56	0,17	Agilent 5977a	Restek Rtx-1	80	C22 - 9,12
137	K136D	4	2	Soil	2818	11,54	0,51	Agilent 5977a	Restek Rtx-1	80	C22 - 9,12
129	V85	157	1	Sherd	2324	9,83	0,05	Agilent 5977a	Restek Rtx-1	80	C22 - 9,12
129	V85	157	1	Inner	2325	1,02	0,07	Agilent 5977a	Restek Rtx-1	80	C22 - 9,12
129	V85	157	1	Outer	2326	2,67	0,1	Agilent 5977a	Restek Rtx-1	80	C22 - 9,12
129	V85	157	1	Soil	2327	9,66	0,6	Agilent 5977a	Restek Rtx-1	80	C22 - 9,12
148	Y89	4	3	Sherd	2328	12,25	0,84	Agilent 5977a	Restek Rtx-1	100	C22 - 9,12
148	Y89	4	3	Inner	2329	0,93	0,07	Agilent 5977a	Restek Rtx-1	100	C22 - 9,12

148	Y89	4	3	Outer	2330	0,28	0,58	Agilent 5977a	Restek Rtx-1	100	C22 - 9,12
145	Y89	5	2	Soil	2302	10,51	1,94	Agilent 5977a	Restek Rtx-1	80	C22 - 9,12
115	Y88	104	1	Sherd	2320	10,47	0,33	Agilent 5977a	Restek Rtx-1	80	C22 - 9,12
115	Y88	104	1	Inner	2321	9,54	0,69	Agilent 5977a	Restek Rtx-1	80	C22 - 9,12
115	Y88	104	1	Outer	2322	1,3	0,05	Agilent 5977a	Restek Rtx-1	80	C22 - 9,12
200	Y88	110	1	Sherd	2813	10,49	0,44	Agilent 5977a	Restek Rtx-1	80	C22 - 10,24
200	Y88	110	1	Inner	2814	1,01	0,16	Agilent 5977a	Restek Rtx-1	80	C22 - 10,24
200	Y88	110	1	Outer	2815	0,24	0,14	Agilent 5977a	Restek Rtx-1	80	C22 - 10,24
115	Y88	104	1	Soil	2323	10,18	0,63	Agilent 5977a	Restek Rtx-1	80	C22 - 9,12
135	Y89	5	4	Sherd	2749	11,72	0,52	Agilent 5977a	Restek Rtx-1	80	C22 - 9,12
135	Y89	5	4	Inner	2750	1,09	0,03	Agilent 5977a	Restek Rtx-1	80	C22 - 9,12
135	Y89	5	4	Outer	2751	0,05	0,42	Agilent 5977a	Restek Rtx-1	80	C22 - 9,12
140	Y89	5	2	Sherd	2317	10,65	0,24	Agilent 5977a	Restek Rtx-1	100	C22 - 9,12
140	Y89	5	2	Inner	2318	2,89	0,21	Agilent 5977a	Restek Rtx-1	100	C22 - 9,12
140	Y89	5	2	Outer	2319	0,1	0,25	Agilent 5977a	Restek Rtx-1	100	C22 - 9,12
191	Y89	5	6	Sherd	2732	10,6	66,92	Agilent 5977a	Restek Rtx-1	500	C22 - 10,24
191	Y89	5	6	Inner	2733	0,52	1,82	Agilent 5977a	Restek Rtx-1	500	C22 - 10,24
191	Y89	5	6	Outer	2734	0,15	0,36	Agilent 5977a	Restek Rtx-1	80	C22 - 10,24
147	Y89	5	2	Sherd	2306	9,9	0,58	Agilent 5977a	Restek Rtx-1	80	C22 - 9,12
147	Y89	5	2	Inner	2307	0,54	0,18	Agilent 5977a	Restek Rtx-1	80	C22 - 9,12
147	Y89	5	2	Outer	2308	0,45	0,52	Agilent 5977a	Restek Rtx-1	80	C22 - 9,12
150	Y89	5	2	Sherd	2303	10,99	0,46	Agilent 5977a	Restek Rtx-1	80	C22 - 9,12
150	Y89	5	2	Inner	2304	1,6	0,22	Agilent 5977a	Restek Rtx-1	80	C22 - 9,12
150	Y89	5	2	Outer	2305	0,25	0,32	Agilent 5977a	Restek Rtx-1	80	C22 - 9,12
196	Y89	5	6	Sherd	2746	10,81	48,27	Agilent 5977a	Restek Rtx-1	500	C22 - 10,24
196	Y89	5	6	Inner	2747	1,04	0,24	Agilent 5977a	Restek Rtx-1	80	C22 - 10,24
196	Y89	5	6	Outer	2748	0,29	0,43	Agilent 5977a	Restek Rtx-1	80	C22 - 10,24
142	Y89	5	6	Soil	2819	10,42	0,84	Agilent 5977a	Restek Rtx-1	80	C22 - 10,24

158	Y88	113	1	Sherd	2540	10,2	83,74	Agilent 5977a	Restek Rtx-1	500	C22 - 10,24
158	Y88	113	1	Inner	2541	0,08	0,28	Agilent 5977a	Restek Rtx-1	100	C22 - 10,24
158	Y88	113	1	Outer	2542	0,15	0,74	Agilent 5977a	Restek Rtx-1	80	C22 - 10,24
127	Y88	113	1	Soil	2544	10,26	0,52	Agilent 5977a	Restek Rtx-1	80	C22 - 9,12
187	Y88	110	1	Sherd	2755	11,33	0,26	Agilent 5977a	Restek Rtx-1	80	C22 - 10,24
187	Y88	110	1	Inner	2756	1,68	0,31	Agilent 5977a	Restek Rtx-1	80	C22 - 10,24
187	Y88	110	1	Outer	2757	1,82	0,18	Agilent 5977a	Restek Rtx-1	80	C22 - 10,24
128	Y88	110	1	Soil	2821	9,96	1,27	Agilent 5977a	Restek Rtx-1	80	C22 - 10,24
176	V85	164	4	Sherd	2599	10,25	0,24	Agilent 5977a	Restek Rtx-1	80	C22 - 9,12
176	V85	164	4	Inner	2600	0,32	0,11	Agilent 5977a	Restek Rtx-1	80	C22 - 9,12
176	V85	164	4	Outer	2601	0,35	0,22	Agilent 5977a	Restek Rtx-1	80	C22 - 9,12
121	V85	164	3	Sherd	2594	10,74	0,19	Agilent 5977a	Restek Rtx-1	80	C22 - 10,24
121	V85	164	3	Inner	2595	1,42	0,15	Agilent 5977a	Restek Rtx-1	80	C22 - 10,24
121	V85	164	3	Outer	2596	0,94	0,12	Agilent 5977a	Restek Rtx-1	80	C22 - 10,24
182	V85	164	1	Sherd	2591	8,48	0,43	Agilent 5977a	Restek Rtx-1	80	C22 - 10,24
182	V85	164	1	Inner	2592	0,13	0,48	Agilent 5977a	Restek Rtx-1	80	C22 - 10,24
182	V85	164	1	Outer	2593	0,26	0,19	Agilent 5977a	Restek Rtx-1	80	C22 - 10,24
155	V85	164	3	Sherd	2605	10,21	0,33	Agilent 5977a	Restek Rtx-1	80	C22 - 10,24
155	V85	164	3	Inner	2606	0,06	0,37	Agilent 5977a	Restek Rtx-1	80	C22 - 10,24
155	V85	164	3	Outer	2607	0,18	0,24	Agilent 5977a	Restek Rtx-1	80	C22 - 10,24
190	V85	164	5	Sherd	2723	9,64	0,68	Agilent 5977a	Restek Rtx-1	80	C22 - 9,12
190	V85	164	5	Inner	2724	0,18	0,43	Agilent 5977a	Restek Rtx-1	80	C22 - 9,12
190	V85	164	5	Outer	2725	0,16	0,1	Agilent 5977a	Restek Rtx-1	80	C22 - 9,12
193	V85	164	4	Sherd	2608	10,35	7,61	Agilent 5977a	Restek Rtx-1	500	C22 - 10,24
193	V85	164	4	Inner	2609	0,17	0,53	Agilent 5977a	Restek Rtx-1	80	C22 - 10,24
193	V85	164	4	Outer	2610	0,24	0,63	Agilent 5977a	Restek Rtx-1	80	C22 - 10,24
165	V85	164	5	Sherd	2602	11,33	0,33	Agilent 5977a	Restek Rtx-1	80	C22 - 9,12
165	V85	164	5	Inner	2603	0,14	0,23	Agilent 5977a	Restek Rtx-1	80	C22 - 9,12

165	V85	164	5	Outer	2604	0,1	0,35	Agilent 5977a	Restek Rtx-1	80	C22 - 9,12
122	V85	164	3	Soil	2598	9,91	1,66	Agilent 5977a	Restek Rtx-1	80	C22 - 9,12
171	V85	105	1	Sherd	2720	0,48	0,21	Agilent 5977a	Restek Rtx-1	80	C22 - 9,12
171	V85	105	1	Inner	2721	0,07	0,37	Agilent 5977a	Restek Rtx-1	80	C22 - 9,12
171	V85	105	1	Outer	2722	9,29	0,91	Agilent 5977a	Restek Rtx-1	80	C22 - 10,24
149	V85	103	1	Sherd	2332	10,45	0,36	Agilent 5977a	Restek Rtx-1	80	C22 - 9,12
149	V85	103	1	Inner	2333	1,03	0,07	Agilent 5977a	Restek Rtx-1	80	C22 - 9,12
149	V85	103	1	Outer	2334	0,23	0,1	Agilent 5977a	Restek Rtx-1	80	C22 - 9,12
151	V85	103	1	Soil	2335	10,29	0,61	Agilent 5977a	Restek Rtx-1	100	C22 - 9,12
175	Y88	108	1	Sherd	2728	11,29	0,51	Agilent 5977a	Restek Rtx-1	80	C22 - 9,12
175	Y88	108	1	Inner	2729	0,61	0,11	Agilent 5977a	Restek Rtx-1	80	C22 - 9,12
175	Y88	108	1	Outer	2730	0,38	0,4	Agilent 5977a	Restek Rtx-1	80	C22 - 9,12
132	Y88	108	1	Sherd	2309	10,45	0,48	Agilent 5977a	Restek Rtx-1	80	C22 - 9,12
132	Y88	108	1	Inner	2310	0,18	0,25	Agilent 5977a	Restek Rtx-1	80	C22 - 9,12
132	Y88	108	1	Outer	2311	0,19	0,39	Agilent 5977a	Restek Rtx-1	80	C22 - 9,12
132	Y88	108	1	Soil	2312	10,48	0,99	Agilent 5977a	Restek Rtx-1	80	C22 - 9,12
201	Y88	113	1	Sherd	2652	10,85	0,28	Agilent 5977a	Restek Rtx-1	80	C22 - 9,12
201	Y88	113	1	Inner	2653	1,91	0,1	Agilent 5977a	Restek Rtx-1	80	C22 - 9,12
201	Y88	113	1	Outer	2654	0,48	0,31	Agilent 5977a	Restek Rtx-1	80	C22 - 9,12
117	Y88	113	1	Soil	2655	11,13	0,78	Agilent 5977a	Restek Rtx-1	80	C22 - 9,12
186	V85	159	1	Sherd	2534	9,99	0,61	Agilent 5977a	Restek Rtx-1	80	C22 - 9,12
186	V85	159	1	Inner	2535	0,54	0,19	Agilent 5977a	Restek Rtx-1	80	C22 - 9,12
186	V85	159	1	Outer	2536	0,57	0,15	Agilent 5977a	Restek Rtx-1	80	C22 - 9,12
124	V85	159	1	Soil	2545	8,2	0,8	Agilent 5977a	Restek Rtx-1	80	C22 - 9,12
179	Y88	114	1	Sherd	2649	10	0,47	Agilent 5977a	Restek Rtx-1	80	C22 - 9,12
179	Y88	114	1	Inner	2650	0,42	0,06	Agilent 5977a	Restek Rtx-1	80	C22 - 9,12
179	Y88	114	1	Outer	2651	0,54	0,48	Agilent 5977a	Restek Rtx-1	80	C22 - 9,12
116	Y88	110	2	Soil	2817	11,98	0,51	Agilent 5977a	Restek Rtx-1	80	C22 - 10,24

156	Y89	5	6	Sherd	2742	10,94	0,2	Agilent 5977a	Restek Rtx-1	80	C22 - 9,12
156	Y89	5	6	Inner	2743	0,06	0,19	Agilent 5977a	Restek Rtx-1	80	C22 - 9,12
156	Y89	5	6	Outer	2744	0,09	0,29	Agilent 5977a	Restek Rtx-1	80	C22 - 9,12
136	Y89	5	6	Soil	2816	9,71	0,97	Agilent 5977a	Restek Rtx-1	80	C22 - 10,24
154	V85	164	3	Sherd	2739	10,18	0,8	Agilent 5977a	Restek Rtx-1	80	C22 - 9,12
154	V85	164	3	Inner	2740	0,24	0,41	Agilent 5977a	Restek Rtx-1	80	C22 - 9,12
154	V85	164	3	Outer	2741	0,34	0,52	Agilent 5977a	Restek Rtx-1	80	C22 - 9,12
125	V85	164	1	Soil	2597	9,67	0,63	Agilent 5977a	Restek Rtx-1	80	C22 - 10,24
130	Y88	108	1	Sherd	2313	9,89	0,62	Agilent 5977a	Restek Rtx-1	80	C22 - 9,12
130	Y88	108	1	Inner	2314	0,42	0,38	Agilent 5977a	Restek Rtx-1	80	C22 - 9,12
130	Y88	108	1	Outer	2315	0,92	0,29	Agilent 5977a	Restek Rtx-1	80	C22 - 9,12
130	Y88	108	4	Soil	2316	9,48	0,28	Agilent 5977a	Restek Rtx-1	80	C22 - 9,12
203	V85	117	2	Sherd	2758	10,42	0,34	Agilent 5977a	Restek Rtx-1	80	C22 - 10,24
203	V85	117	2	Inner	2759	1,11	0,21	Agilent 5977a	Restek Rtx-1	80	C22 - 10,24
203	V85	117	2	Outer	2760	0,61	0,09	Agilent 5977a	Restek Rtx-1	80	C22 - 10,24
180	V85	117	2	Sherd	2531	10,05	0,52	Agilent 5977a	Restek Rtx-1	80	C22 - 9,12
180	V85	117	2	Inner	2532	1,5	0,27	Agilent 5977a	Restek Rtx-1	80	C22 - 9,12
180	V85	117	2	Outer	2533	0,46	0,2	Agilent 5977a	Restek Rtx-1	80	C22 - 9,12
120	V85	117	2	Soil	2543	10,75	0,76	Agilent 5977a	Restek Rtx-1	80	C22 - 9,12
181	Y89	3	2	Sherd	2537	11,48	0,2	Agilent 5977a	Restek Rtx-1	80	C22 - 9,12
181	Y89	3	2	Inner	2538	0,06	0,15	Agilent 5977a	Restek Rtx-1	80	C22 - 9,12
181	Y89	3	2	Outer	2539	0,18	0,21	Agilent 5977a	Restek Rtx-1	80	C22 - 9,12
143	Y89	3	3	Soil	2331	9,85	2,69	Agilent 5977a	Restek Rtx-1	80	C22 - 9,12

Table A.3: List of samples analysed for this thesis (years 2017-2018)

Type	BECS I.D.	PWD (g)	TLE (mg)	GC-MS	Col.	Dil.	I.S. (µg/ml)
WHEAT BEER (freeze dried)	3044	0,13	2,36	Agilent 5977a	Restek Rtx-1	100	C22 - 9,12
BARLEY BEER (freeze dried)	3043	0,11	1,93	Agilent 5977a	Restek Rtx-1	100	C22 - 9,12
NUTMEG	2366	6,07	48,53	Agilent 5977a	Restek Rtx-1	500	C22 - 9,12
NUTMEG #2	3092	6,09	48,9	Agilent 5977a	Restek Rtx-1	500	n/a
MALTED BARLEY	2367	4,32	13,65	Agilent 5977a	Restek Rtx-1	500	C22 - 9,12
DATES	3090	5,77	13,4	Agilent 5977a	Restek Rtx-1	500	n/a

Table A.4: List of reference samples analysed for this thesis

APPENDIX B
Chromatograms Pilot Study

This appendix contains the chromatograms of each pilot study sample analysed and presented in this thesis, as well as control samples (soil samples and laboratory blanks).

The chromatogram is a two-dimensional plot with the ordinate axis giving average concentration in terms of detector response and the abscissa represents the retention time of each compound represented by a peak.

Major compounds and archaeologically significant compounds found exclusively in the sherd samples have been identified and labelled.

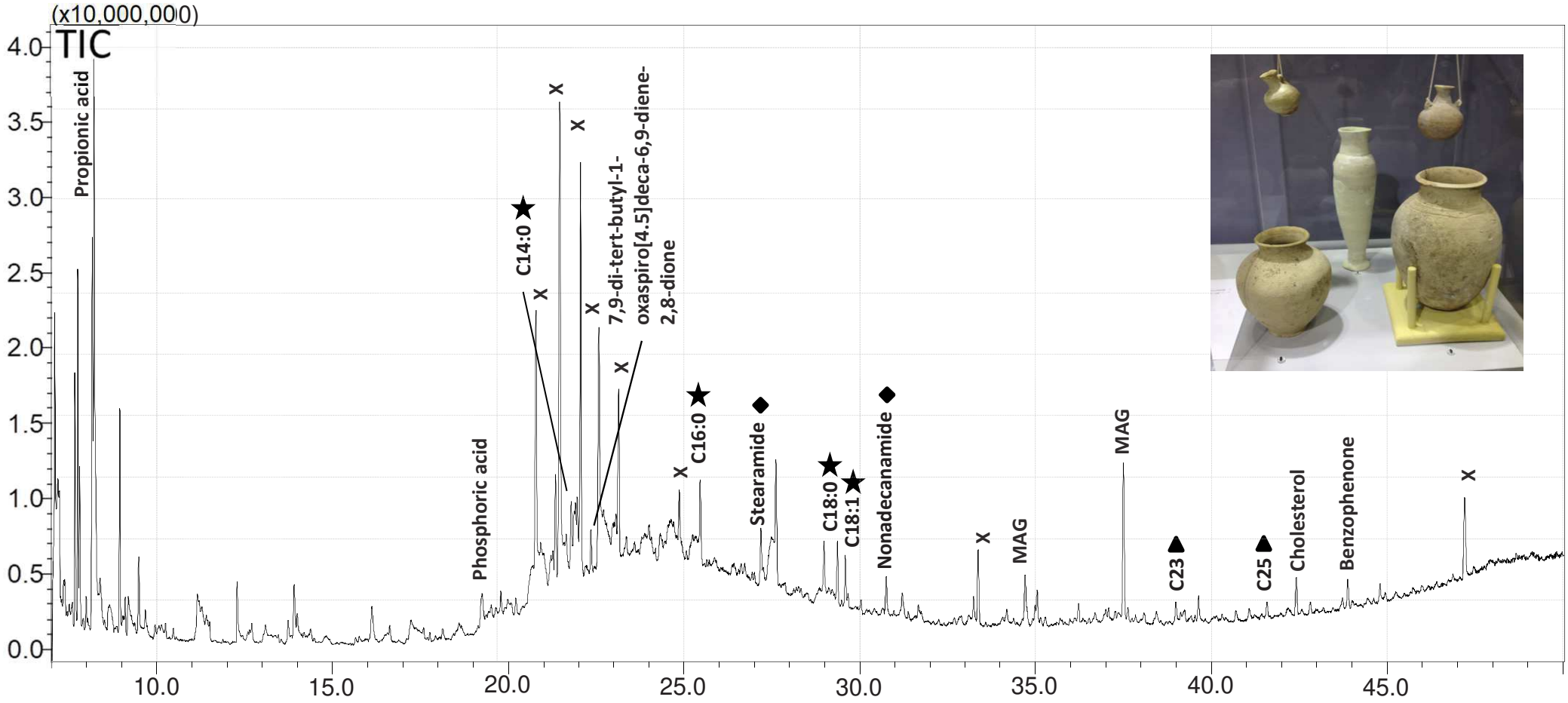


Fig. 1 : Partial total ion chromatogram of Sample BECS 1237 of a footed goblet from SRP 46: Cx:y fatty acids ★, CxOH alcohols ■ , Cx alkanes ▲ , aldehydes and amides ♦ , ketones ⬟ , **MAG** and **DAG** mono- and diacylglycerols, wax esters ● , plasticizers (cross).

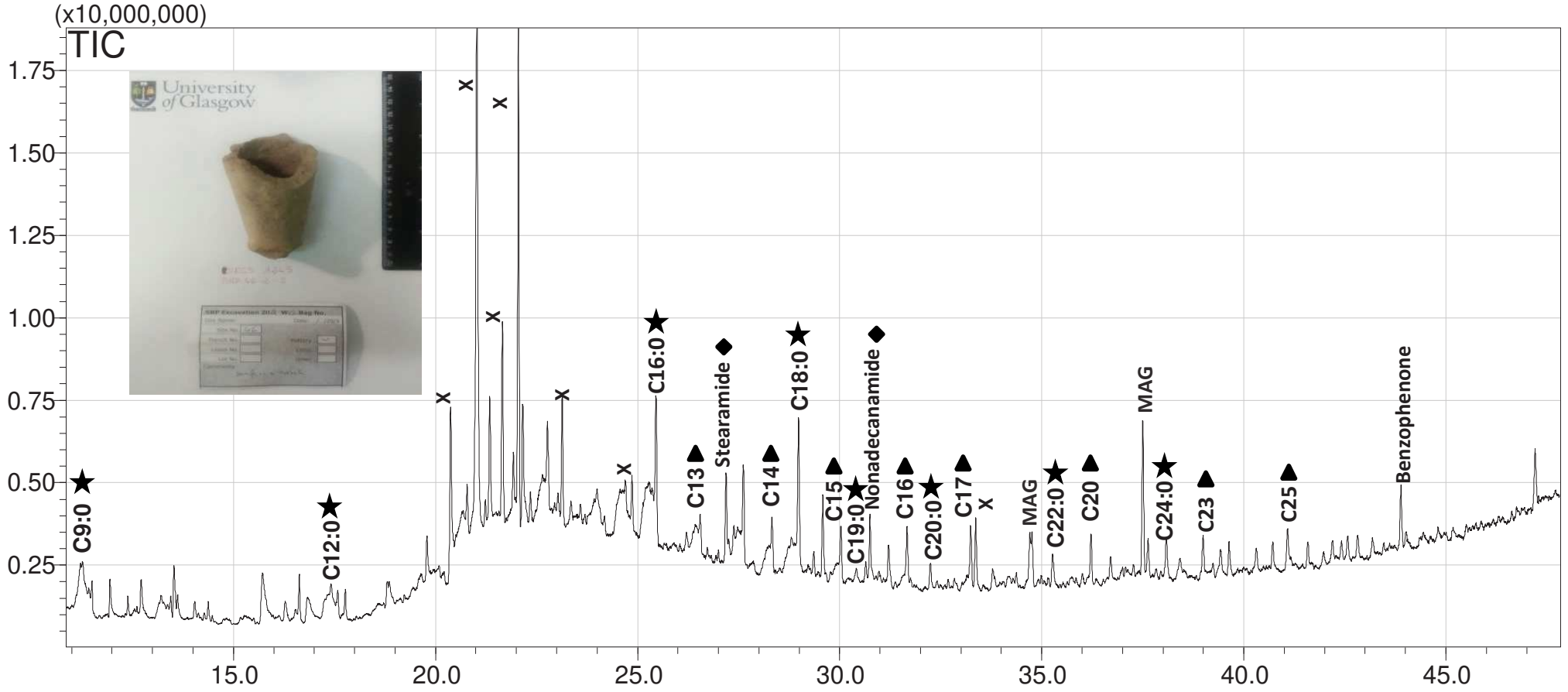


Fig. 2 : Partial total ion chromatogram of Sample BECS 1245 of a footed goblet from SRP 46: Cx:y fatty acids ★, CxOH alcohols ■ , Cx alkanes ▲ , aldehydes and amides ♦ , ketones ⬟ , **MAG** and **DAG** mono- and diacylglycerols, wax esters ● , plasticizers (cross).

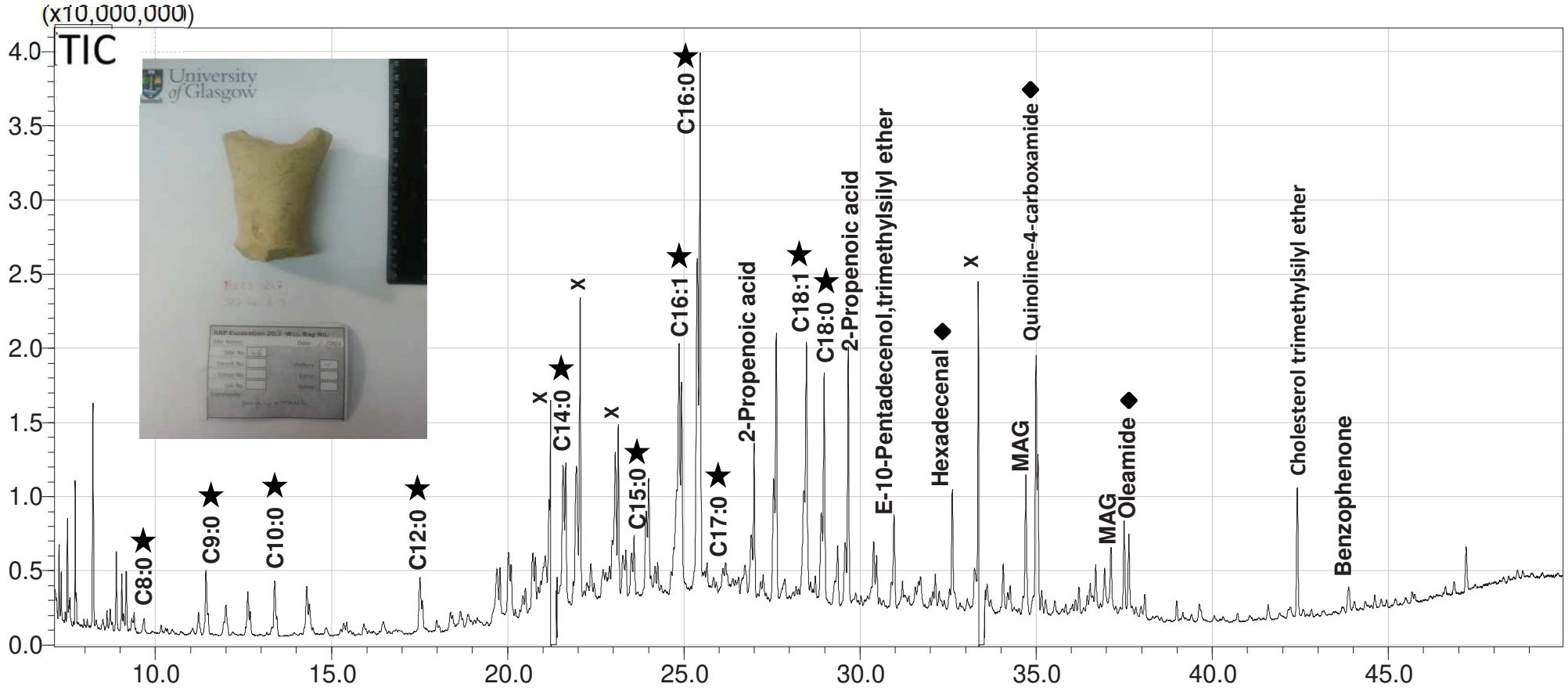


Fig. 3 : Partial total ion chromatogram of Sample BECS 1247 of a footed goblet from SRP 46: Cx:y fatty acids ★, CxOH alcohols ■ , Cx alkanes ▲ , aldehydes and amides ♦ , ketones ⬟ , **MAG** and **DAG** mono- and diacylglycerols, wax esters ● , plasticizers (cross).

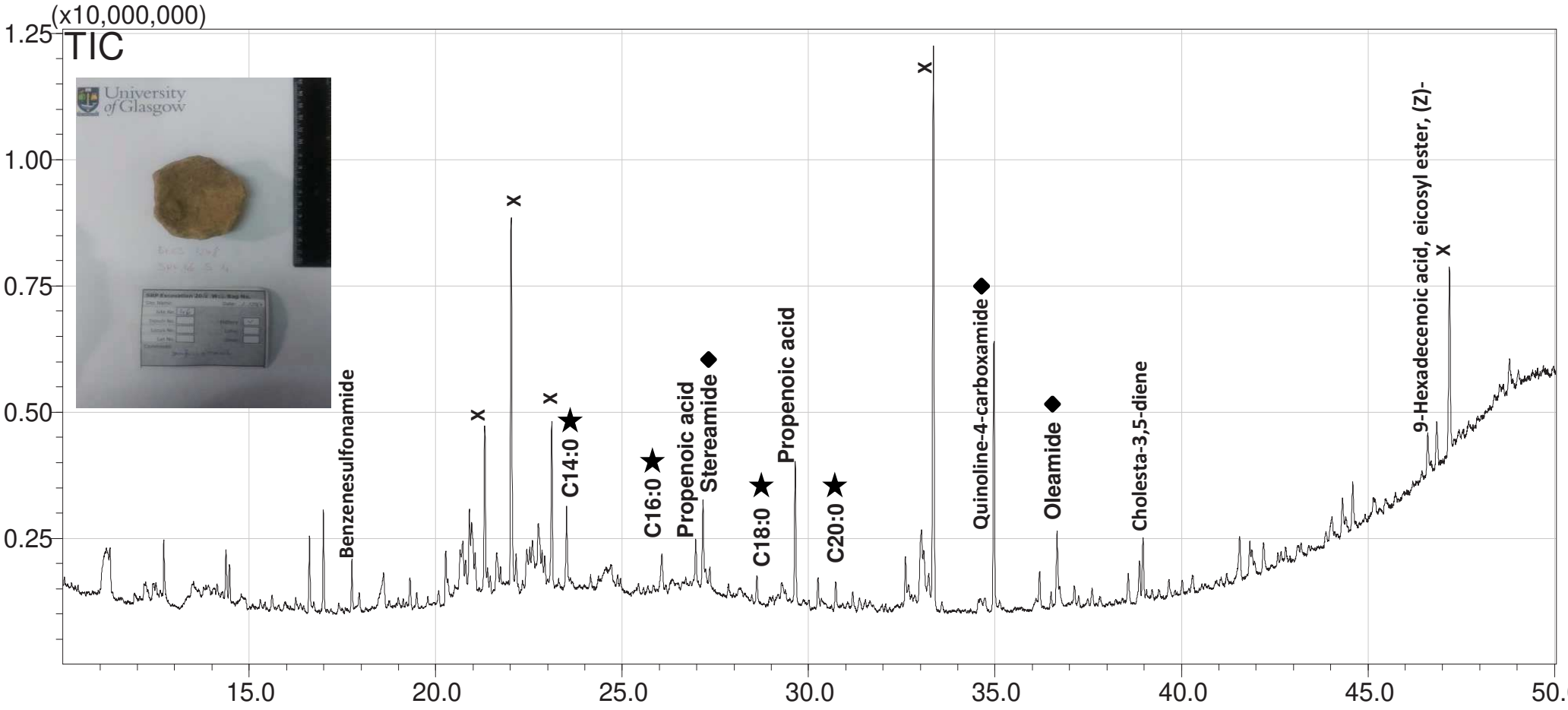


Fig. 4 : Partial total ion chromatogram of Sample BECS 1248 of an unknown vessel from SRP 46: Cx:y fatty acids ★, CxOH alcohols ■ , Cx alkanes ▲ , aldehydes and amides ♦ , ketones ⬟ , **MAG** and **DAG** mono- and diacylglycerols, wax esters ● , plasticizers (cross).

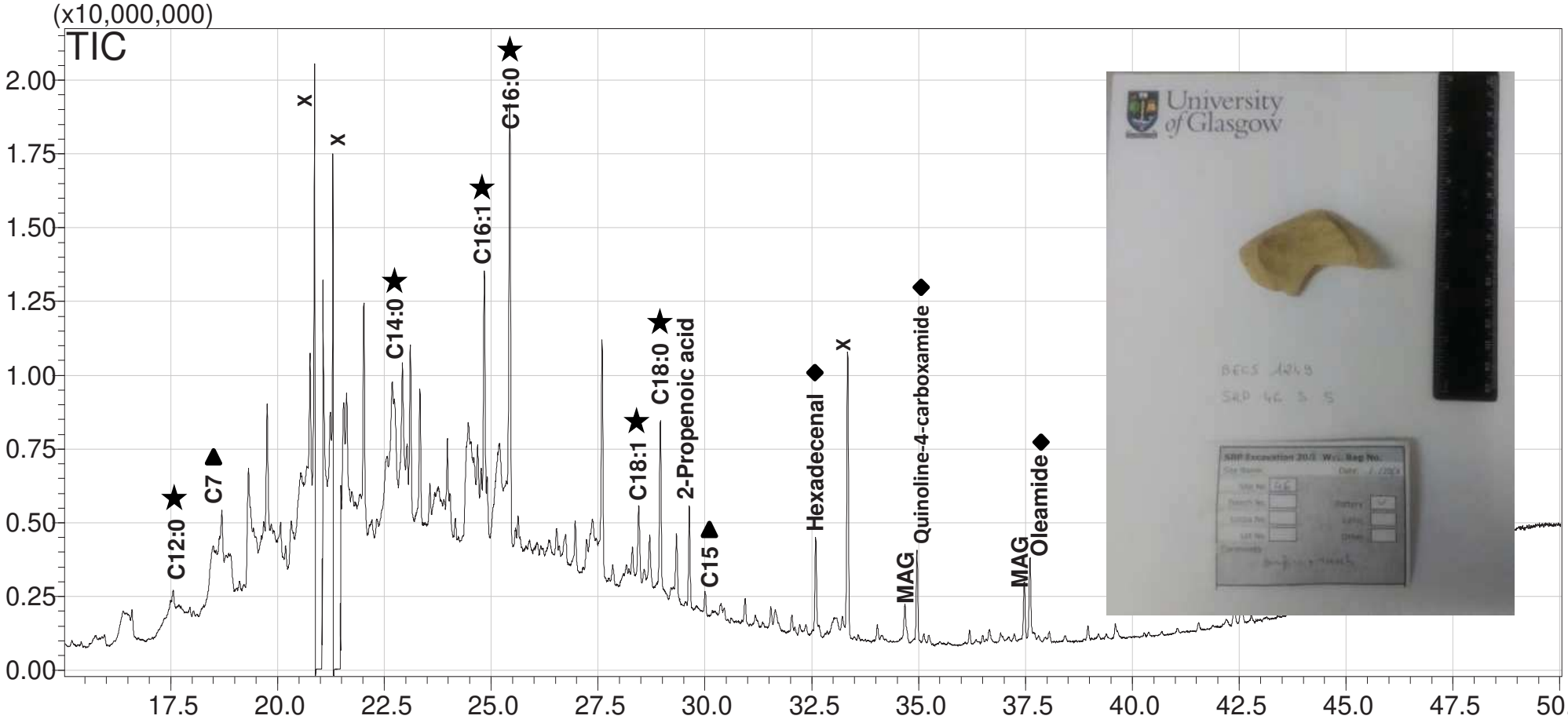


Fig. 5 : Partial total ion chromatogram of Sample BECS 1249 of a footed goblet from SRP 46: Cx:y fatty acids ★, CxOH alcohols ■, Cx alkanes ▲, aldehydes and amides ♦, ketones ⬟, **MAG** and **DAG** mono- and diacylglycerols, wax esters ●, plasticizers (cross).

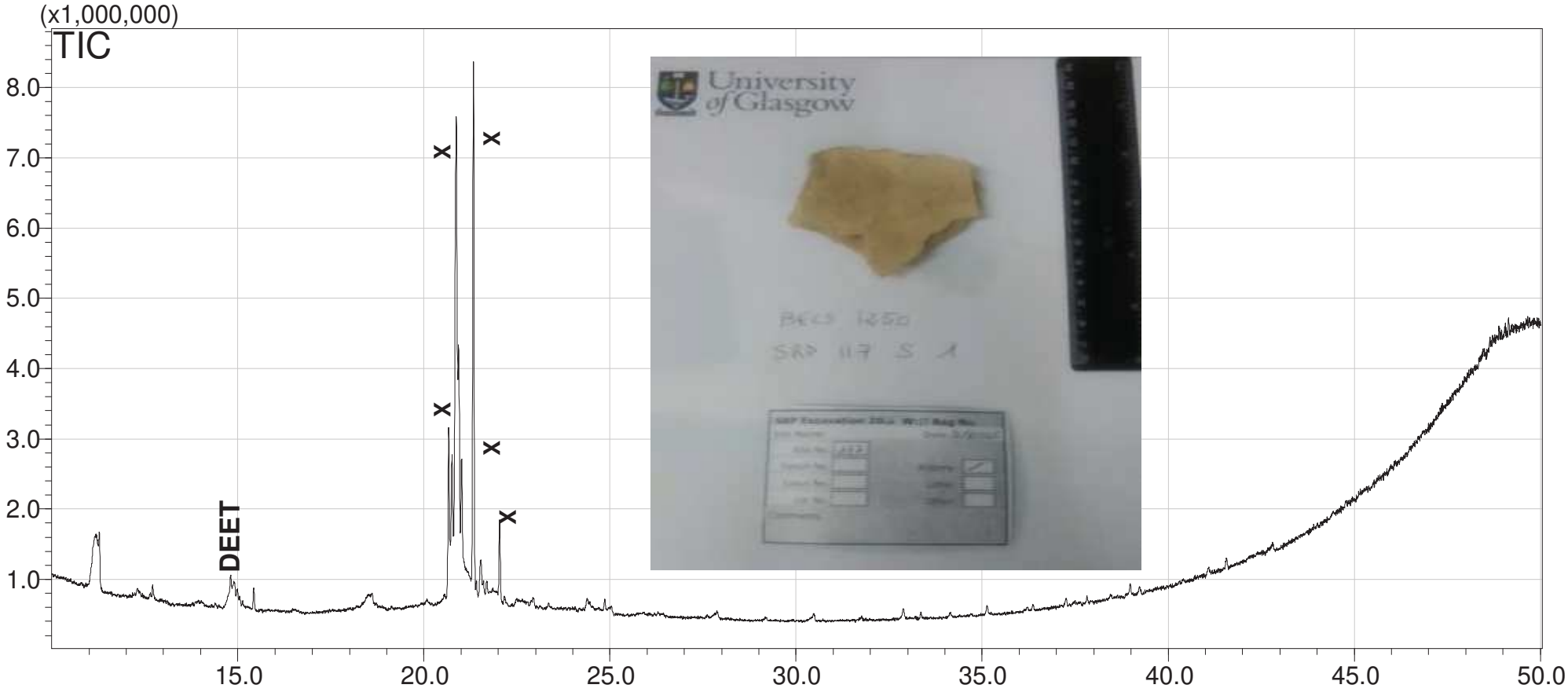


Fig. 6: Partial total ion chromatogram of Sample BECS 1250 of an unknown vessel from SRP 117: Cx:y fatty acids ★, CxOH alcohols ■ , Cx alkanes ▲ , aldehydes and amides ♦ , ketones ⬟ , **MAG** and **DAG** mono- and diacylglycerols, wax esters ● , plasticizers (cross).

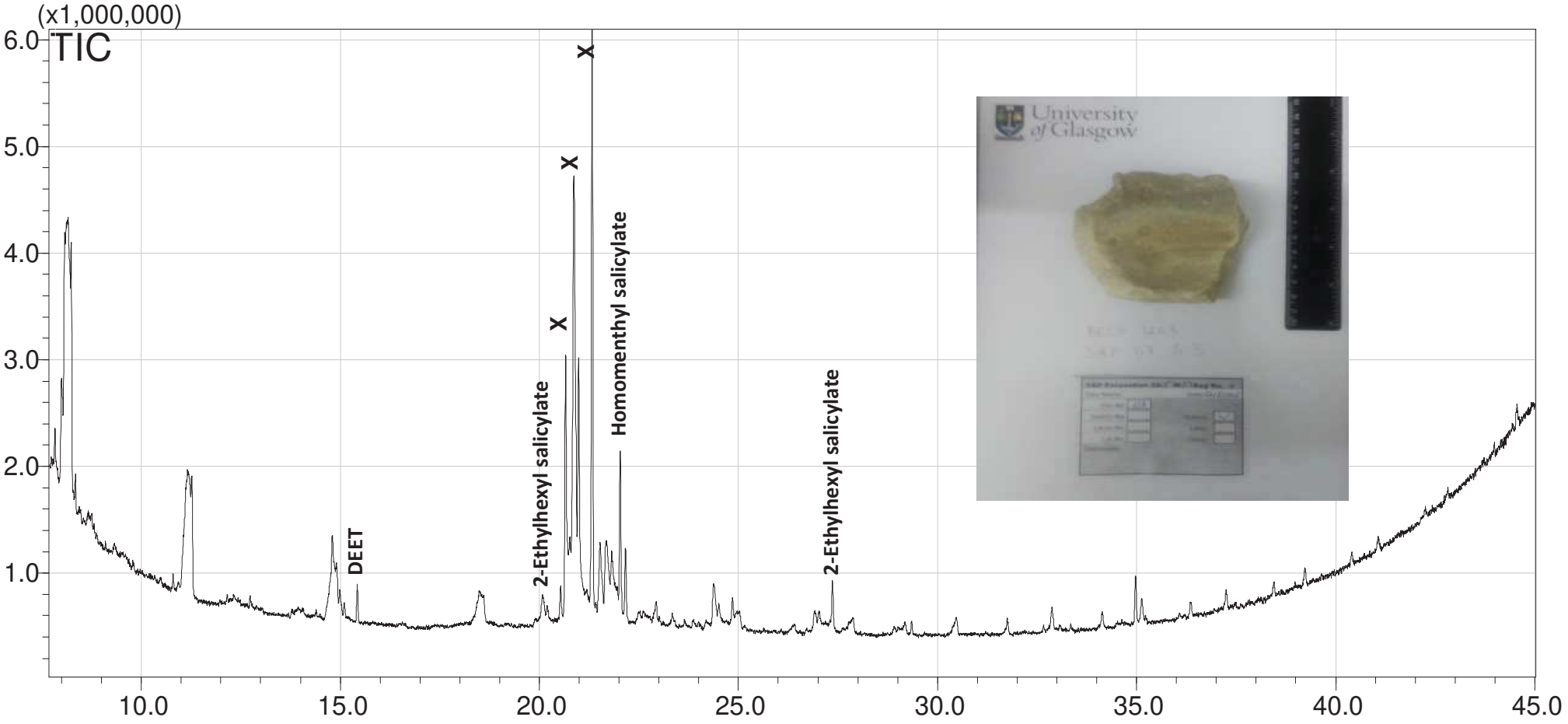


Fig. 7 : Partial total ion chromatogram of Sample BECS 1253 of an unknown vessel from SRP 117: Cx:y fatty acids ★, CxOH alcohols ■, Cx alkanes ▲ , aldehydes and amides ♦ , ketones ⬟ , **MAG** and **DAG** mono- and diacylglycerols, wax esters ● , plasticizers (cross).

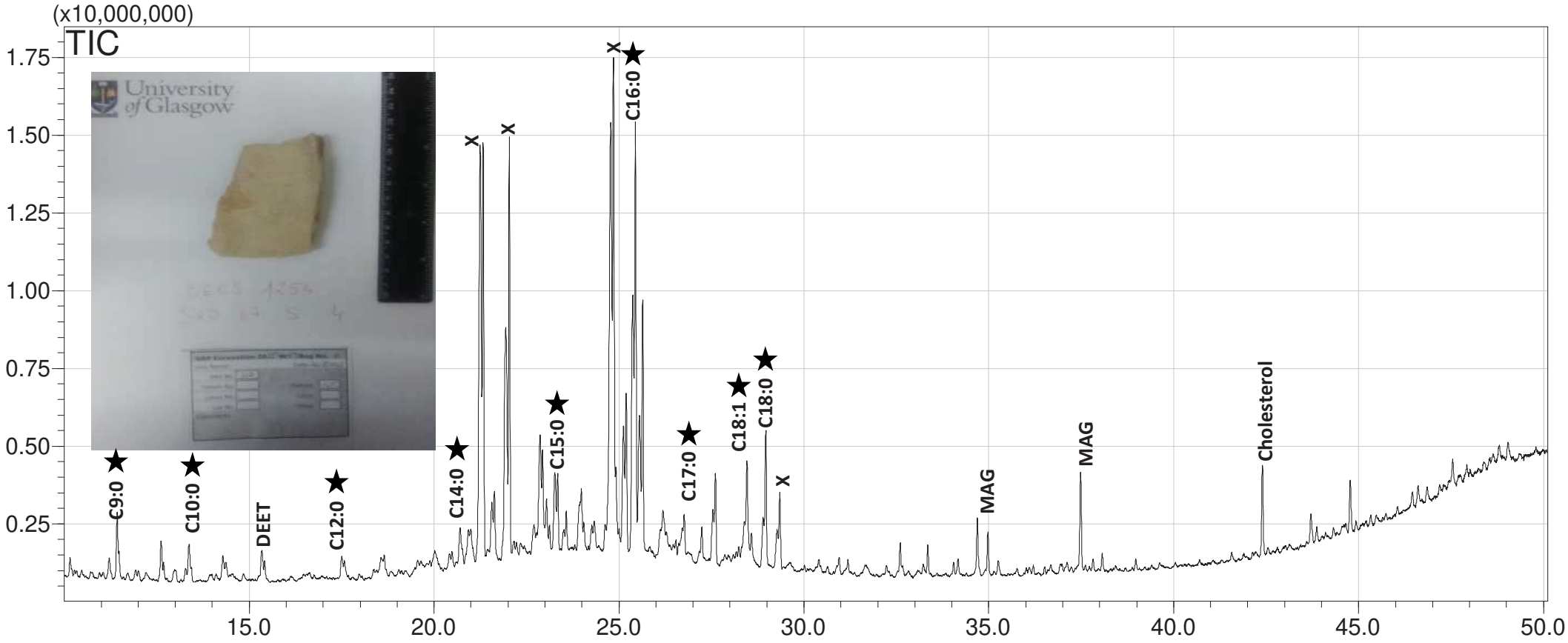


Fig. 8 : Partial total ion chromatogram of Sample BECS 1254 of an unknown vessel from SRP 117: Cx:y fatty acids ★, CxOH alcohols ■ , Cx alkanes ▲ , aldehydes and amides ♦ , ketones ⬟ , **MAG** and **DAG** mono- and diacylglycerols, wax esters ● , plasticizers (cross).

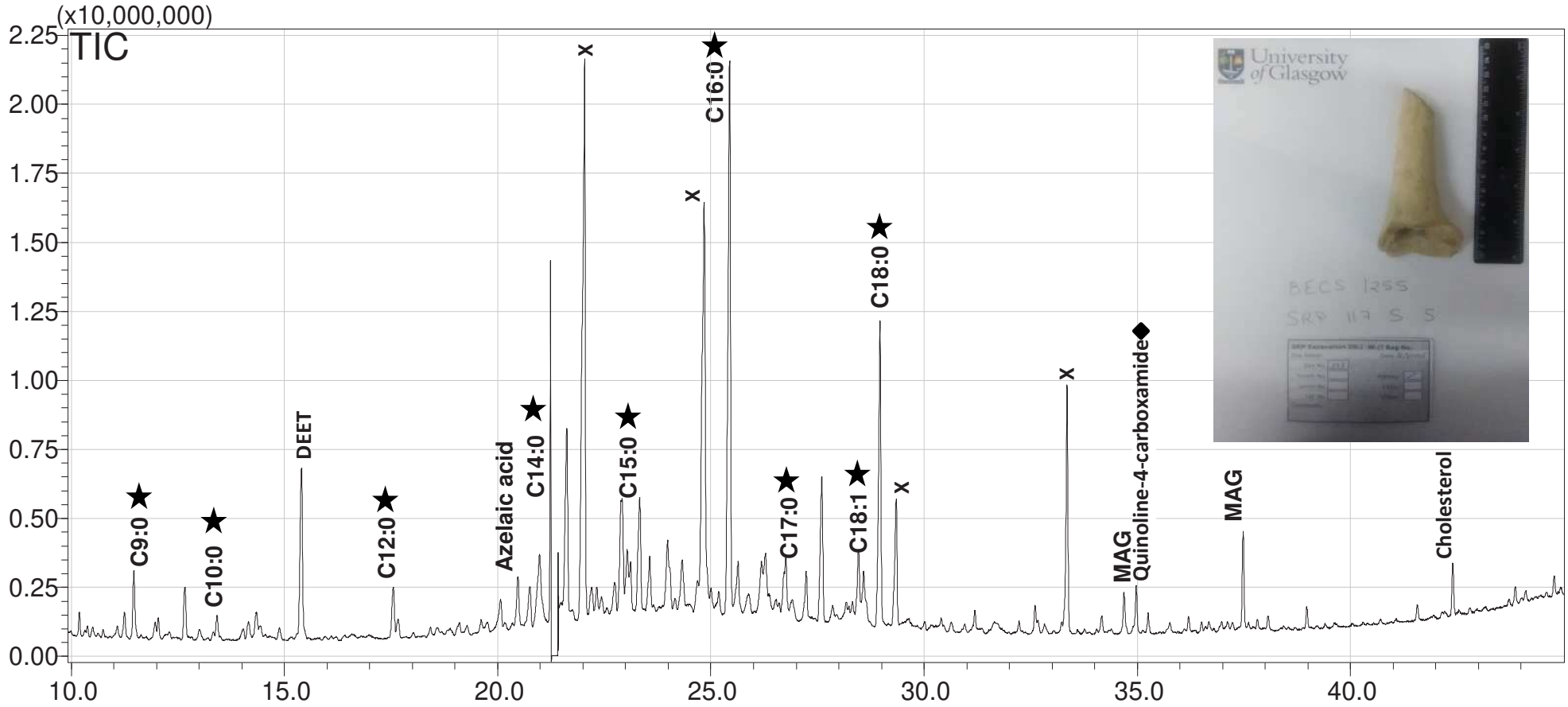


Fig. 9 : Partial total ion chromatogram of Sample BECS 1256 of spout from SRP 117: Cx:y fatty acids ★, CxOH alcohols ■ , Cx alkanes ▲ , aldehydes and amides ♦ , ketones ⬟ , **MAG** and **DAG** mono- and diacylglycerols, wax esters ● , plasticizers (cross).

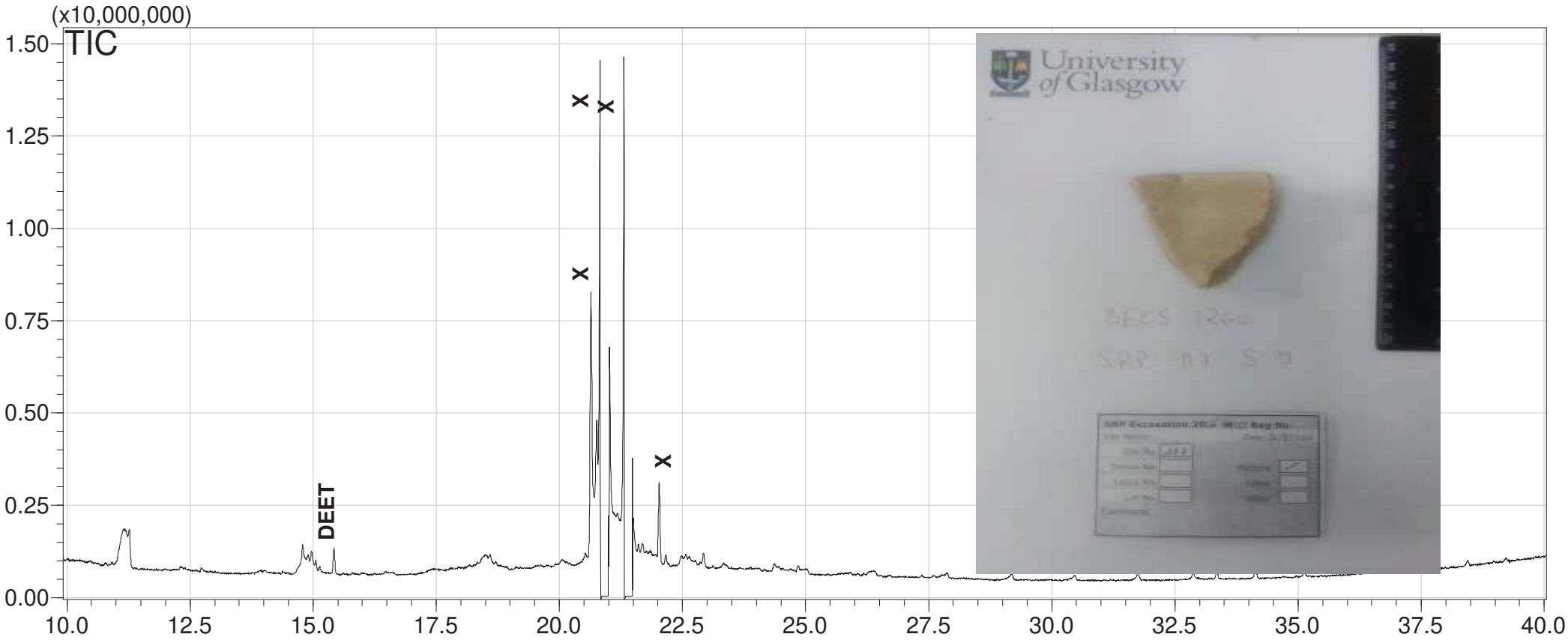


Fig. 10 : Partial total ion chromatogram of Sample BECS 1256 of an unknown vessel from SRP 36: Cx:y fatty acids ★, CxOH alcohols ■ , Cx alkanes ▲ , aldehydes and amides ♦ , ketones ⬟ , **MAG** and **DAG** mono- and diacylglycerols, wax esters ● , plasticizers (cross).

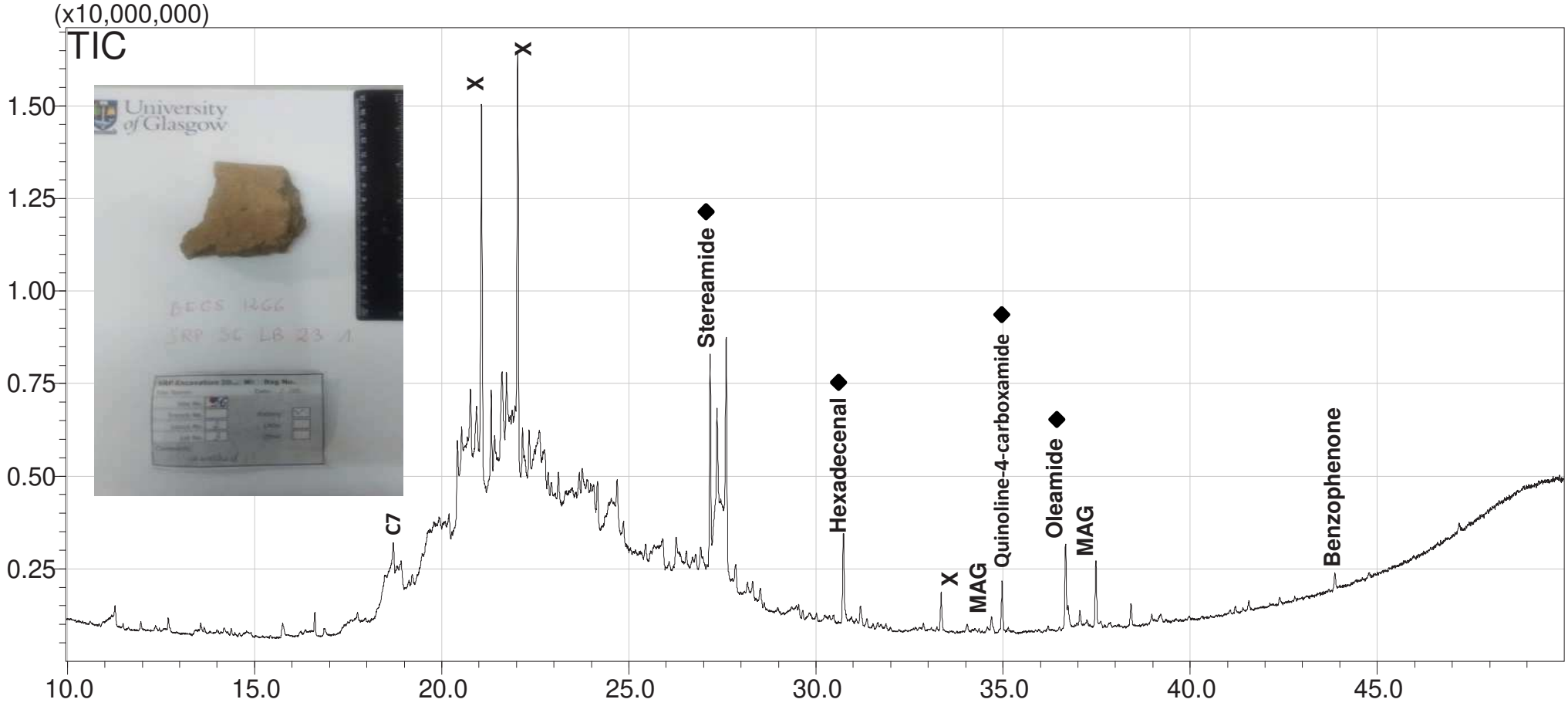


Fig. 11 : Partial total ion chromatogram of Sample BECS 1266 of an unknown vessel from SRP 36: Cx:y fatty acids ★, CxOH alcohols ■ , Cx alkanes ▲ , aldehydes and amides ♦ , ketones ⬟ , **MAG** and **DAG** mono- and diacylglycerols, wax esters ● , plasticizers (cross).

APPENDIX C
Chromatograms 2016-2017

This appendix contains the chromatograms of sample analysed in 2016-2017 and presented in this thesis, as well as control samples (soil samples, inner and outer surfaces samples and laboratory blanks).

The chromatogram is a two-dimensional plot with the ordinate axis giving average concentration in terms of detector response and the abscissa represents the retention time of each compound represented by a peak.

Major compounds and archaeologically significant compounds found exclusively in the sherd samples have been identified and labelled.

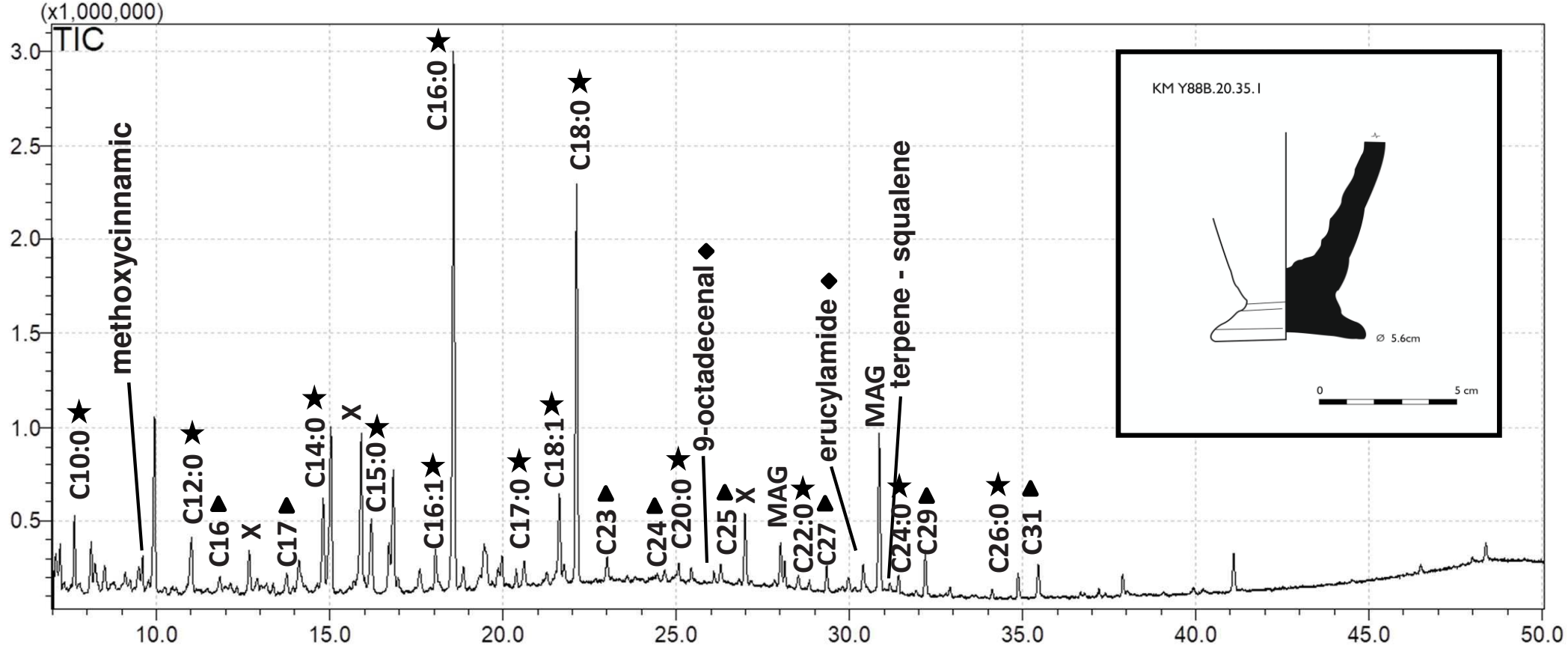


Fig. 12 : Partial total ion chromatogram of Sample KM49 – E175 (BECS 1747) of a 'Kassite' Goblet discovered in Trench Y88 (Locus 20 Lot 35) : Cx:y fatty acids ★, CxOH alcohols ■ , Cx alkanes ▲ , aldehydes and amides ♦ , ketones ⬟ , **MAG** and **DAG** mono- and diacylglycerols, wax esters ● , plasticizers (cross).

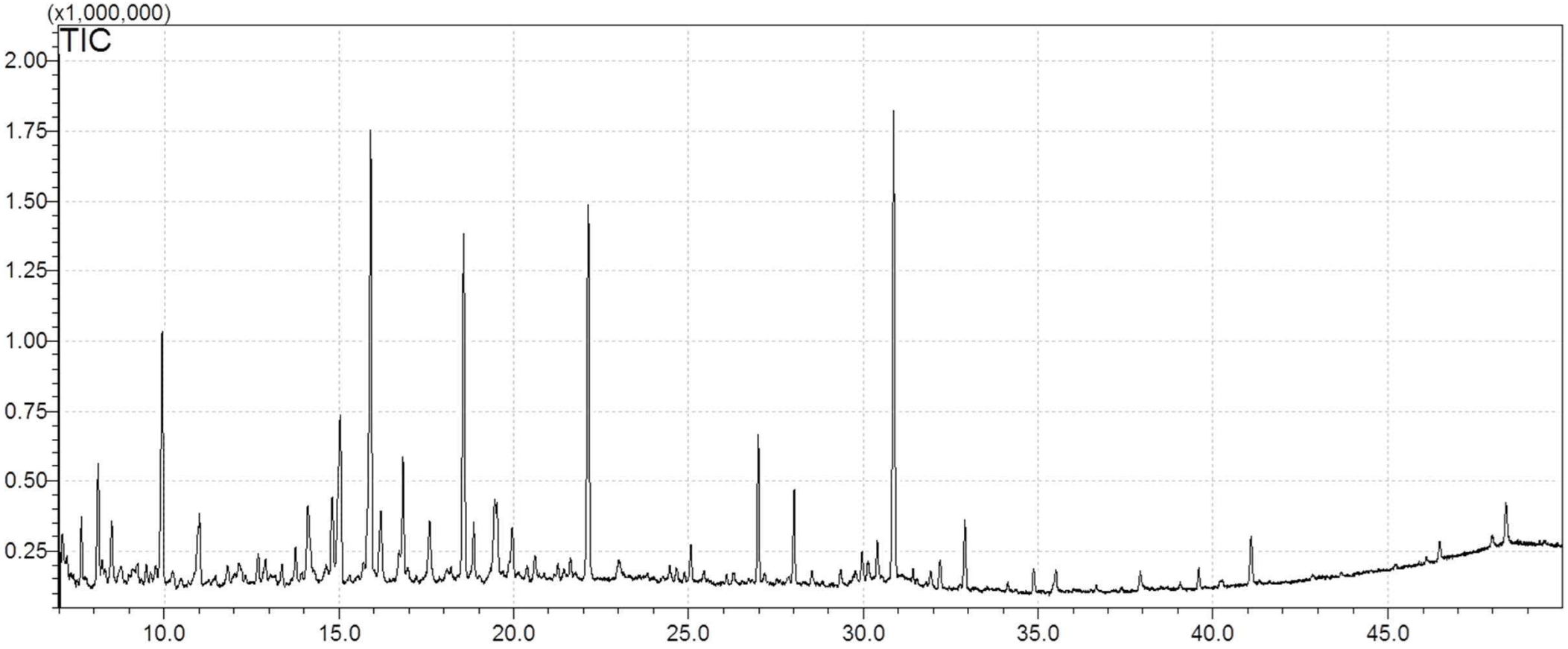


Fig. 13 : Partial total ion chromatogram of the inner surface (BECS 1748) of Sample KM49 – E175 (BECS 1747)

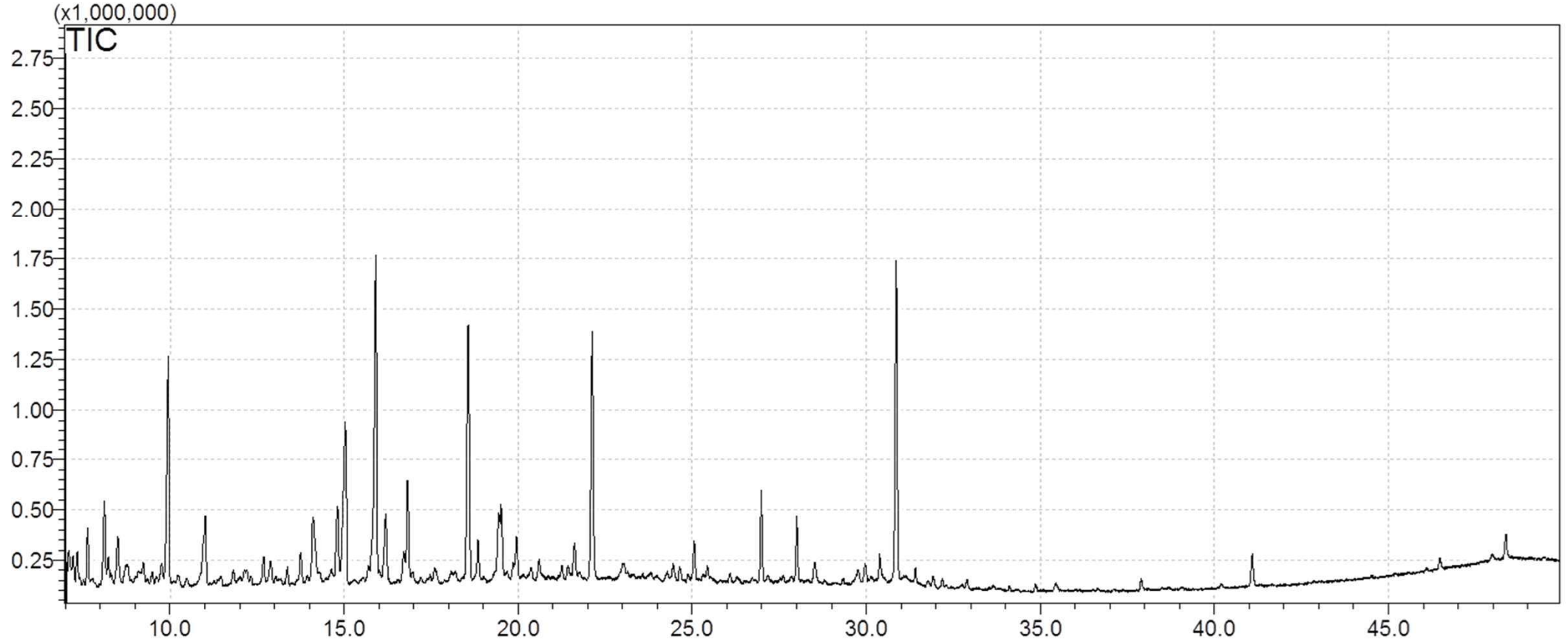


Fig. 14 : Partial total ion chromatogram of the outer surface (BECS 1749) of Sample KM49 – E175 (BECS 1747)

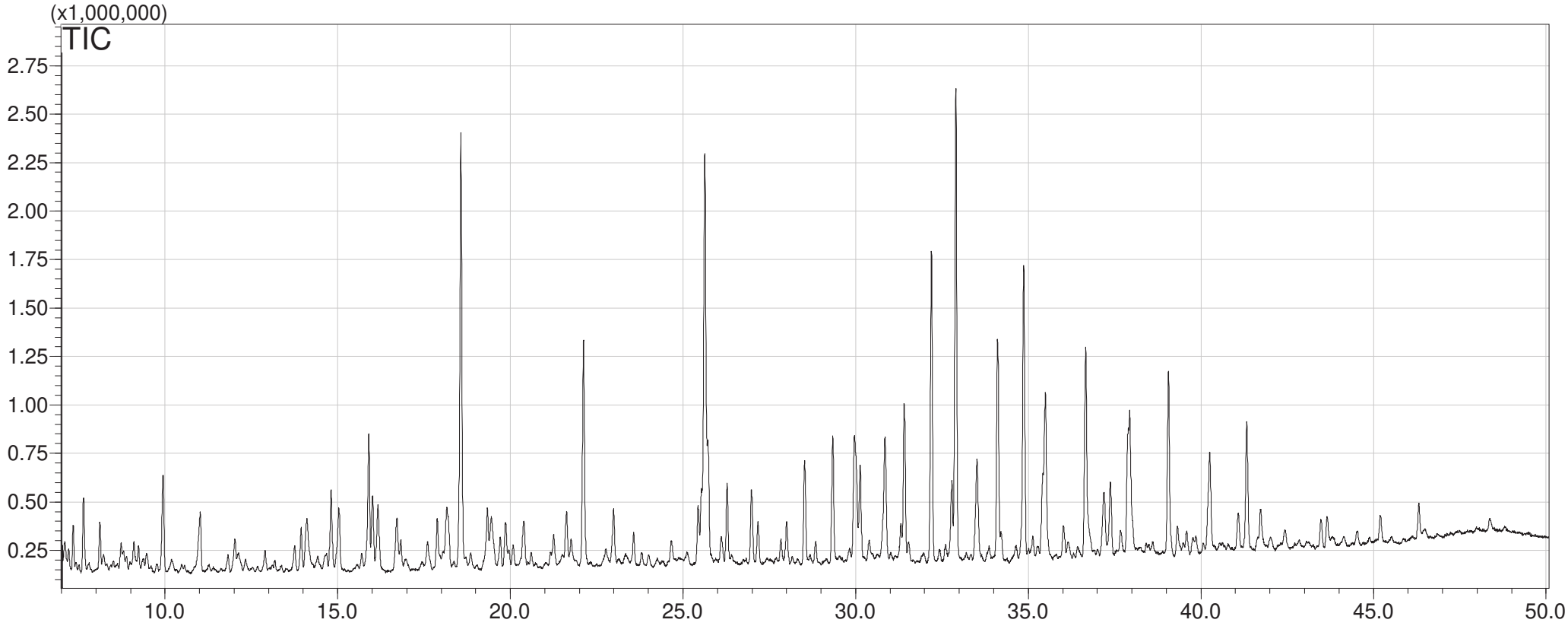


Fig. 15 : Partial total ion chromatogram of the soil sample (BECS 1765) associated with Samples KM49 – E175 (BECS 1747), KM56 – E184 (BECS 1756), KM55 – E182 (BECS 1757), KM51 – E177 (BECS 2015), KM48 – E174 (BECS 2018) and KM54 – E181 (BECS 1935).

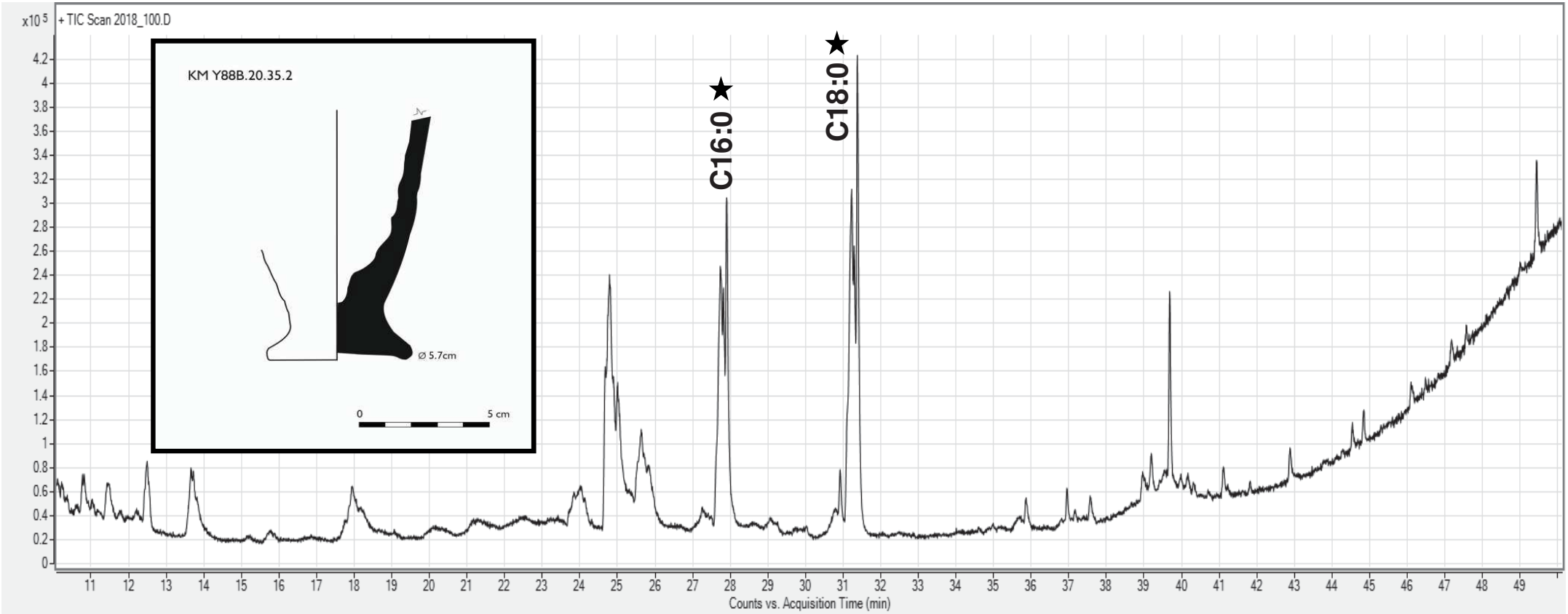


Fig. 16: Partial total ion chromatogram of Sample KM48– E174 (BECS 2018) of a 'Kassite' Goblet discovered in Trench Y88 (Locus 20 Lot 35): Cx:y fatty acids ★, CxOH alcohols ■ , Cx alkanes ▲ , aldehydes and amides ♦ , ketones ⬣ , **MAG** and **DAG** mono- and diacylglycerols, wax esters ● , plasticizers (cross).

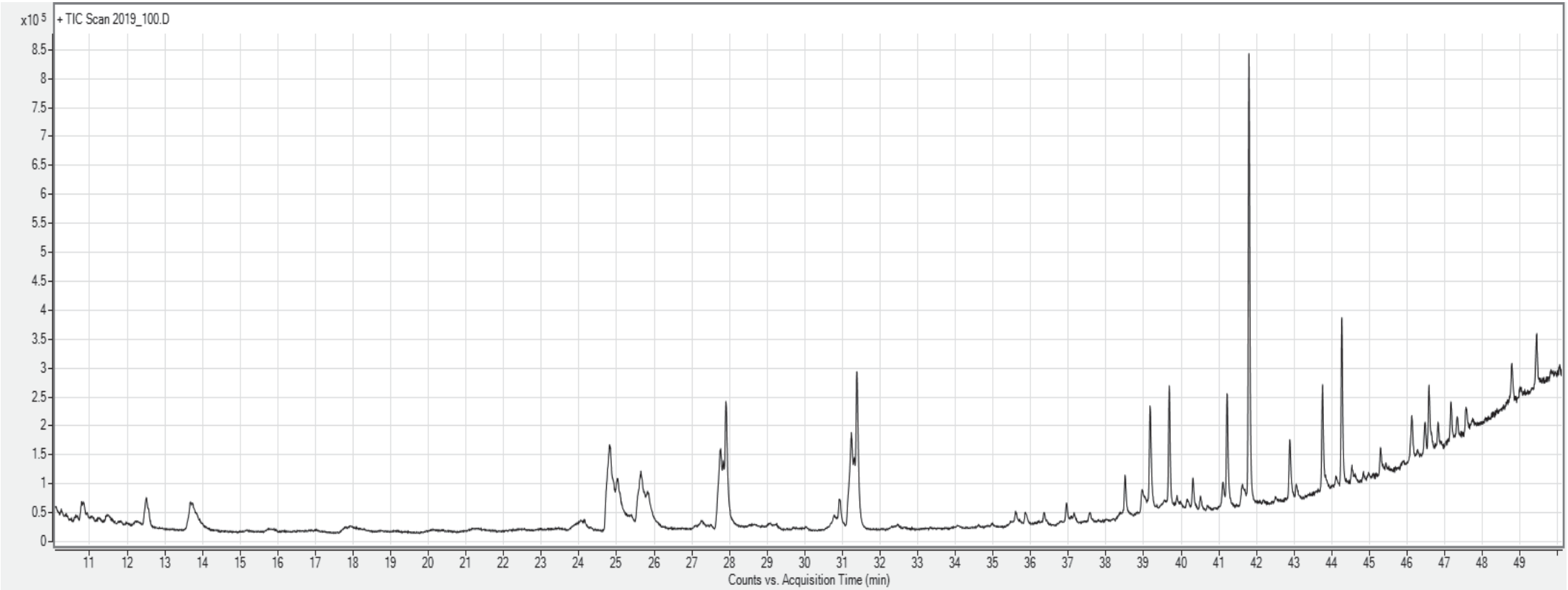


Fig. 17 : Partial total ion chromatogram of the inner surface (BECS 2019) of Sample KM48– E174 (BECS 2018)

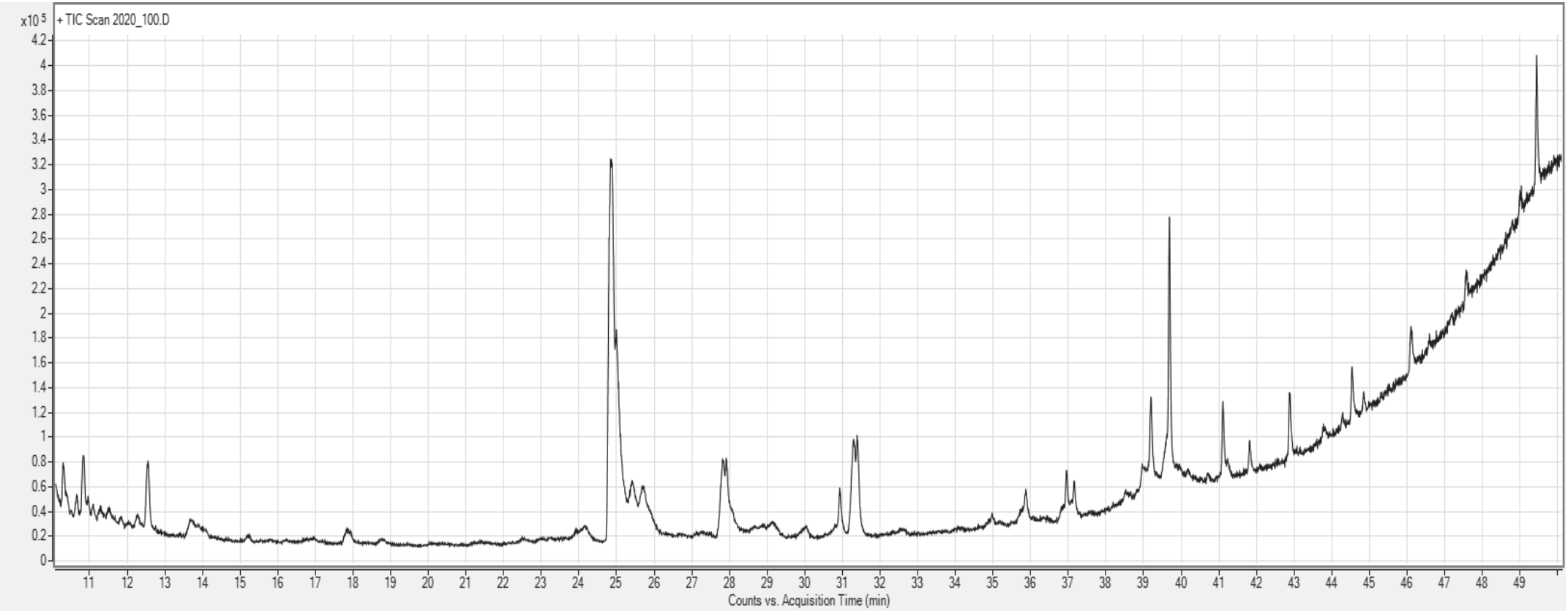


Fig. 18: Partial total ion chromatogram of the outer surface (BECS 2020) of Sample KM48– E174 (BECS 2018)

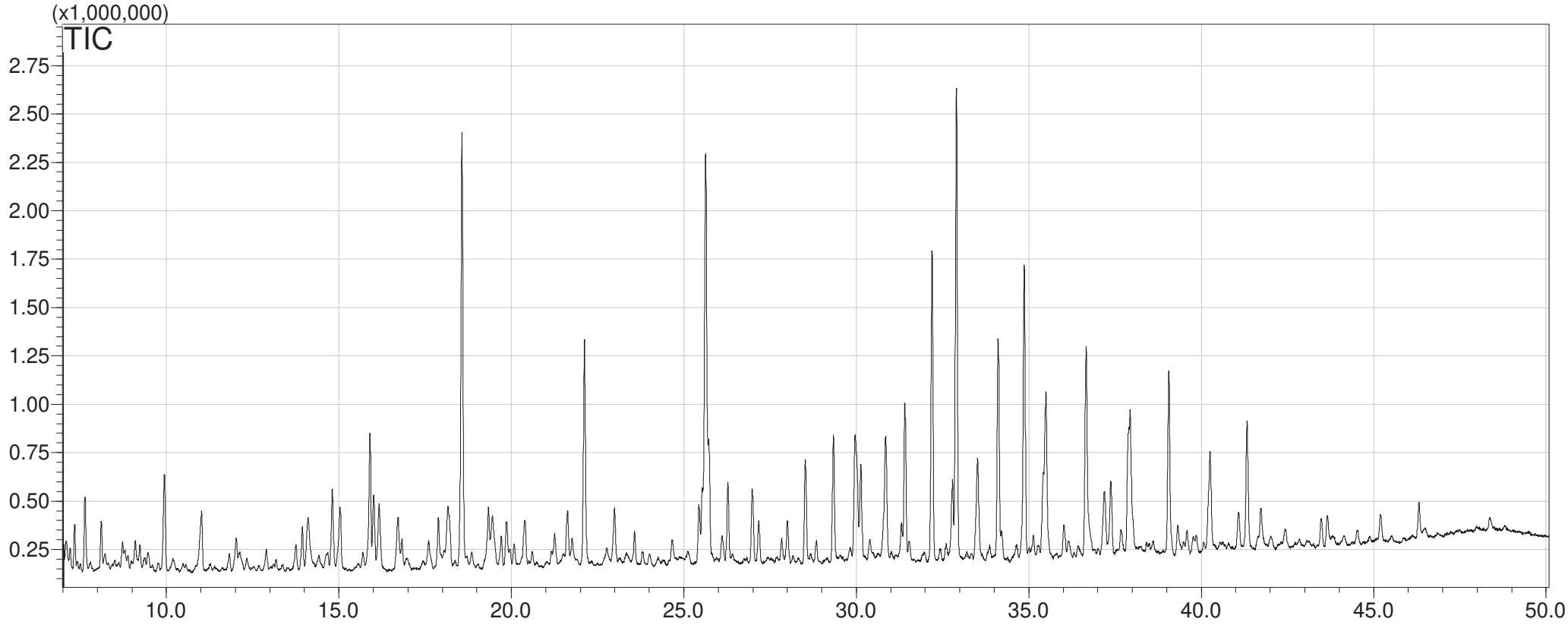


Fig. 19: Partial total ion chromatogram of the soil sample (BECS 1765) associated with Samples KM49 – E175 (BECS 1747), KM56 – E184 (BECS 1756), KM55 – E182 (BECS 1757), KM51 – E177 (BECS 2015), KM48 – E174 (BECS 2018) and KM54 – E181 (BECS 1935).

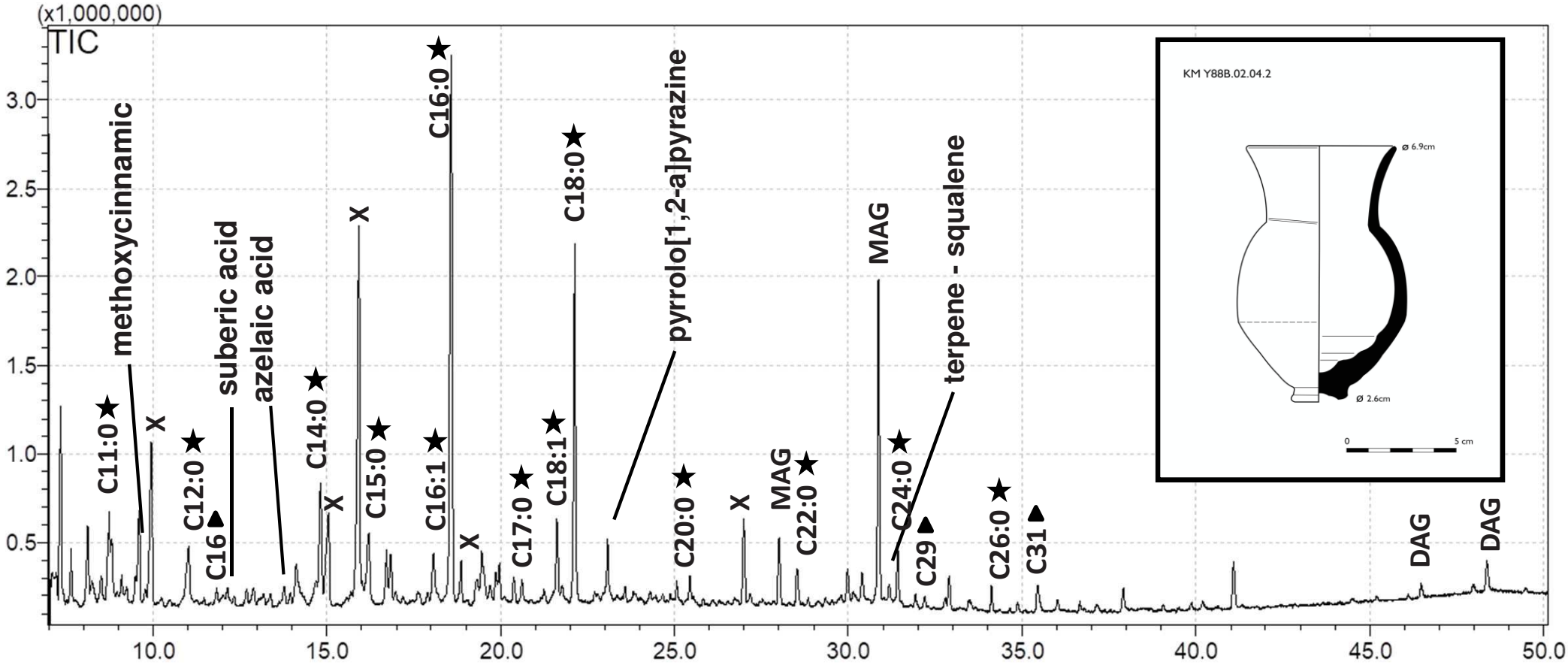


Fig. 20: Partial total ion chromatogram of Sample KM2 – E83 (BECS 1750) of a juglet discovered in Trench Y88 (Locus 2 Lot 4) : Cx:y fatty acids ★, CxOH alcohols ■ , Cx alkanes ▲ , aldehydes and amides ♦ , ketones ⬟ , **MAG** and **DAG** mono- and diacylglycerols, wax esters ● , plasticizers (cross).

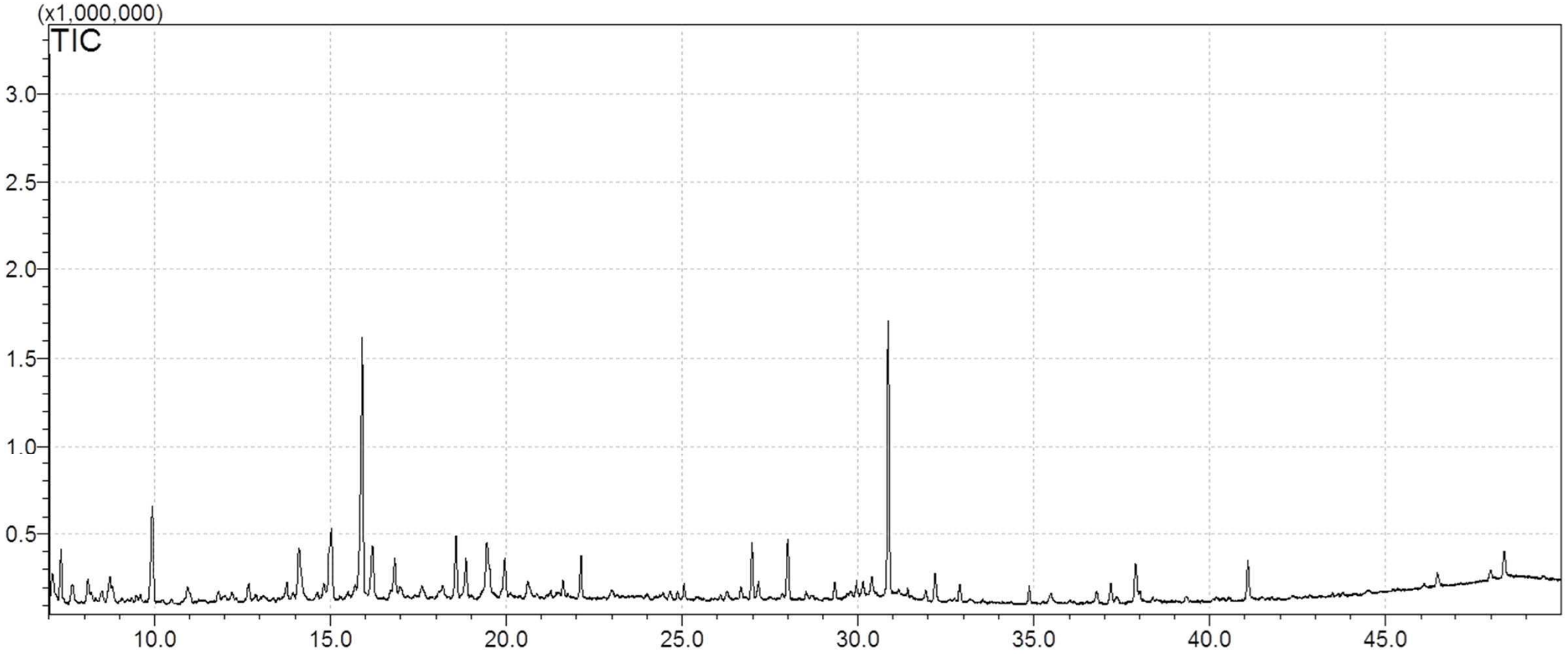


Fig. 21 : Partial total ion chromatogram of the inner surface (BECS 1751) of Sample KM2 – E83 (BECS 1750)

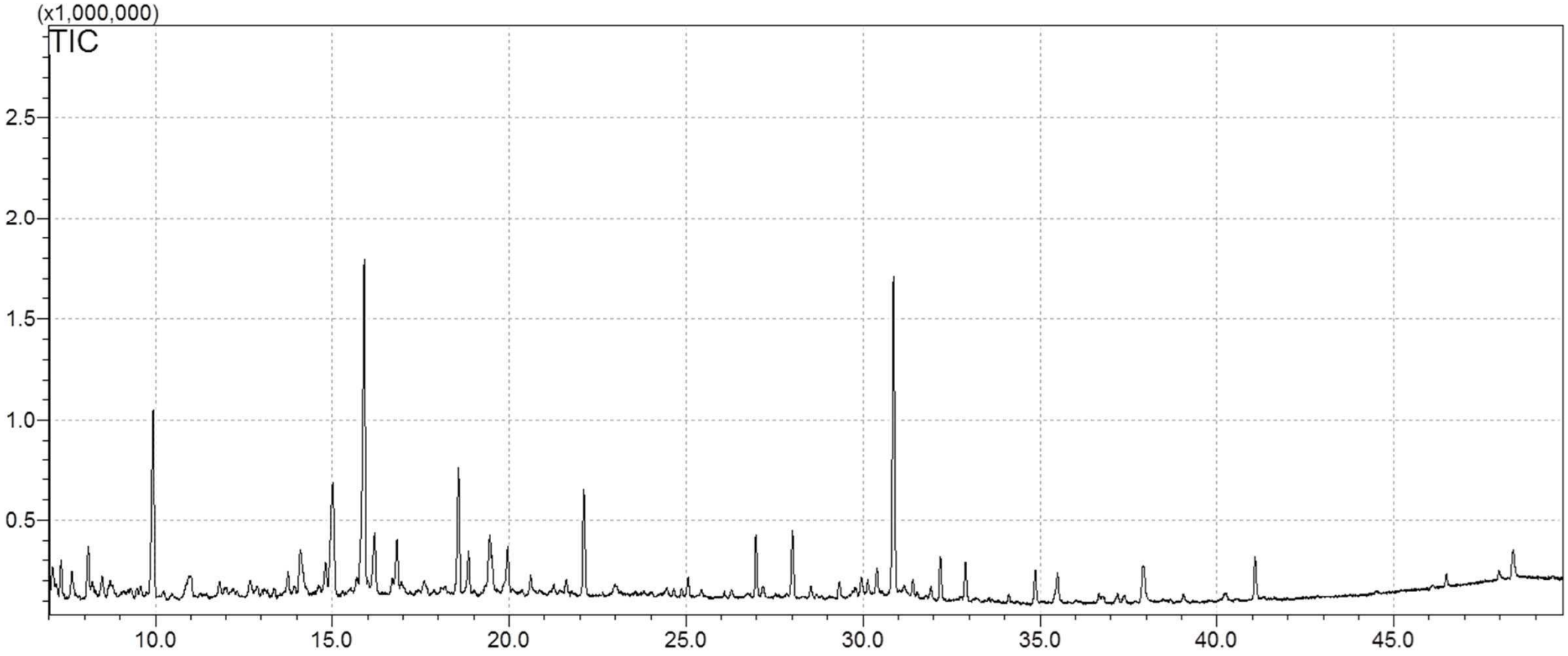


Fig. 22 : Partial total ion chromatogram of the outer surface (BECS 1752) of Sample KM2 – E83 (BECS 1750)

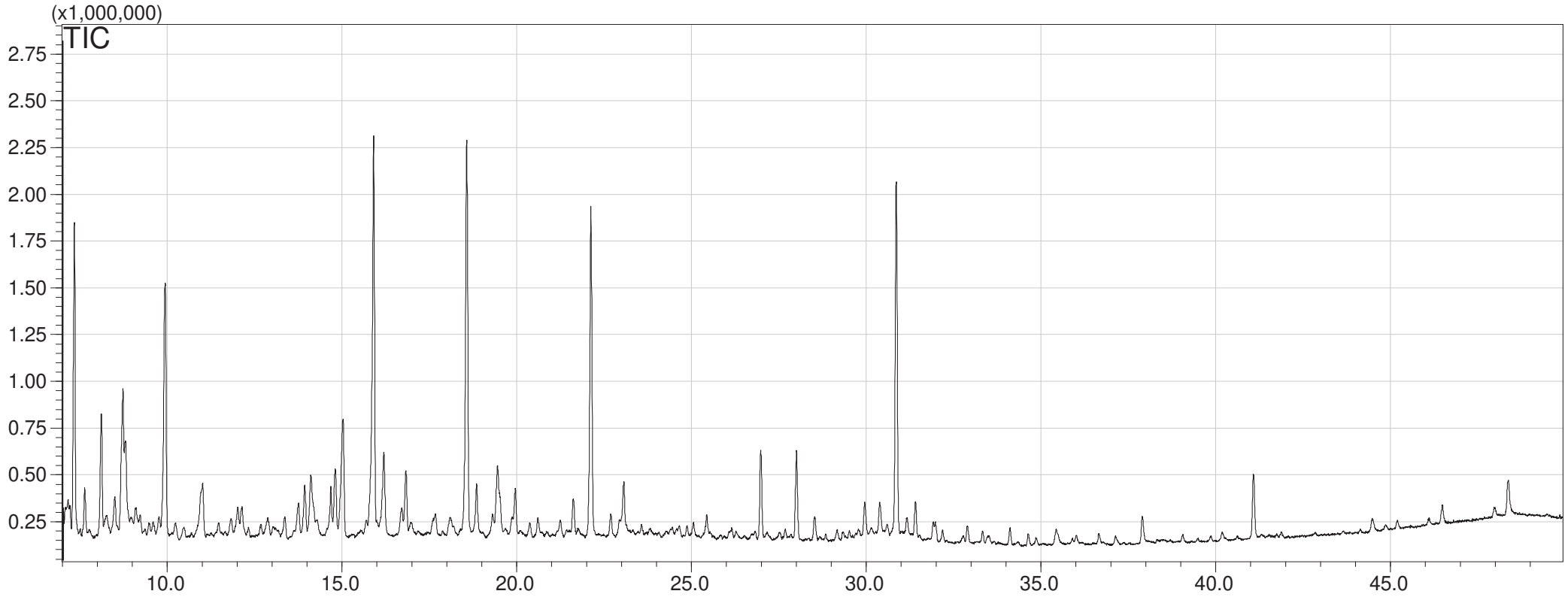


Fig. 23 : Partial total ion chromatogram of the soil sample (BECS 1762) associated with Samples KM2 – E83 (BECS 1750), KM30 – E151 (BECS 2218), KM41 – E167 (BECS 2223) and KM42 – E168 (BECS 2215).

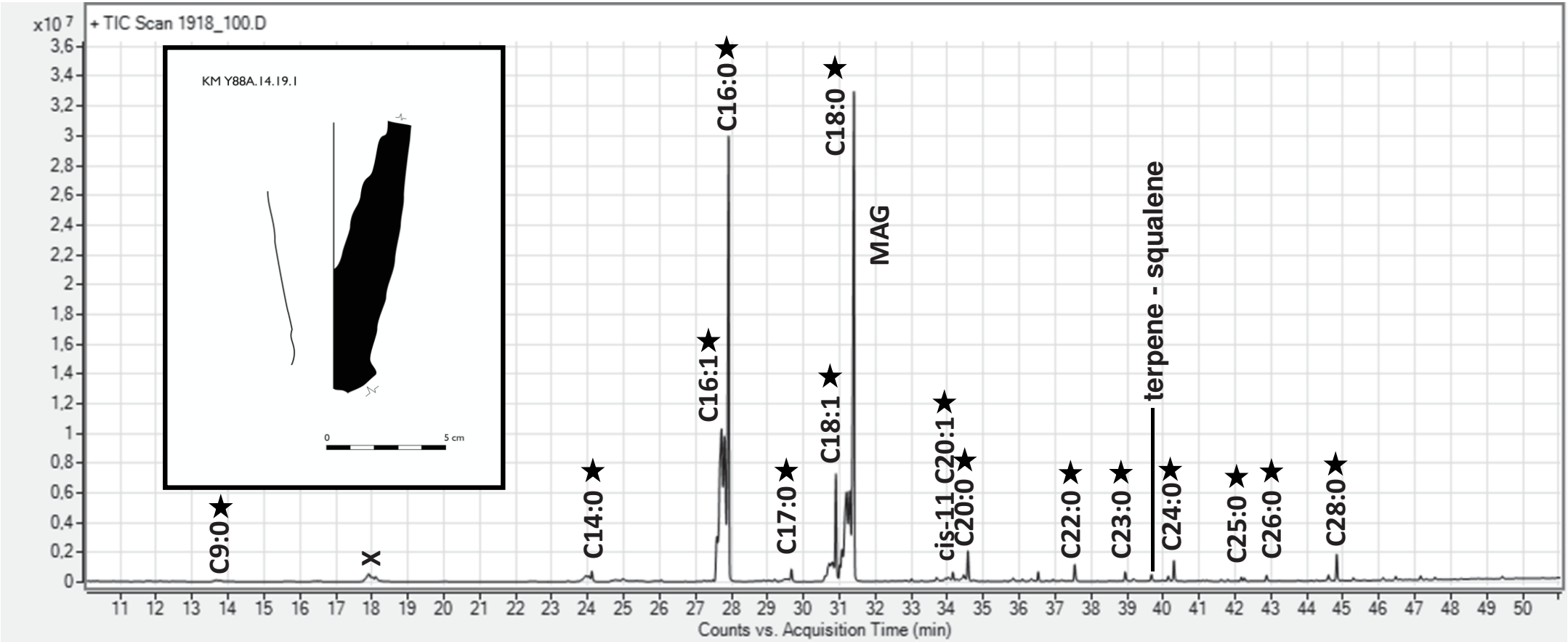


Fig. 24: Partial total ion chromatogram of Sample KM18 – E122 (BECS 1918) of a Kassite Goblet discovered in Trench Y88 (Locus 14 Lot 19) : Cx:y fatty acids ★, CxOH alcohols ■ , Cx alkanes ▲ , aldehydes and amides ♦ , ketones ⬟ , **MAG** and **DAG** mono- and diacylglycerols, wax esters ● , plasticizers (cross).

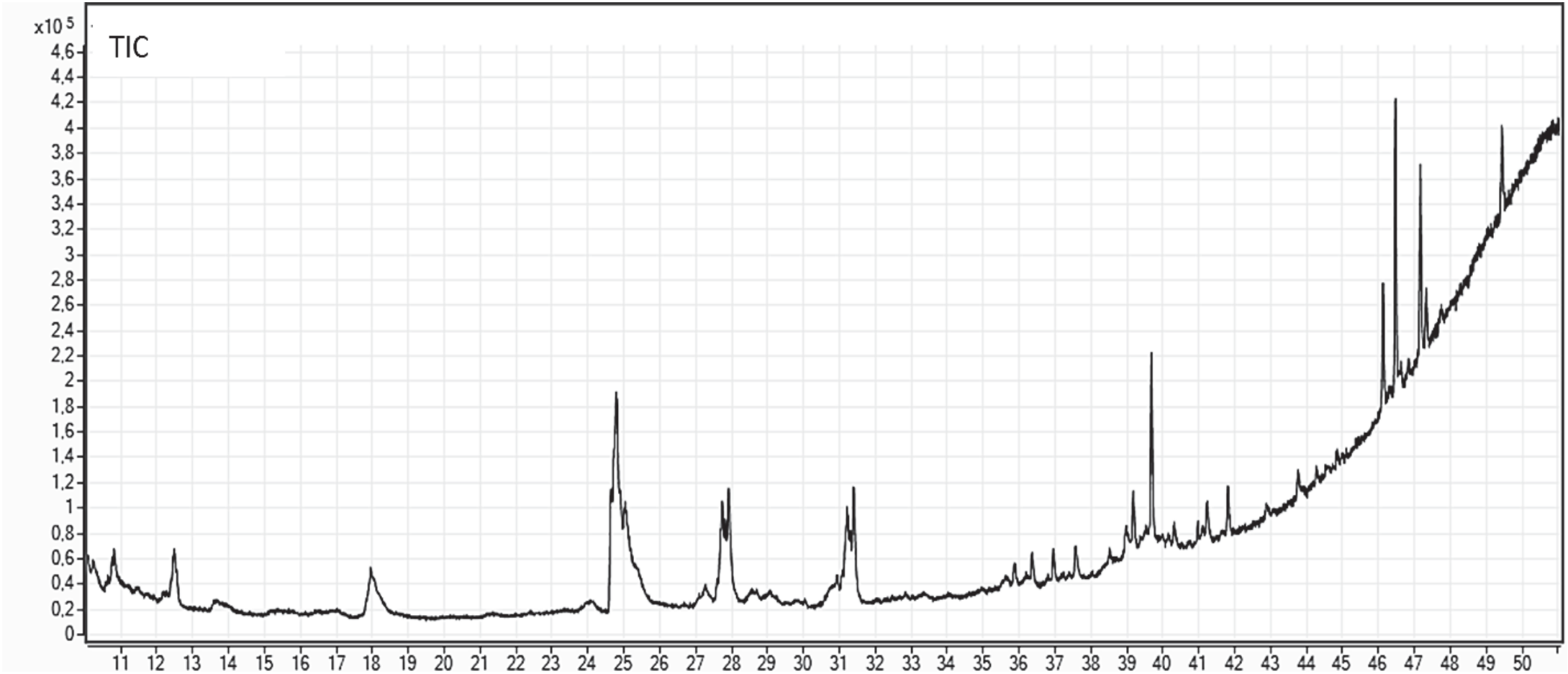


Fig. 25 : Partial total ion chromatogram of the inner surface (BECS 1919) of Sample KM18 – E122 (BECS 1918)

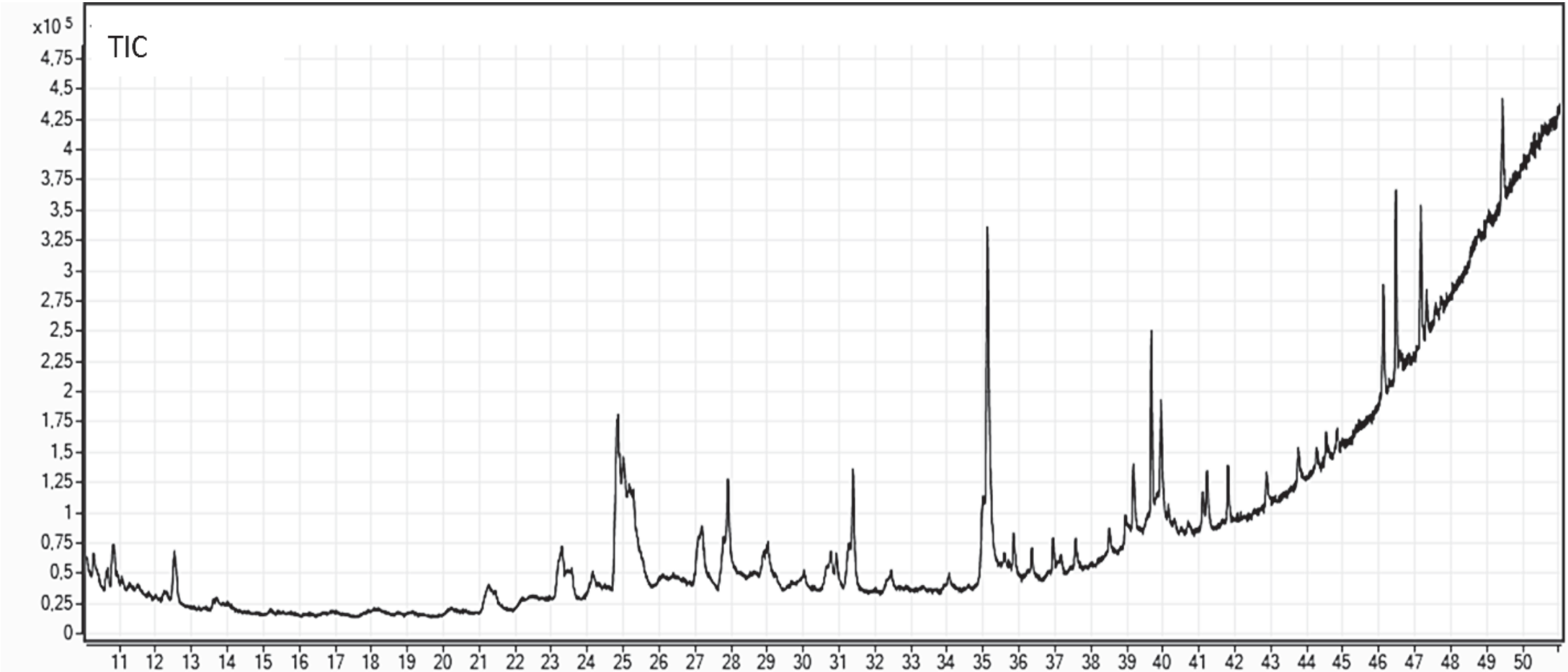


Fig. 26 : Partial total ion chromatogram of the outer surface (BECS 1920) of Sample KM18 – E122 (BECS 1918)

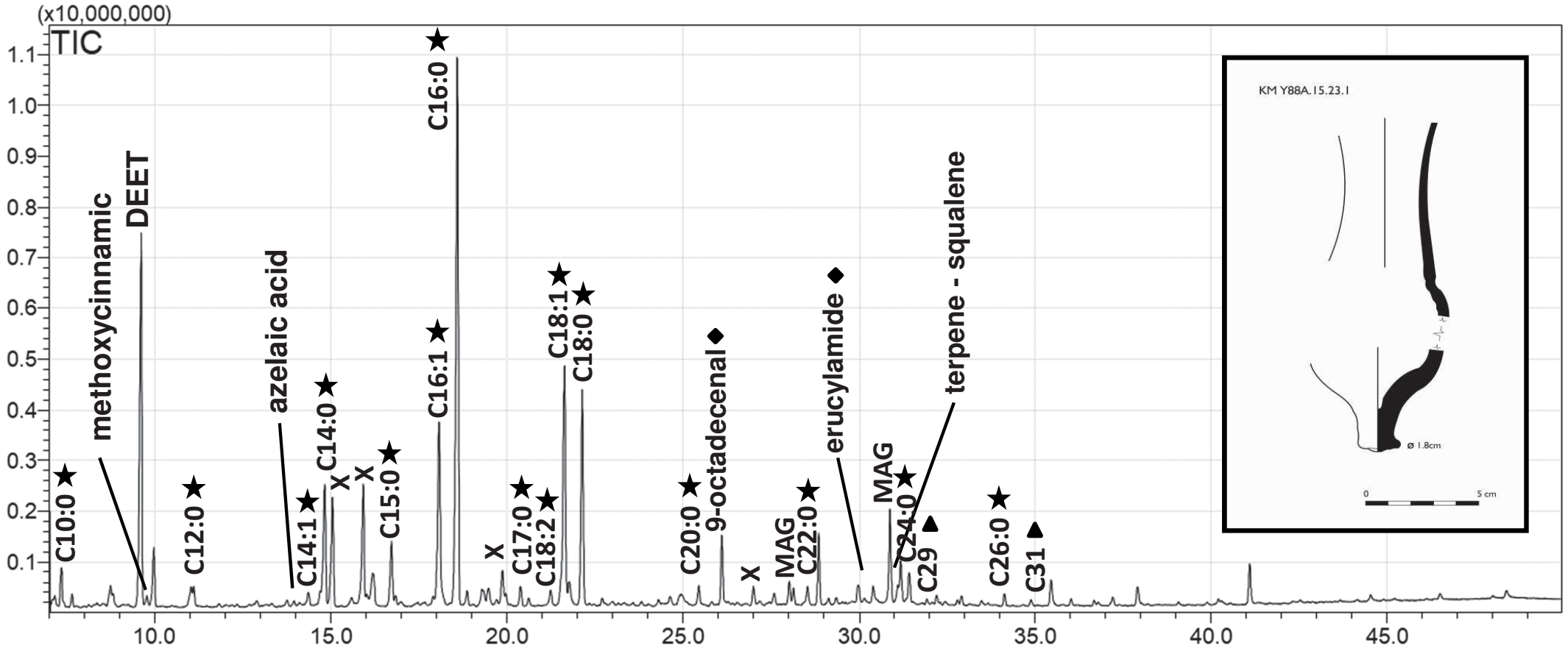


Fig. 27: Partial total ion chromatogram of Sample KM29 – E150 (BECS 1781) of a high neck footed cup discovered in Trench Y88 (Locus 15 Lot23) : Cx:y fatty acids ★, CxOH alcohols ■ , Cx alkanes ▲ , aldehydes and amides ♦ , ketones ⬟ , **MAG** and **DAG** mono- and diacylglycerols, wax esters ● , plasticizers (cross).

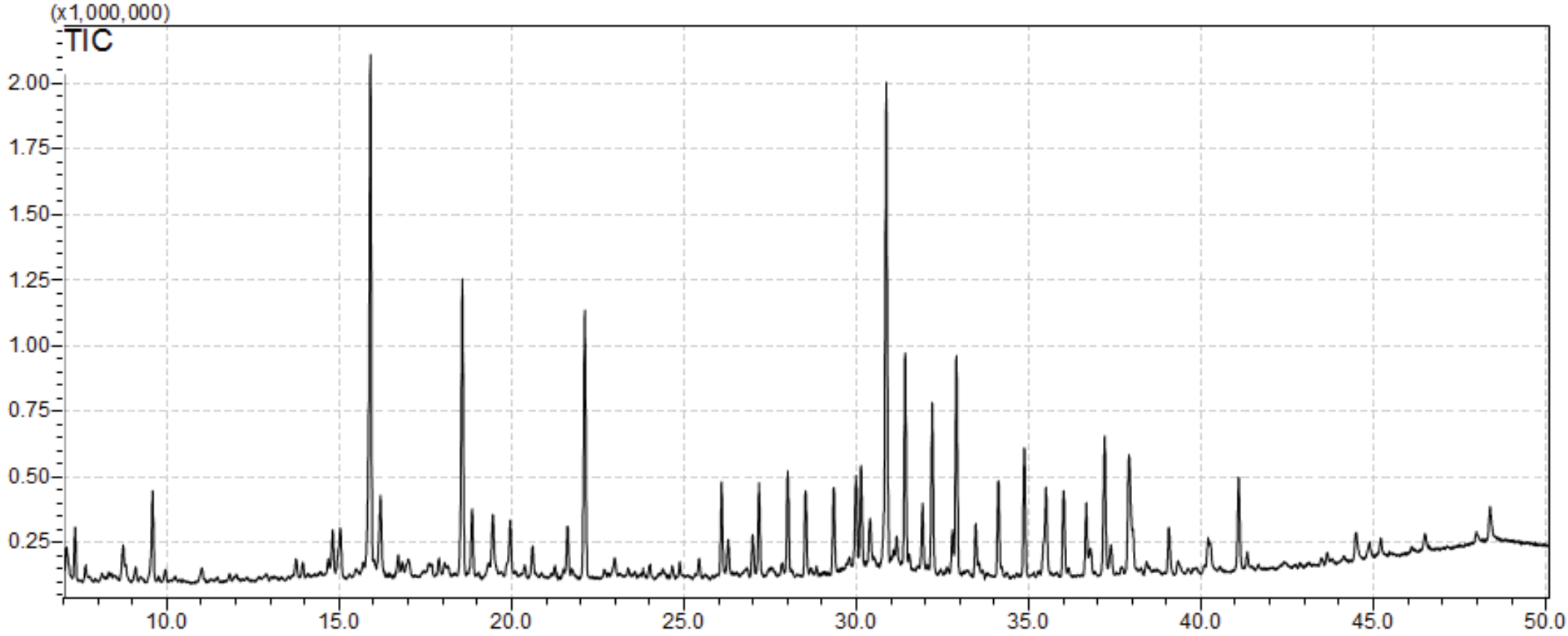


Fig. 28: Partial total ion chromatogram of the inner surface (1782) of Sample KM29 – E150 (BECS 1781).

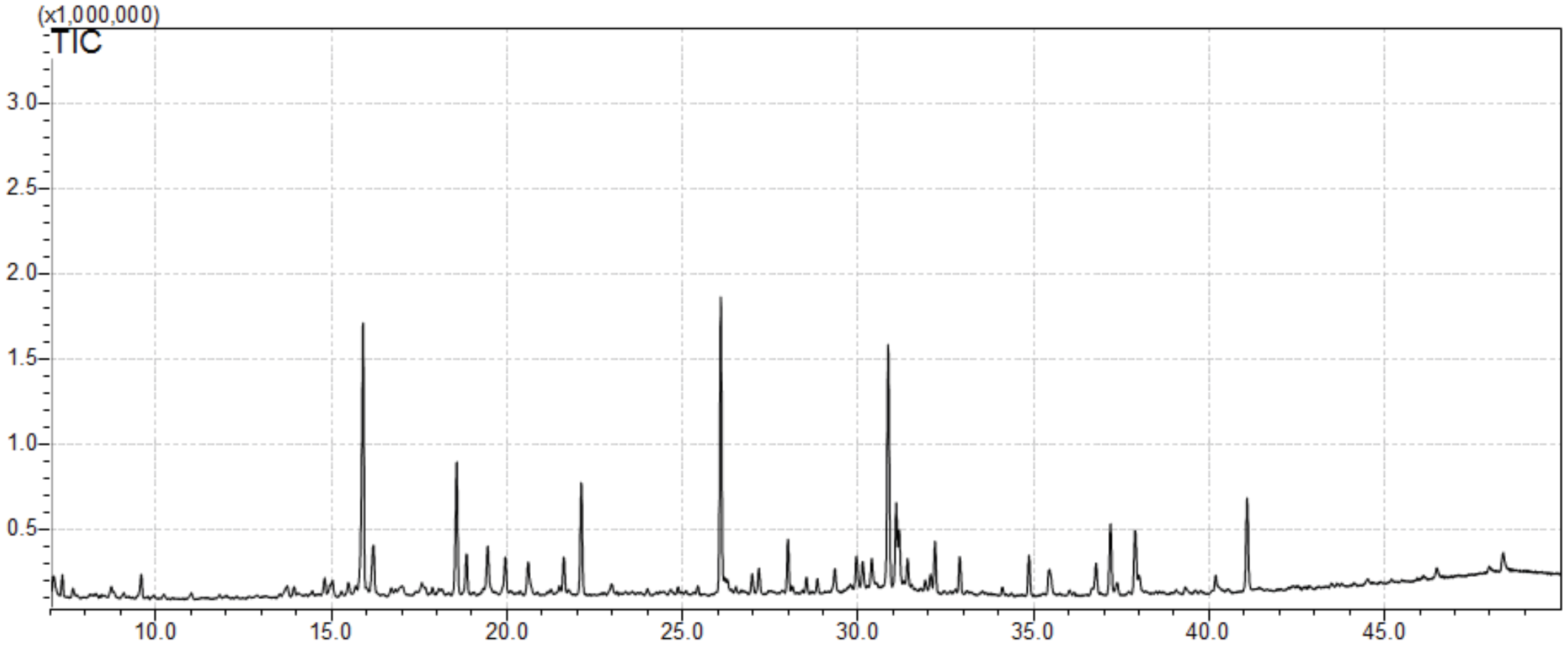


Fig. 29: Partial total ion chromatogram of the outer surface (1783) of Sample KM29 – E150 (BECS 1781)

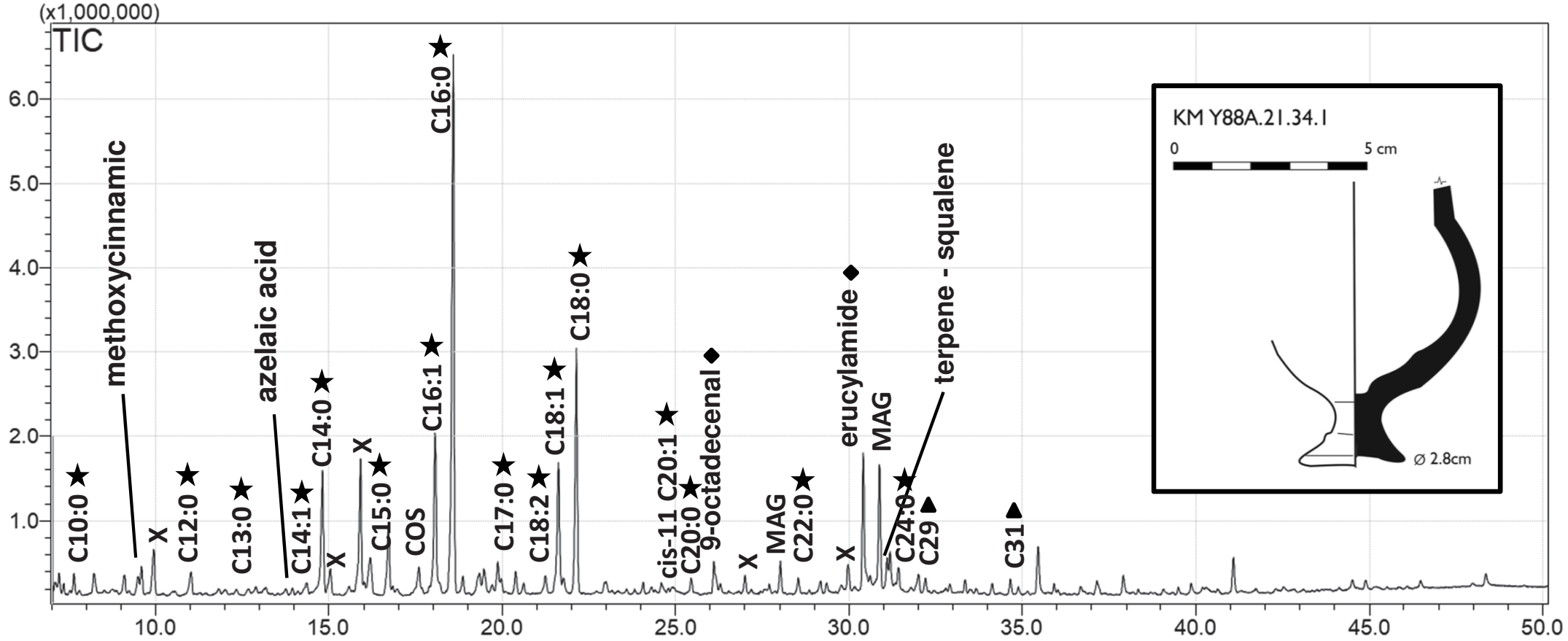


Fig. 30: Partial total ion chromatogram of Sample KM38 – E162 (BECS 1769) of a footed cup discovered in Trench Y88 (Locus 21 Lot 34) : Cx:y fatty acids ★, CxOH alcohols ■ , Cx alkanes ▲ , aldehydes and amides ♦ , ketones ⬟ , **MAG** and **DAG** mono- and diacylglycerols, wax esters ● , plasticizers (cross).

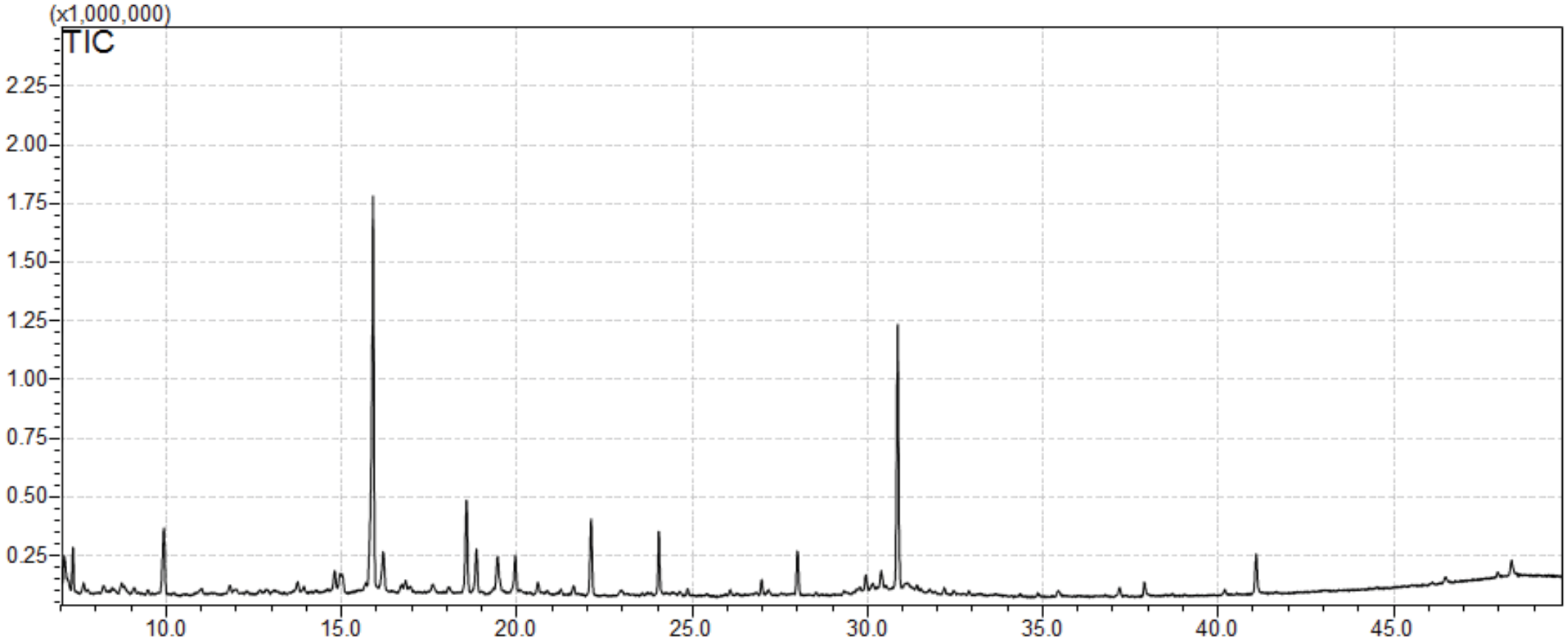


Fig. 31: Partial total ion chromatogram of the inner surface (BECS 1770) of Sample KM38 – E162 (BECS 1769)

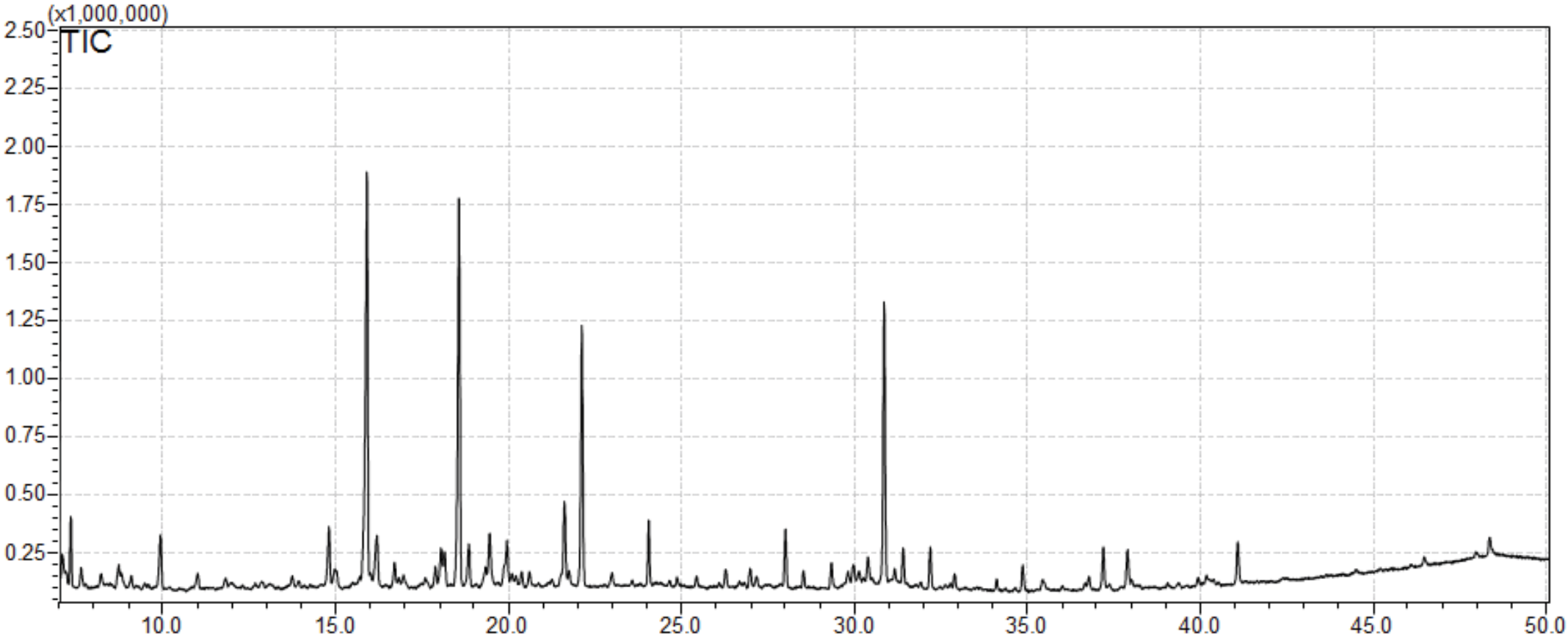


Fig. 32: Partial total ion chromatogram of the outer surface (BECS 1771) of Sample KM38 – E162 (BECS 1769)

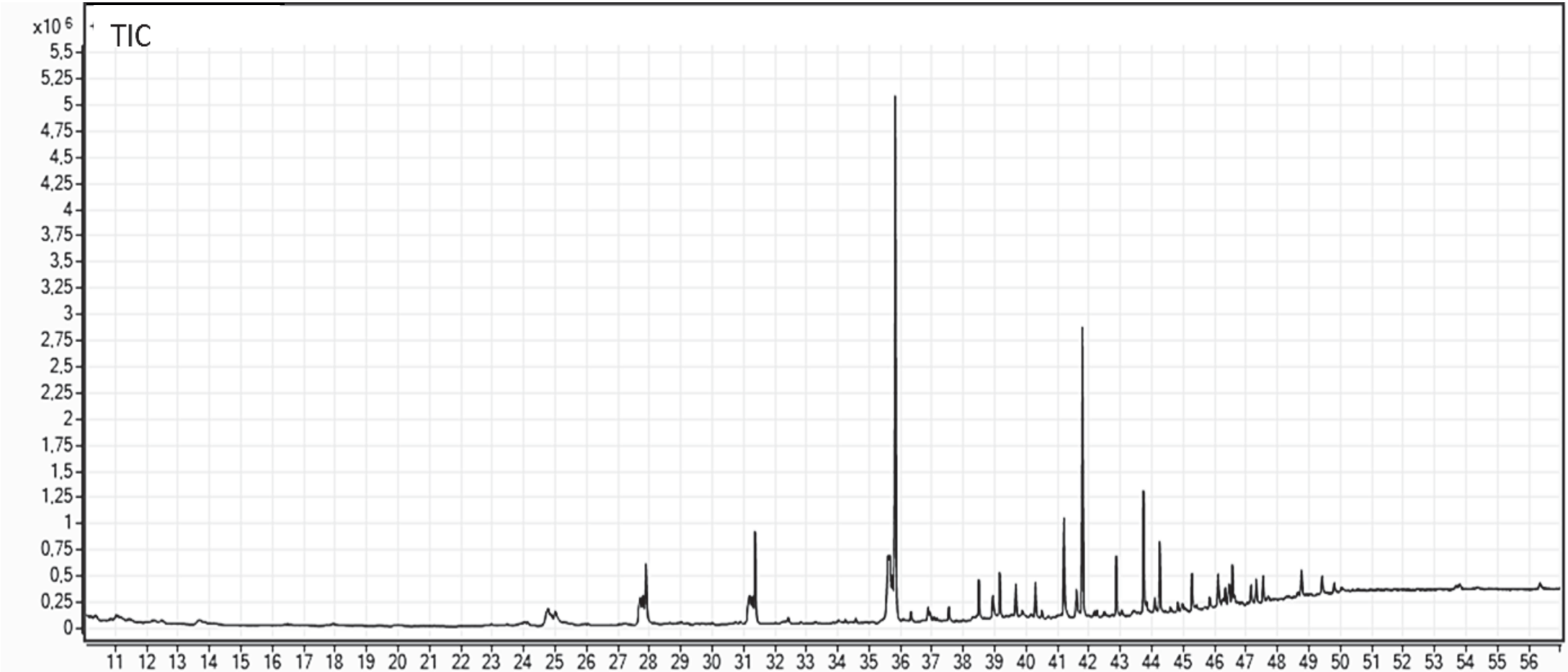


Fig. 33 : Partial total ion chromatogram of the soil sample (BECS 1941) associated with Samples KM38 – E162 (BECS 1769), KM34 – E157 (BECS 1766), KM66 – E196 (BECS 1915) and KM70 – E201 (BECS 1938).

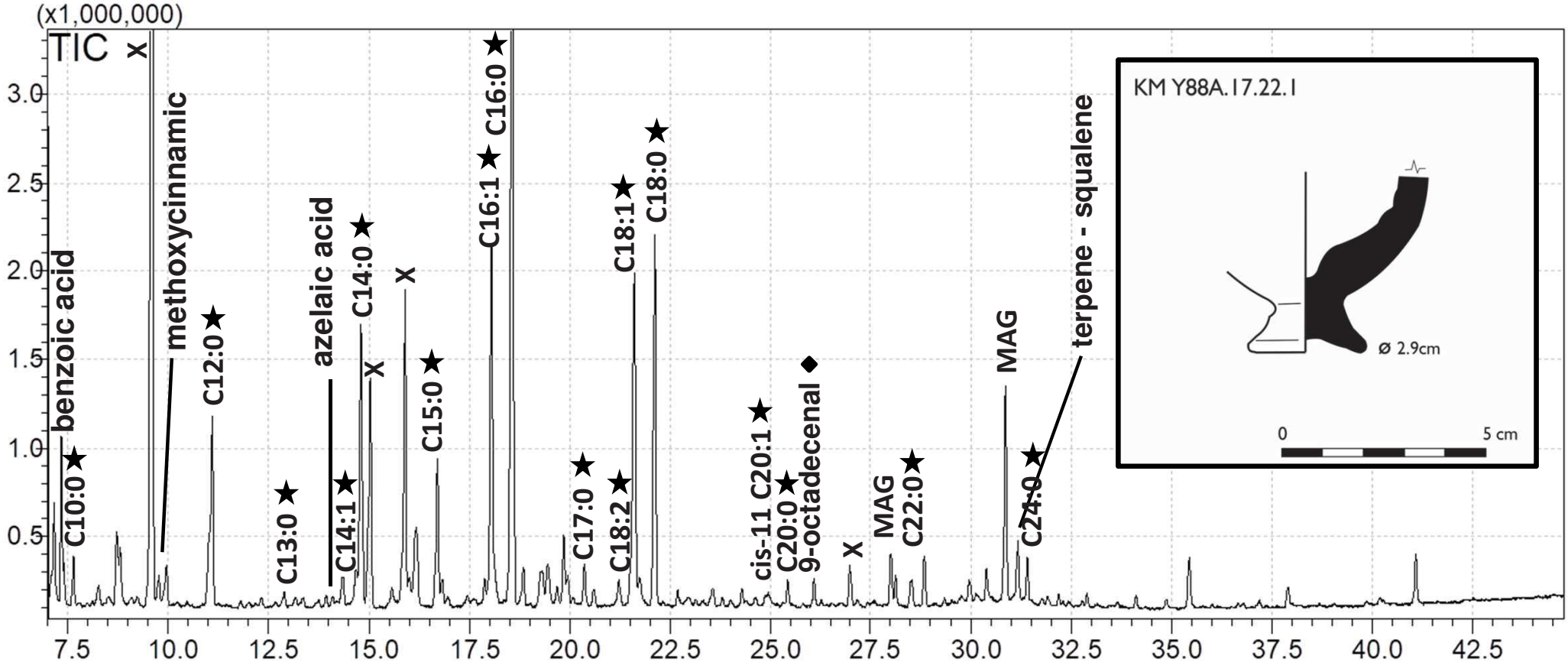


Fig. 34: Partial total ion chromatogram of Sample KM34 – E157 (BECS 1766) of a footed cup discovered in Trench Y88 (Locus 17 Lot 22): Cx:y fatty acids ★, CxOH alcohols ■ , Cx alkanes ▲ , aldehydes and amides ♦ , ketones ⬟ , **MAG** and **DAG** mono- and diacylglycerols, wax esters ● , plasticizers (cross).

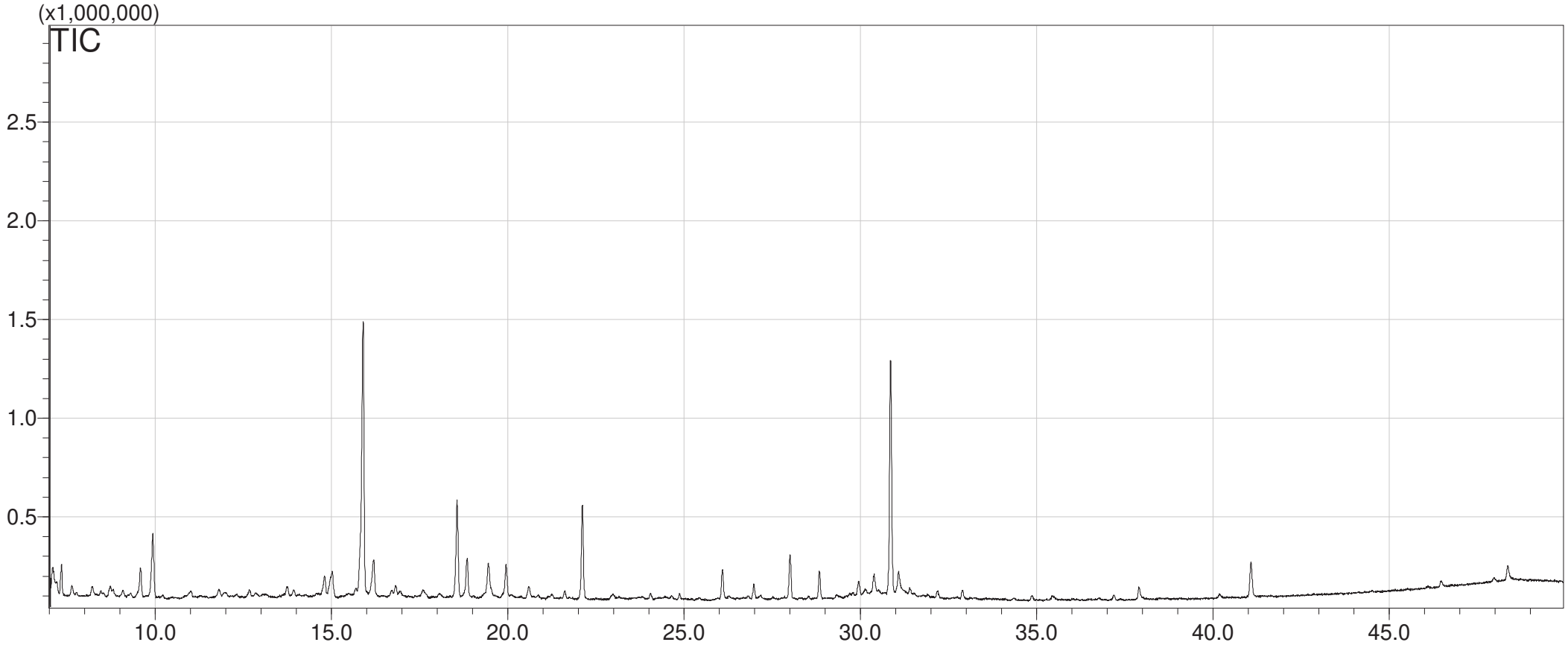


Fig. 35: Partial total ion chromatogram of the inner surface (BECS 1767) of KM34 – E157 (BECS 1766)

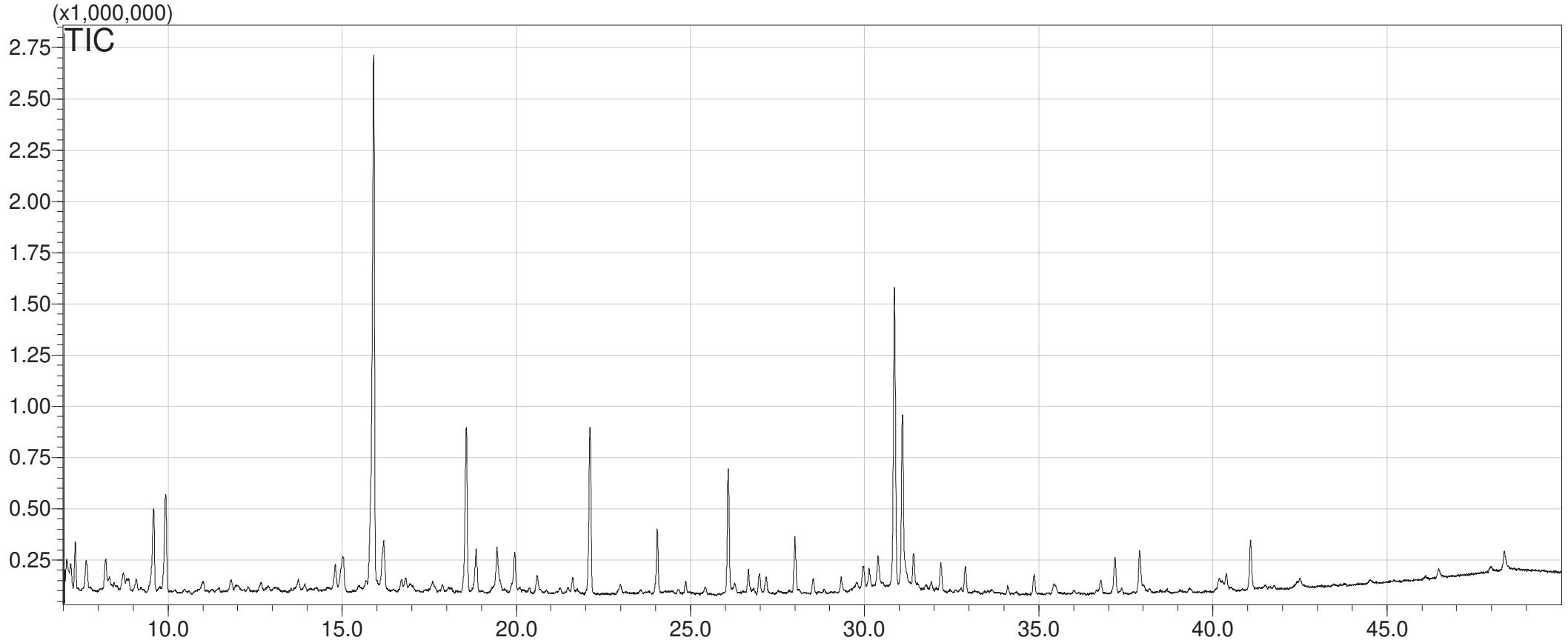


Fig. 36: Partial total ion chromatogram of the outer surface (BECS 1768) of Sample KM34 – E157 (BECS 1766)

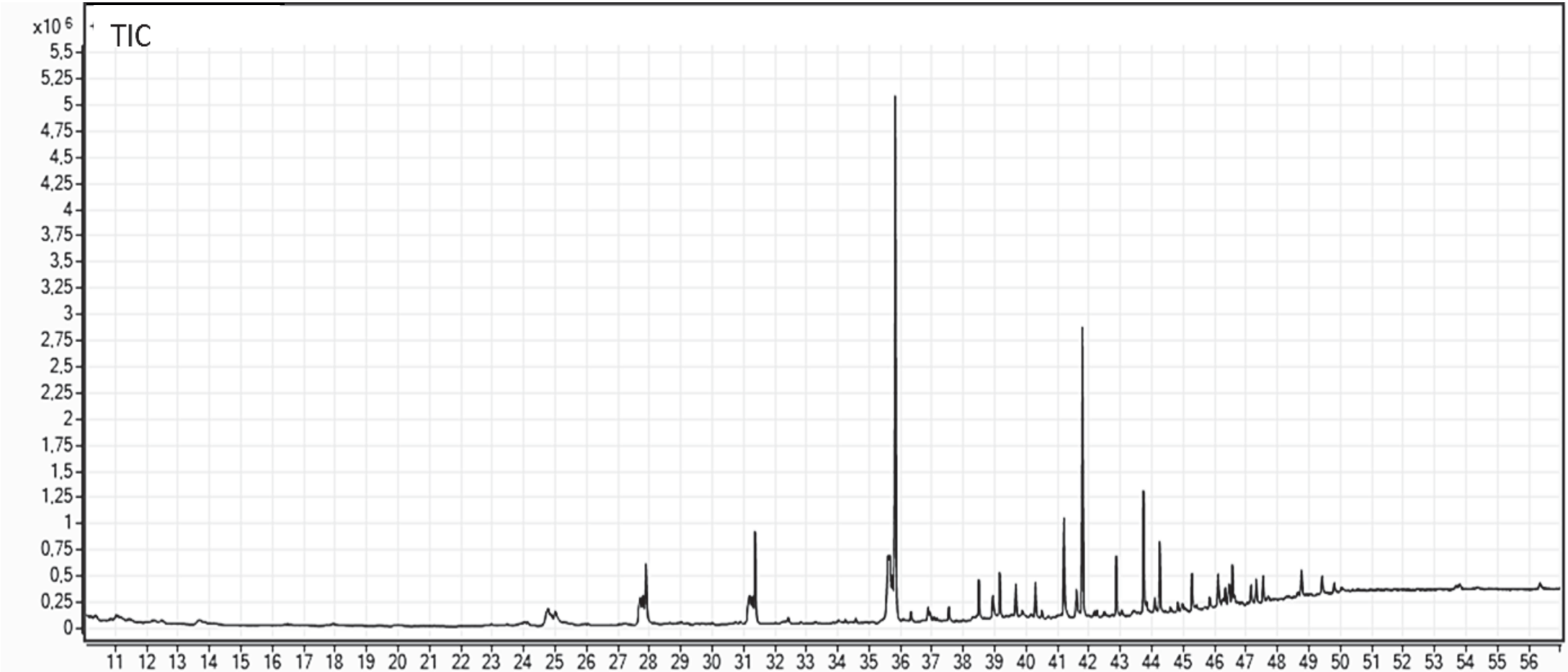


Fig. 37 : Partial total ion chromatogram of the soil sample (BECS 1941) associated with Samples KM38 – E162 (BECS 1769), KM34 – E157 (BECS 1766), KM66 – E196 (BECS 1915) and KM70 – E201 (BECS 1938).

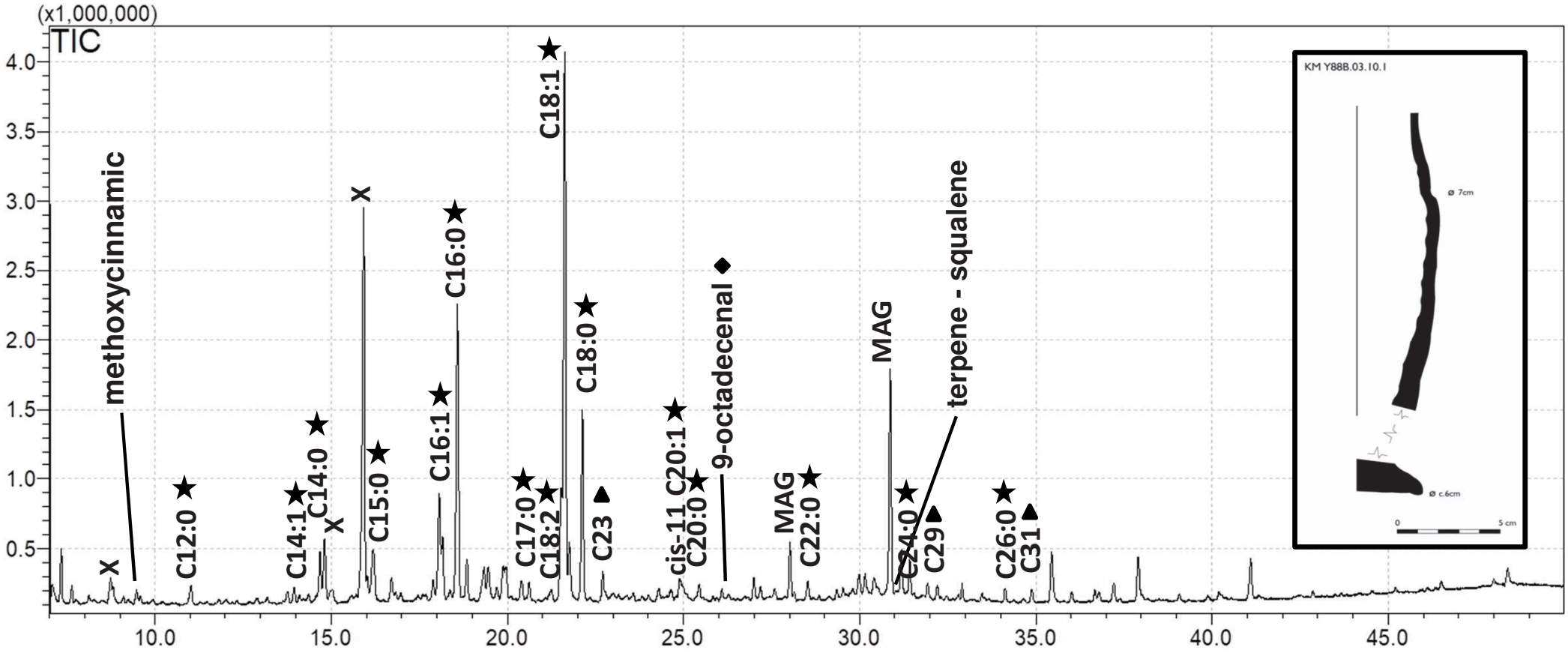


Fig. 38: Partial total ion chromatogram of Sample KM17 – E119 (BECS 1777) of a Kassite goblet discovered in Trench Y88 (Locus 3 Lot 10) : Cx:y fatty acids ★, CxOH alcohols ■ , Cx alkanes ▲ , aldehydes and amides ♦ , ketones ⬣ , **MAG** and **DAG** mono- and diacylglycerols, wax esters ● , plasticizers (cross).

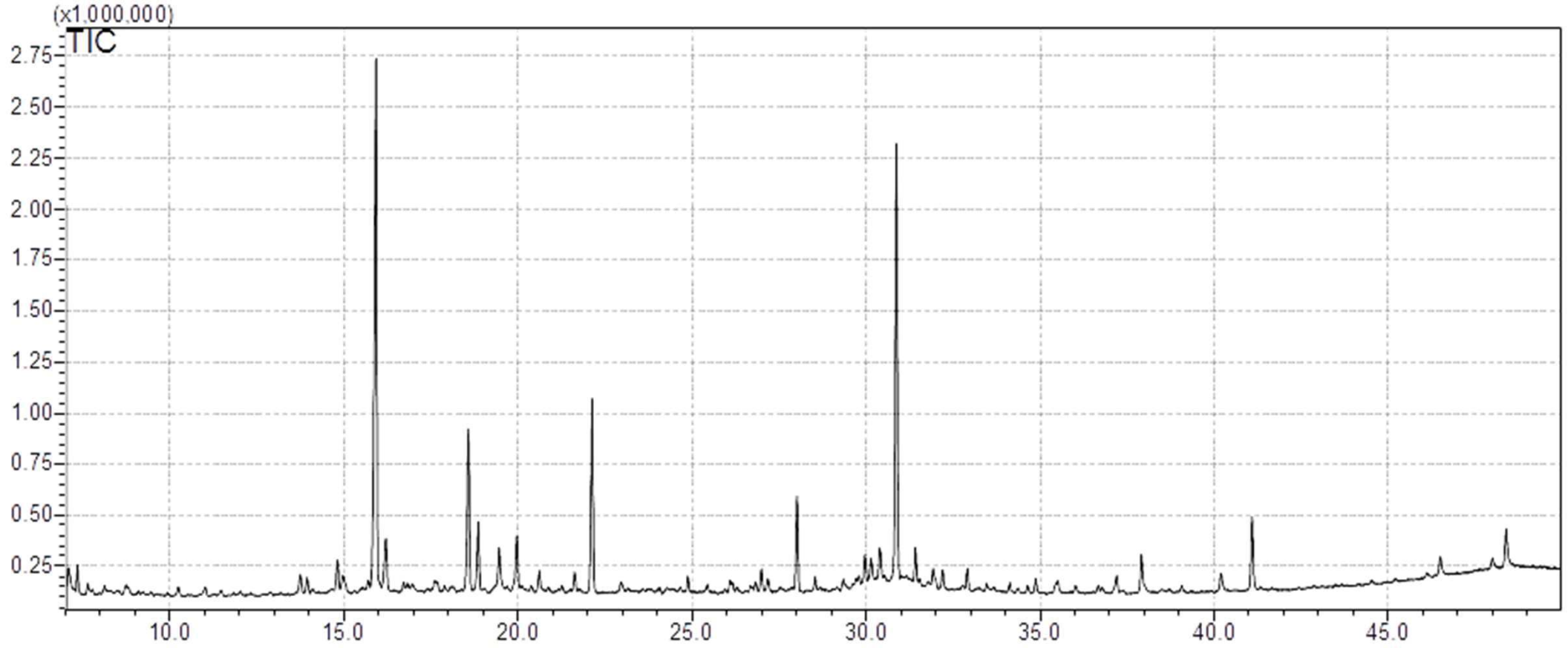


Fig. 39 : Partial total ion chromatogram of the inner surface (BECS 1779) of Sample KM17 – E119 (BECS 1777)

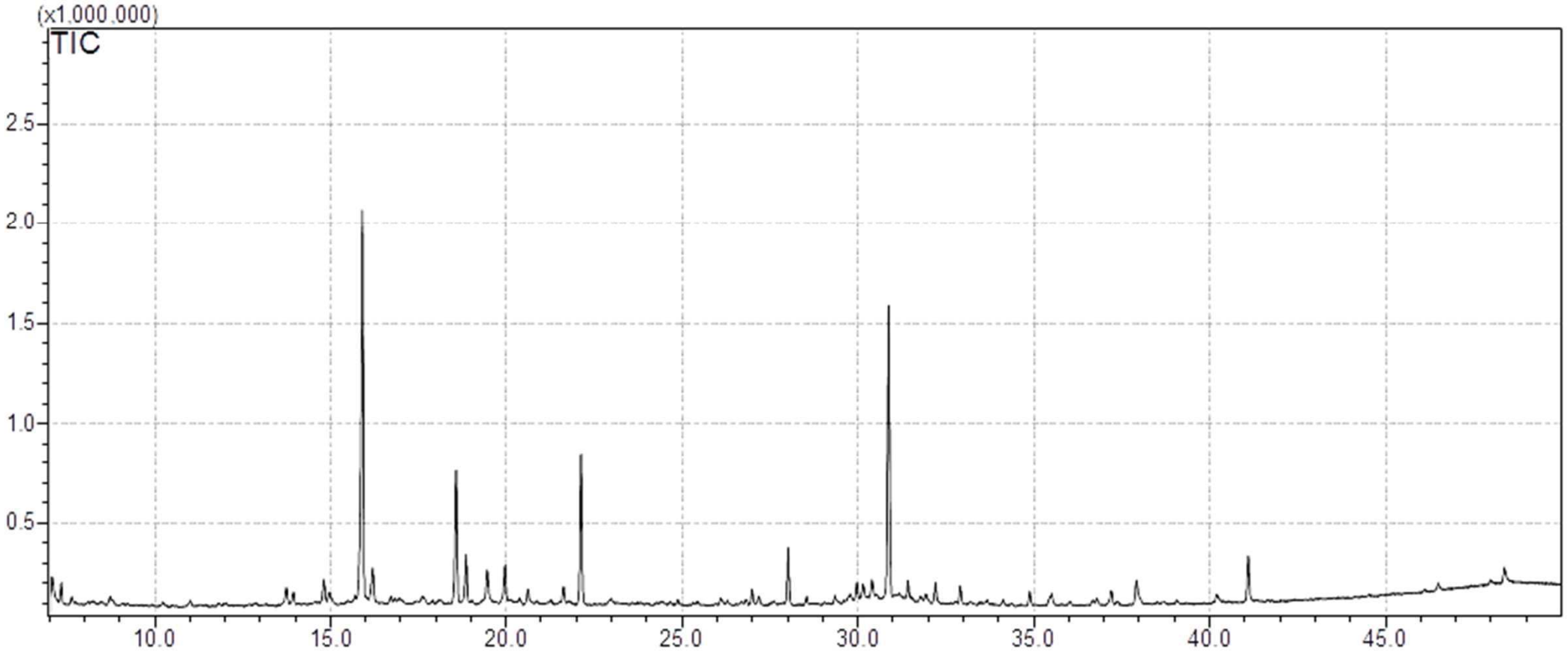


Fig. 40: Partial total ion chromatogram of the outer surface (BECS 1780) of Sample KM17 – E119 (BECS 1777)

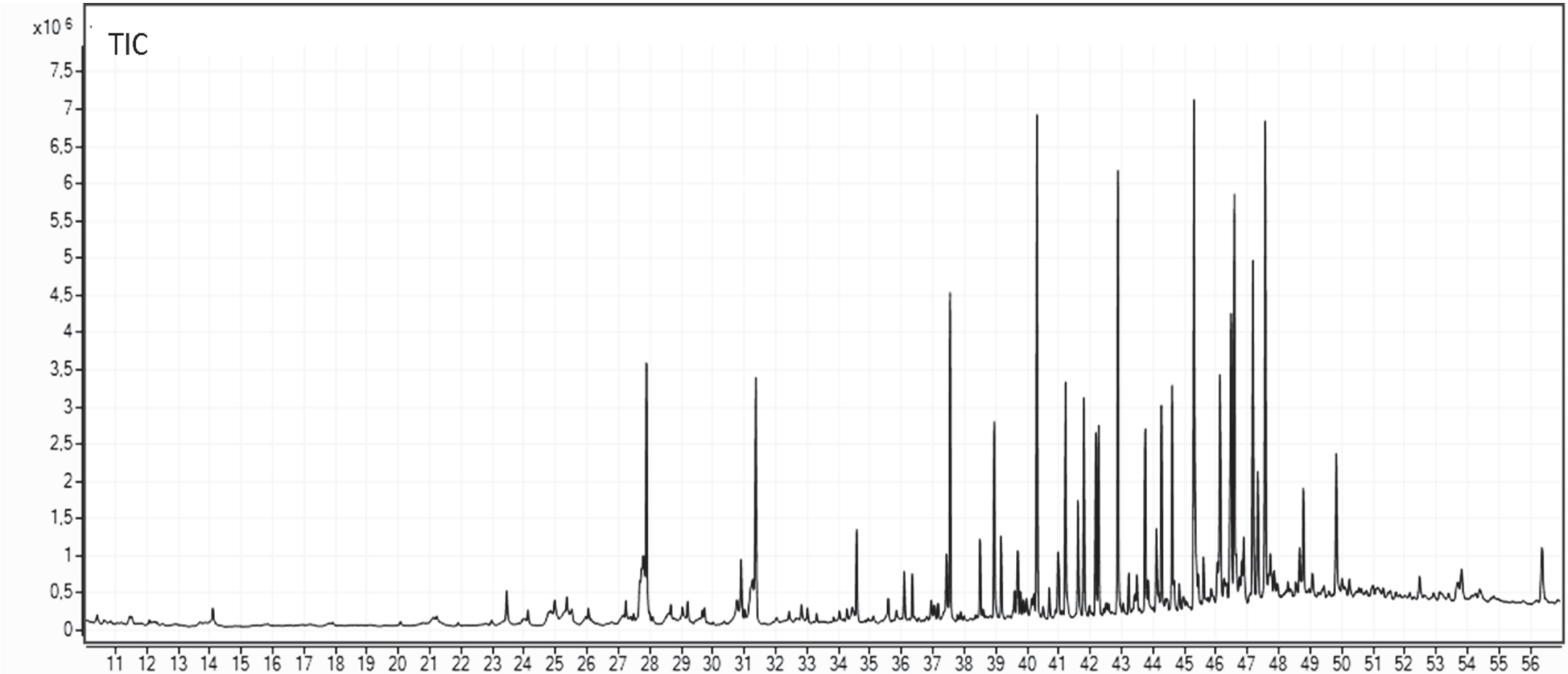


Fig. 41: Partial total ion chromatogram of the soil sample (BECS 1913) associated with Samples KM11 – E101 (BECS 1910), KM17 – E119 (BECS 1777), KM19 – E124 (BECS 1772), and KM20 – E126 (BECS 1774).

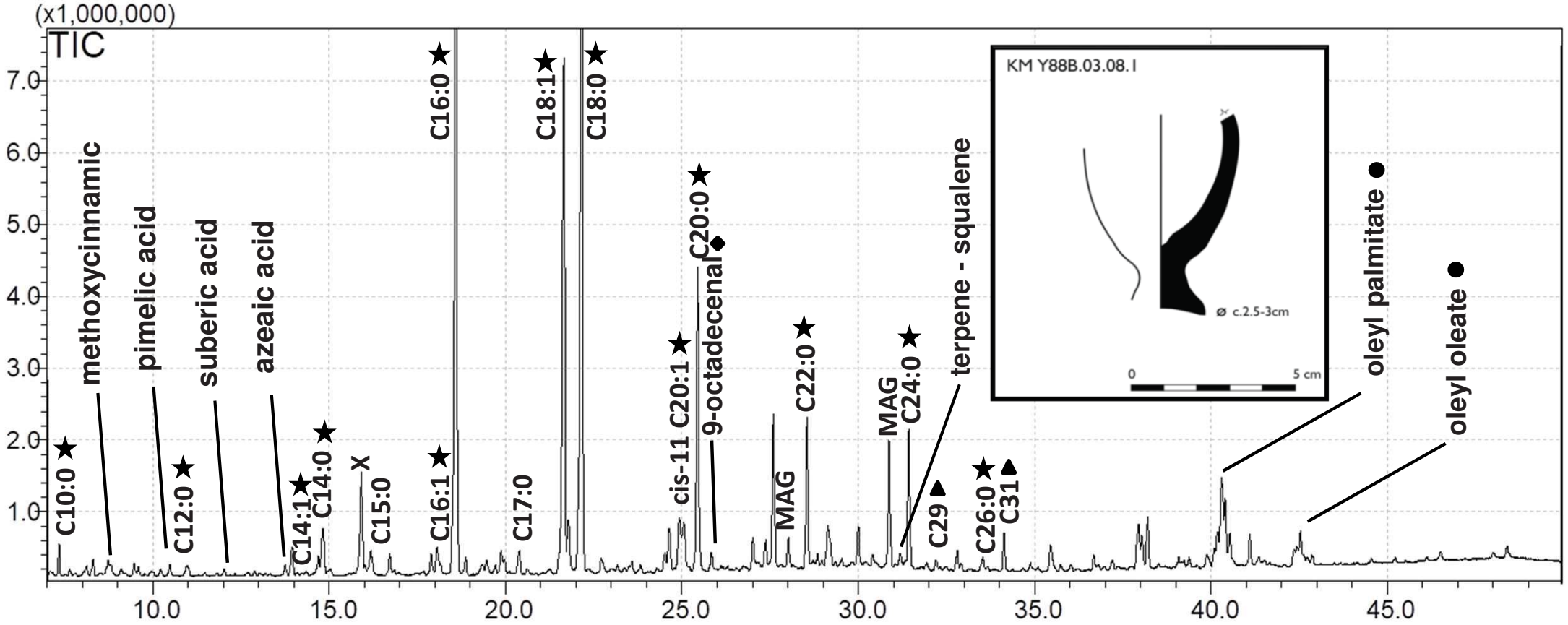


Fig. 42 : Partial total ion chromatogram of Sample KM20 – E126 (BECS 1774) of a cup discovered in Trench Y88 (Locus 3 Lot 8) :
Cx:y fatty acids ★, CxOH alcohols ■ , Cx alkanes ▲ , aldehydes and amides ♦ , ketones ⬢ , **MAG** and **DAG** mono- and diacylglycerols, wax esters ● , plasticizers (cross).

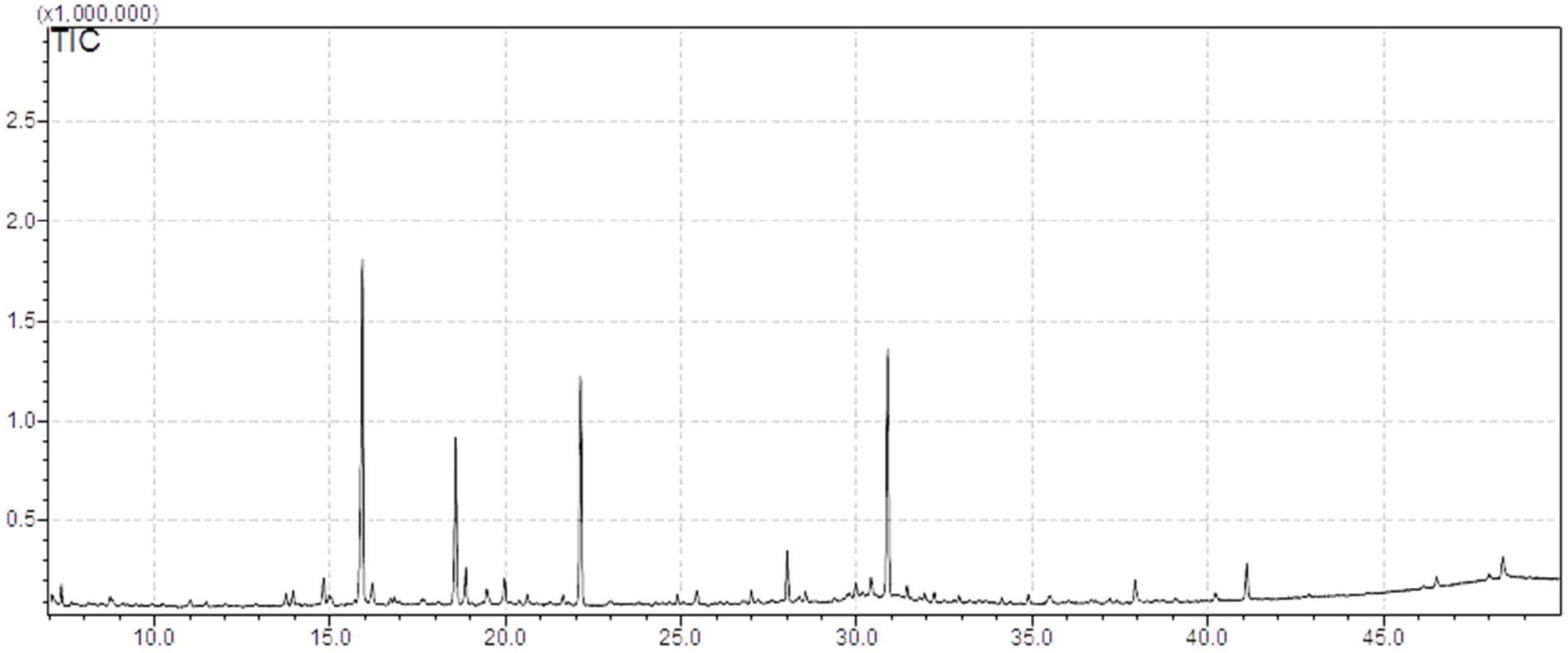


Fig. 43: Partial total ion chromatogram of the inner surface (BECS 1775) of Sample KM20 – E126 (BECS 1774)

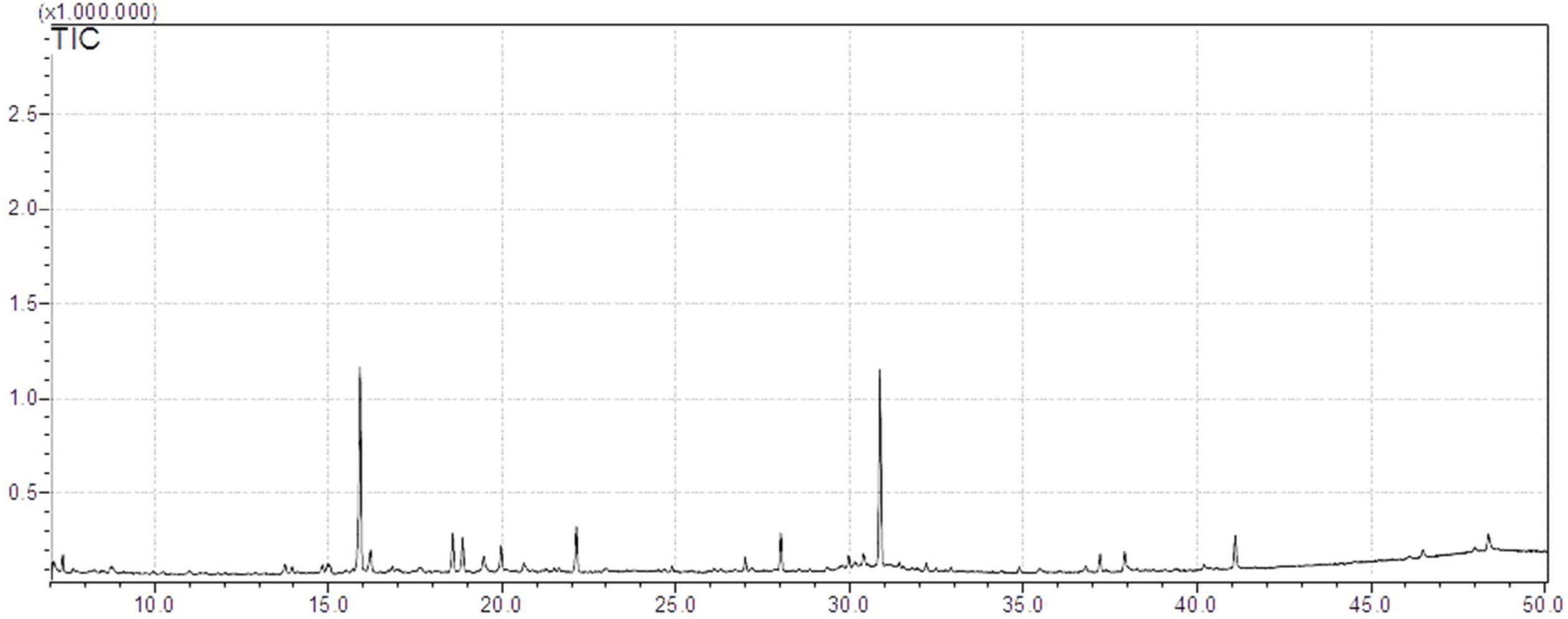


Fig.44 : Partial total ion chromatogram of the outer surface (BECS 1776) of Sample KM20 – E126 (BECS 1774)

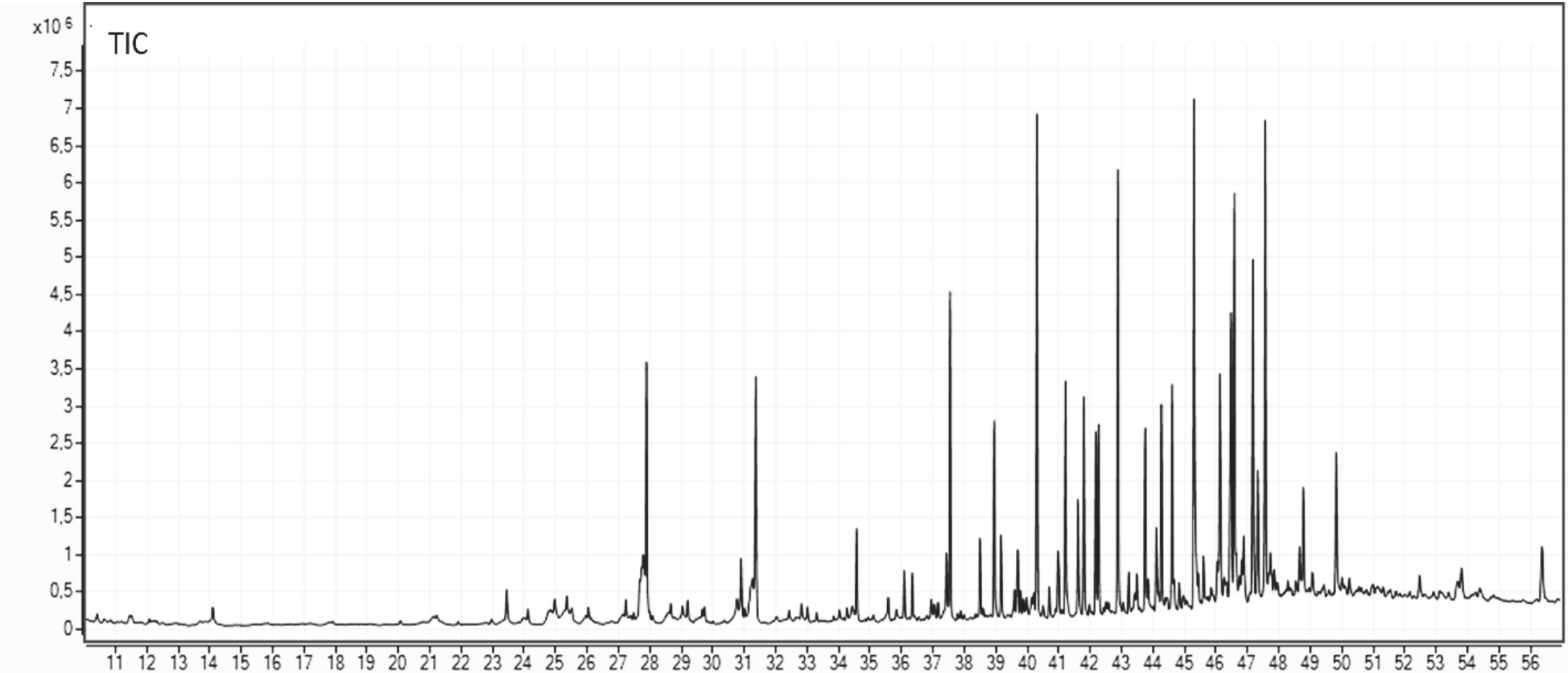


Fig. 45: Partial total ion chromatogram of the soil sample (BECS 1913) associated with Samples KM11 – E101 (BECS 1910), KM17 – E119 (BECS 1777), KM19 – E124 (BECS 1772), and KM20 – E126 (BECS 1774).

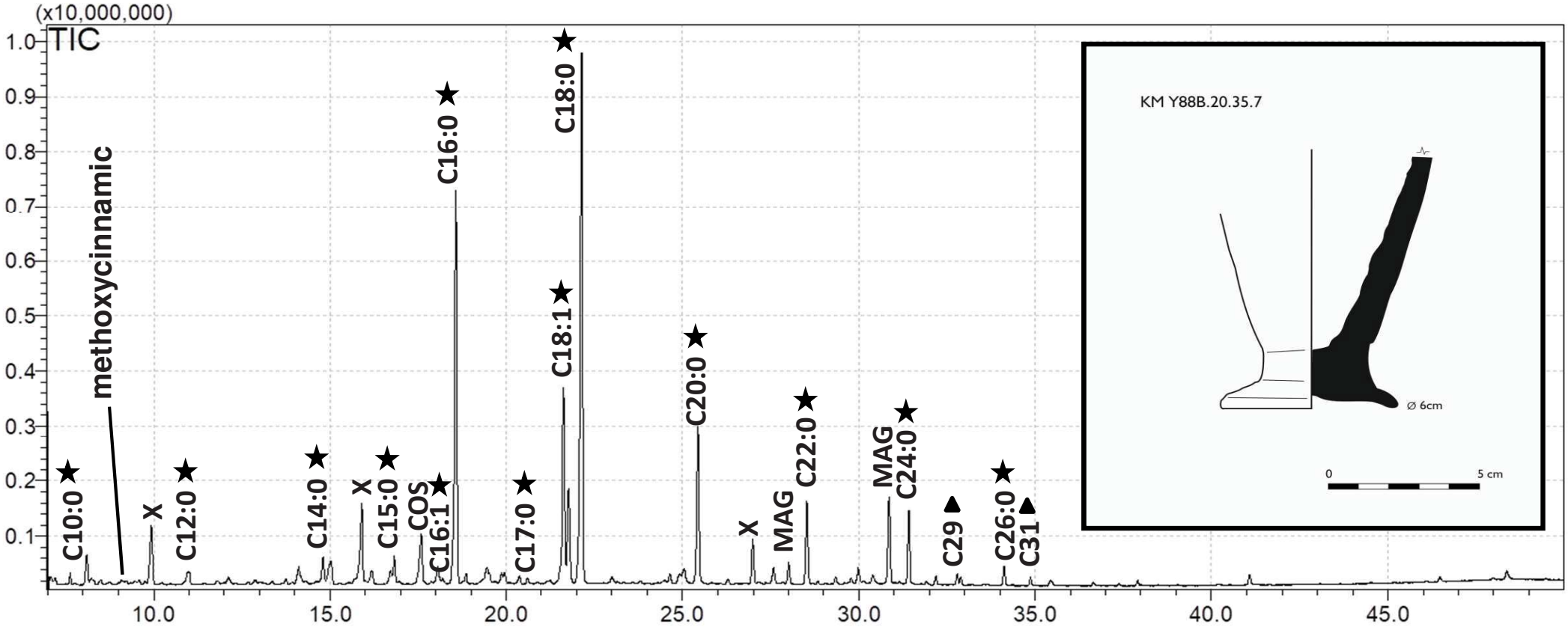


Fig. 46: Partial total ion chromatogram of Sample KM56 – E184 (BECS 1756) of a 'Kassite' Goblet discovered in Trench Y88 (Locus 20 Lot 35) : Cx:y fatty acids ★, CxOH alcohols ■ , Cx alkanes ▲ , aldehydes and amides ♦ , ketones ⬟ , **MAG** and **DAG** mono- and diacylglycerols, wax esters ● , plasticizers (cross).

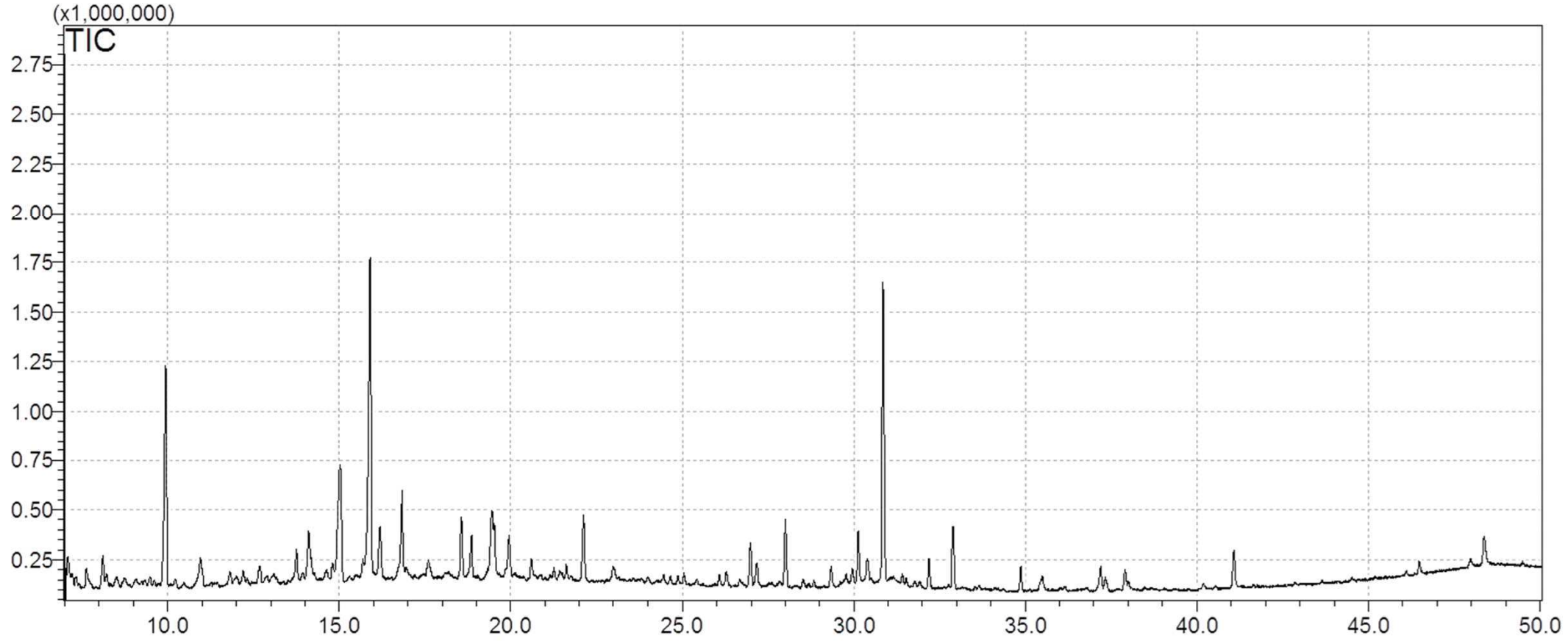


Fig.47 : Partial total ion chromatogram of the inner surface (BECS 1754) of Sample KM56 – E184 (BECS 1756)

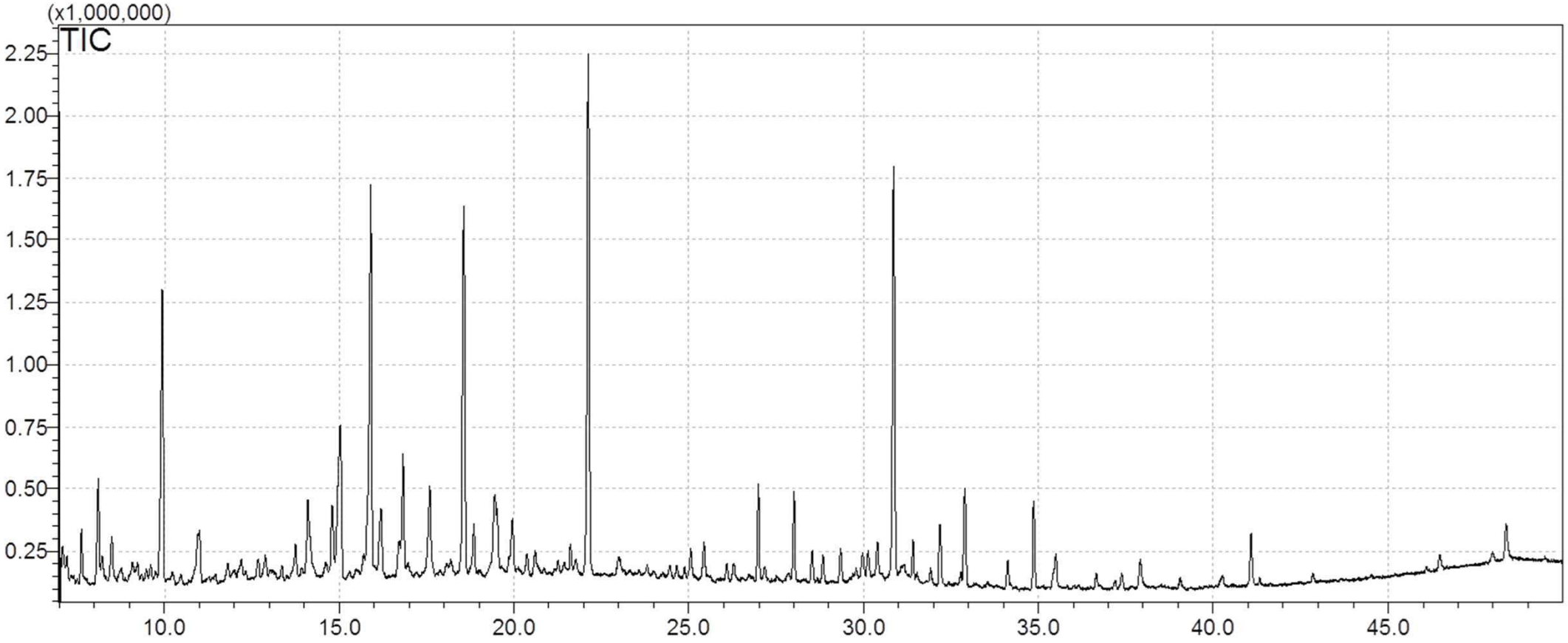


Fig. 48 : Partial total ion chromatogram of the outer surface (BECS 1755) of Sample KM56 – E184 (BECS 1756)

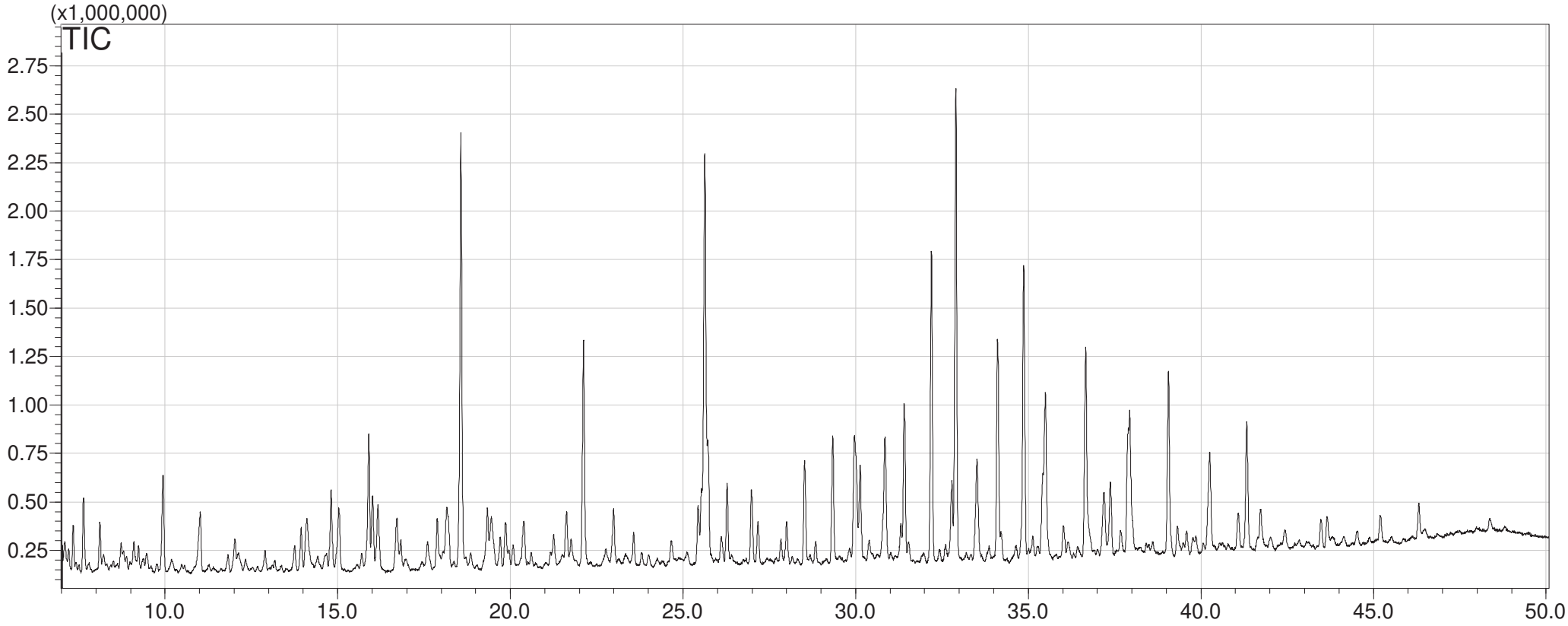


Fig. 49 : Partial total ion chromatogram of the soil sample (BECS 1765) associated with Samples KM49 – E175 (BECS 1747), KM56 – E184 (BECS 1756), KM55 – E182 (BECS 1757), KM51 – E177 (BECS 2015), KM48 – E174 (BECS 2018) and KM54 – E181 (BECS 1935).

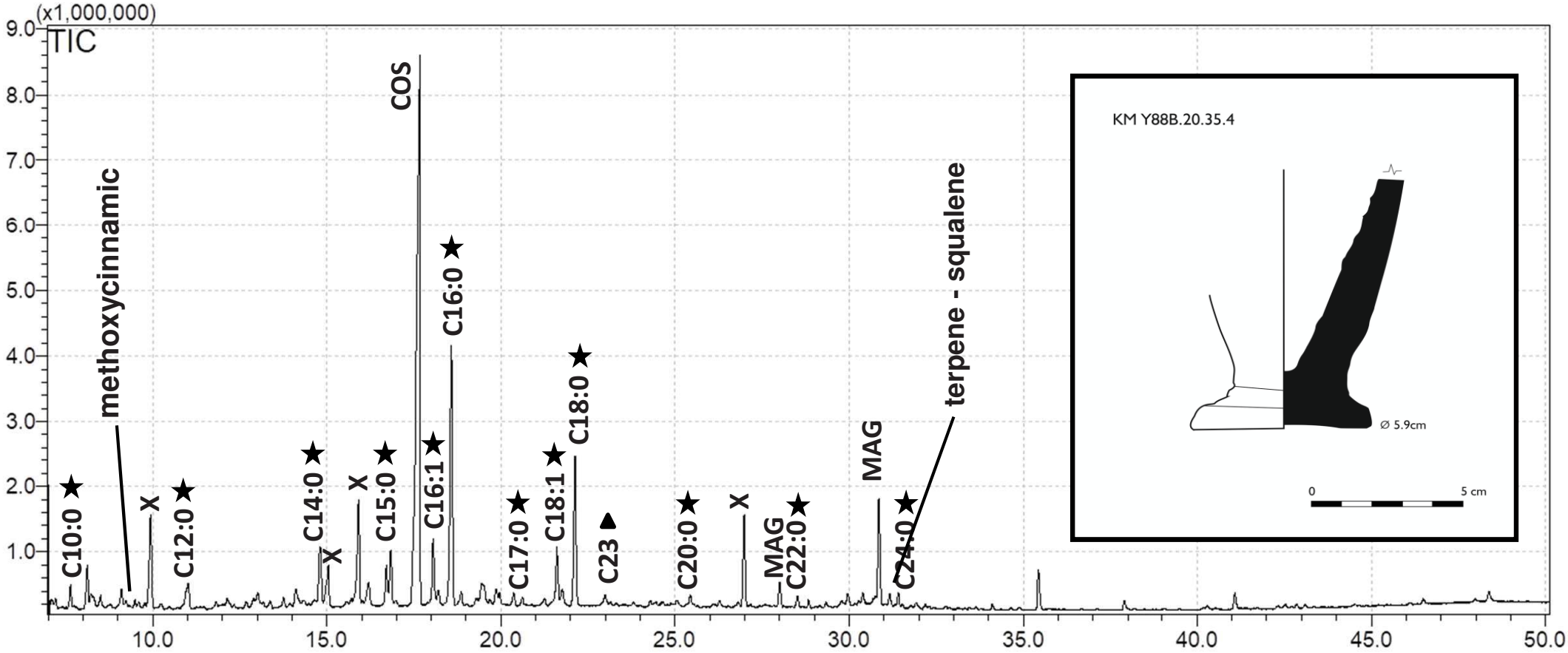


Fig. 50 : Partial total ion chromatogram of Sample KM55 – E182 (BECS 1757) of a 'Kassite' Goblet discovered in Trench Y88 (Locus 20 Lot 35): Cx:y fatty acids ★, CxOH alcohols ■ , Cx alkanes ▲ , aldehydes and amides ♦ , ketones ⬟ , **MAG** and **DAG** mono- and diacylglycerols, wax esters ● , plasticizers (cross).

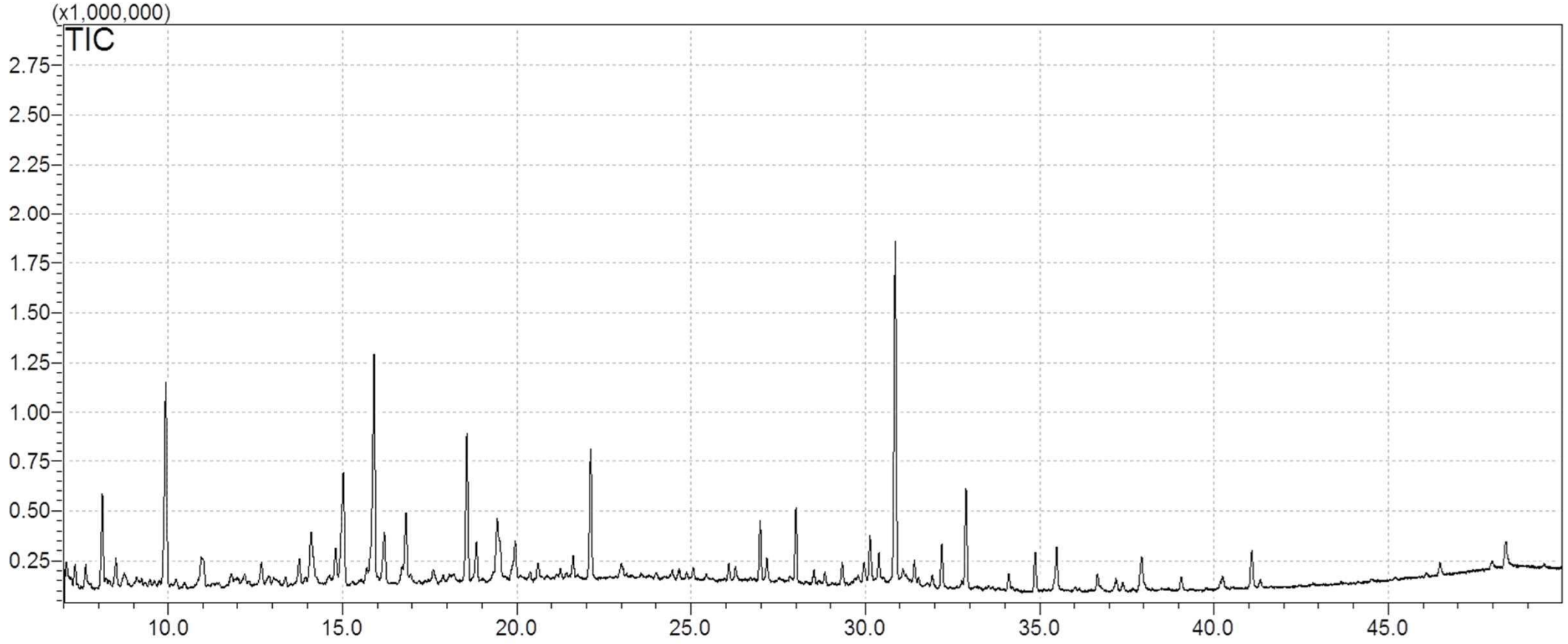


Fig. 51 : Partial total ion chromatogram of the inner surface (BECS 1758) of Sample KM55 – E182 (BECS 1757)

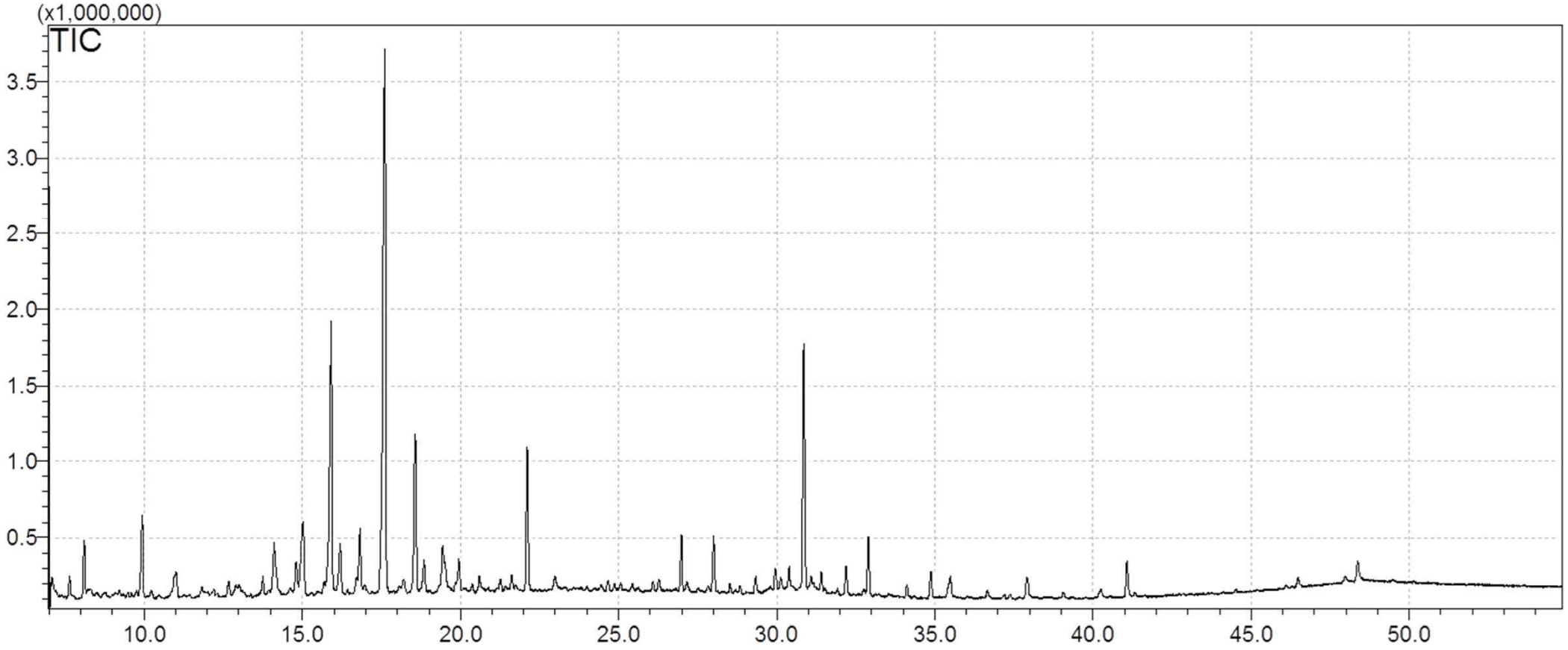


Fig. 52: Partial total ion chromatogram of the outer surface (BECS 1759) of Sample KM55 – E182 (BECS 1757)

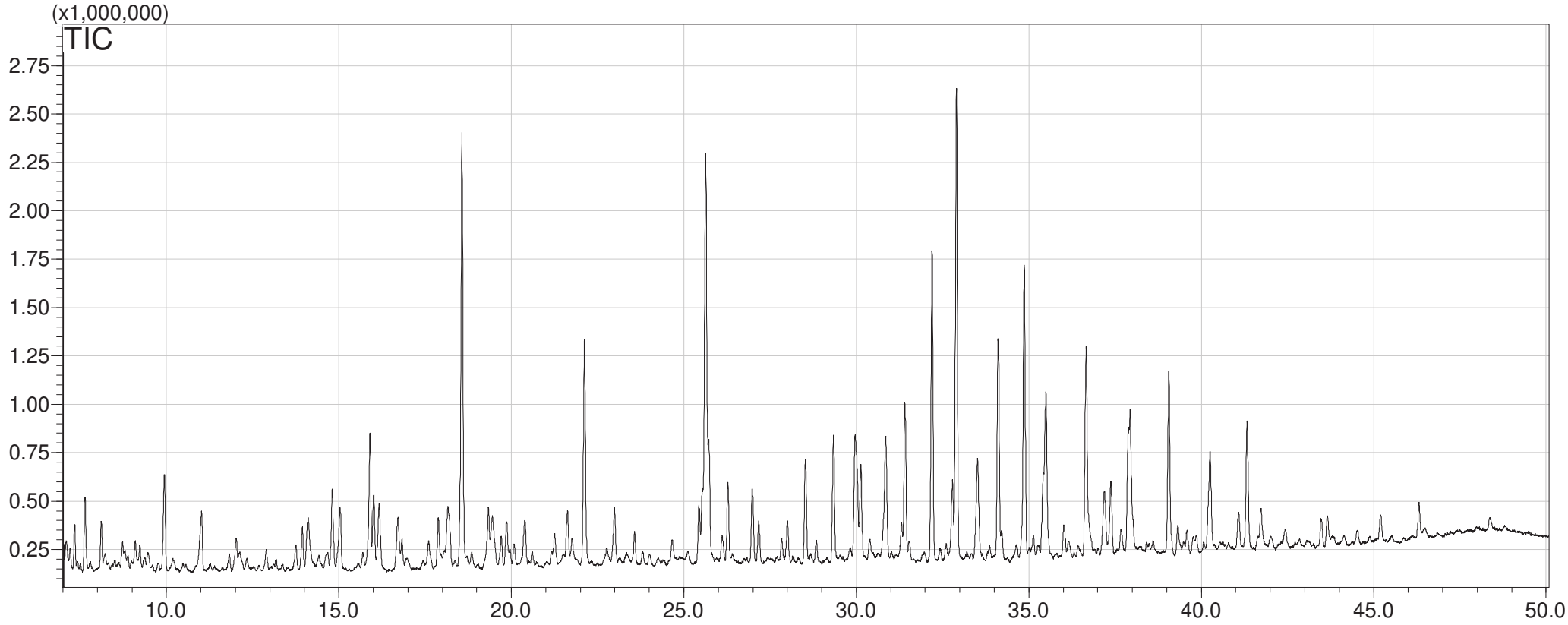


Fig. 53 : Partial total ion chromatogram of the soil sample (BECS 1765) associated with Samples KM49 – E175 (BECS 1747), KM56 – E184 (BECS 1756), KM55 – E182 (BECS 1757), KM51 – E177 (BECS 2015), KM48 – E174 (BECS 2018) and KM54 – E181 (BECS 1935).

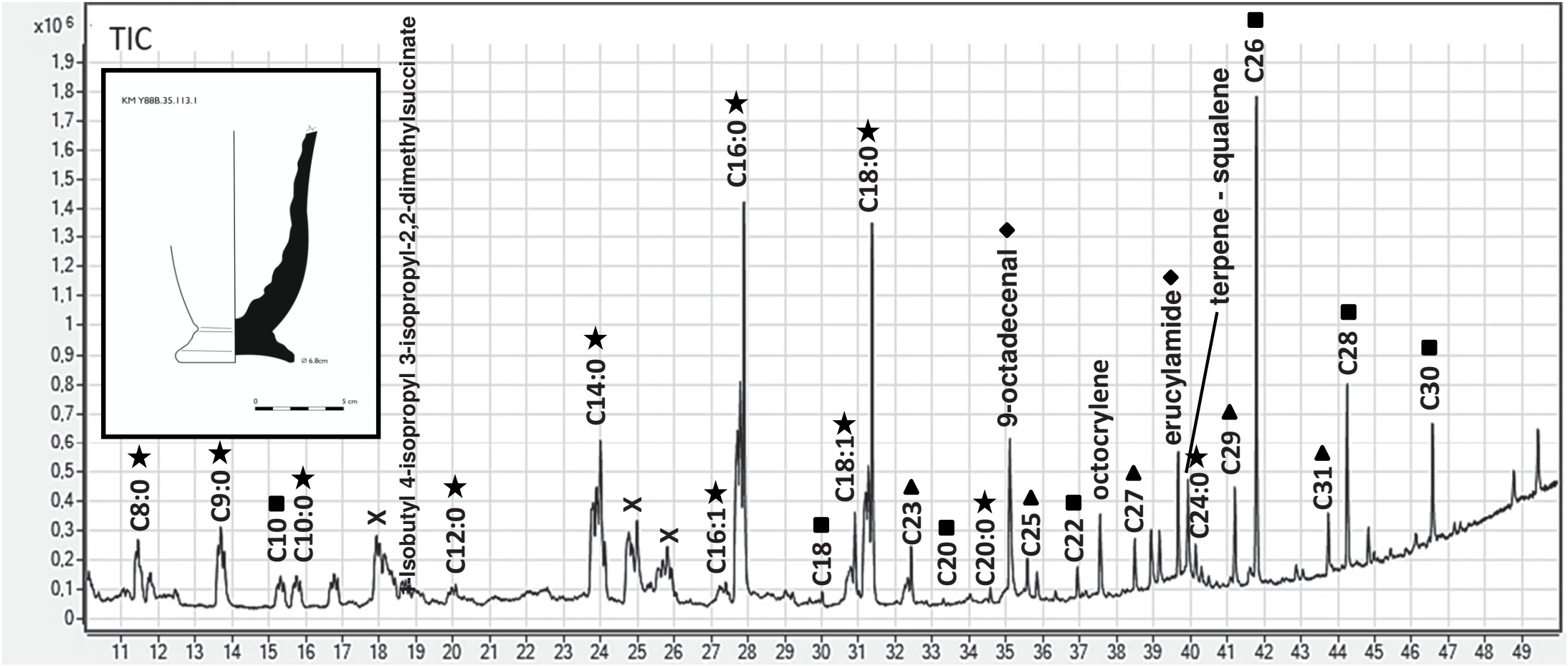


Fig. 54 : Partial total ion chromatogram of Sample KM54 – E181 (BECS 1935) of a 'Kassite' Goblet discovered in Trench Y88 (Locus 35 Lot 113) : Cx:y fatty acids ★, CxOH alcohols ■ , Cx alkanes ▲ , aldehydes and amides ♦ , ketones ⬟ , **MAG** and **DAG** mono- and diacylglycerols, wax esters ● , plasticizers (cross).

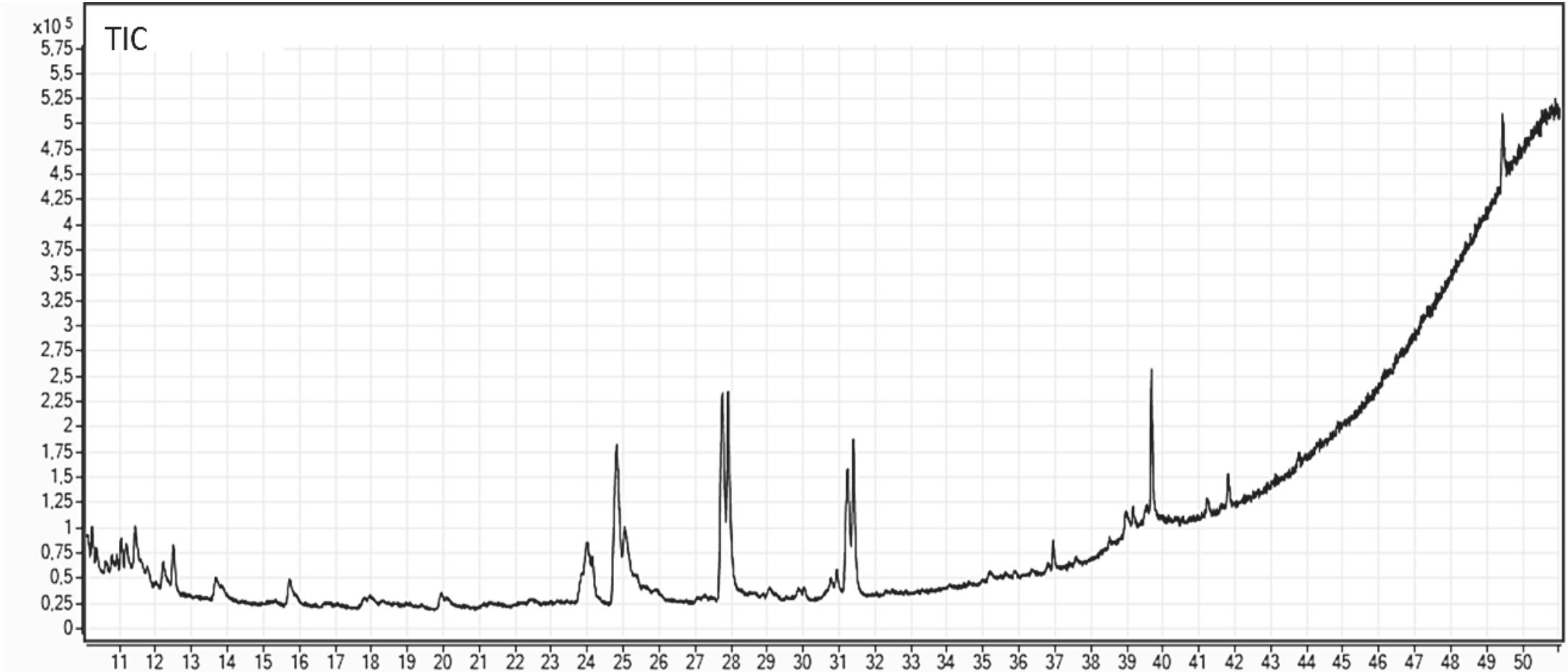


Fig.55 : Partial total ion chromatogram of the inner surface (BECS 1936) of Sample KM54 – E181 (BECS 1935)

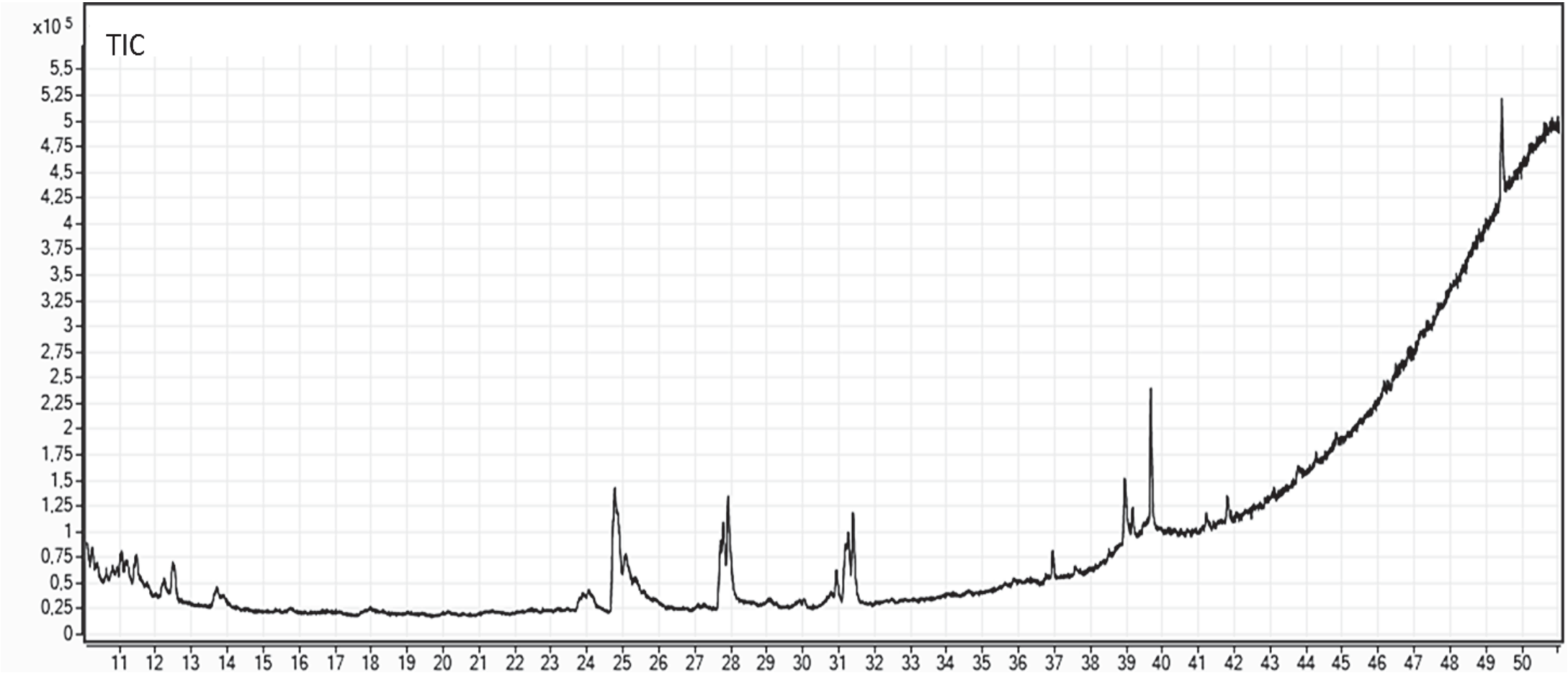


Fig. 56 : Partial total ion chromatogram of the outer surface (BECS 1937) of Sample KM54 – E181 (BECS 1935)

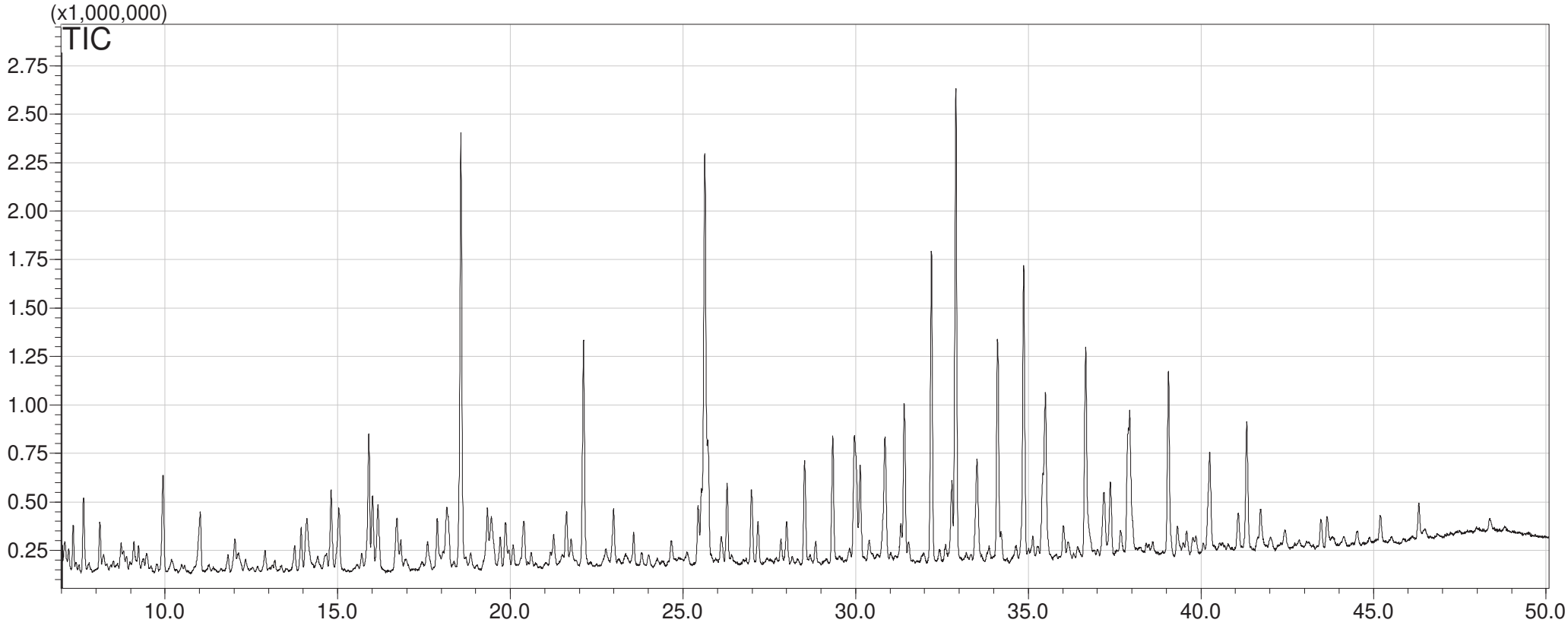


Fig. 57 : Partial total ion chromatogram of the soil sample (BECS 1765) associated with Samples KM49 – E175 (BECS 1747), KM56 – E184 (BECS 1756), KM55 – E182 (BECS 1757), KM51 – E177 (BECS 2015), KM48 – E174 (BECS 2018) and KM54 – E181 (BECS 1935).

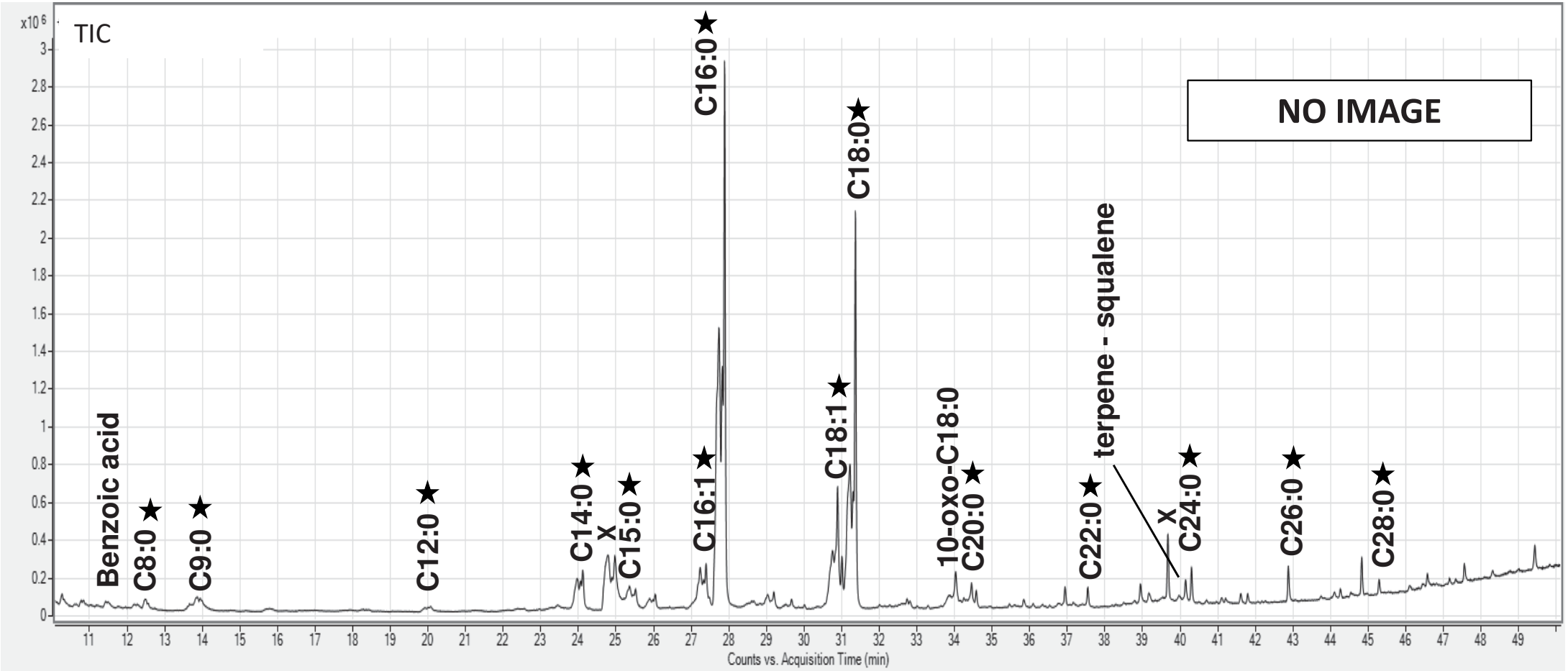


Fig. 58: Partial total ion chromatogram of Sample KM66 – E196 (BECS 1915) of a 'Kassite' Goblet discovered in Trench Y88 (Locus 40 Lot 46) : Cx:y fatty acids ★, CxOH alcohols ■ , Cx alkanes ▲ , aldehydes and amides ♦ , ketones ⬟ , **MAG** and **DAG** mono- and diacylglycerols, wax esters ● , plasticizers (cross).

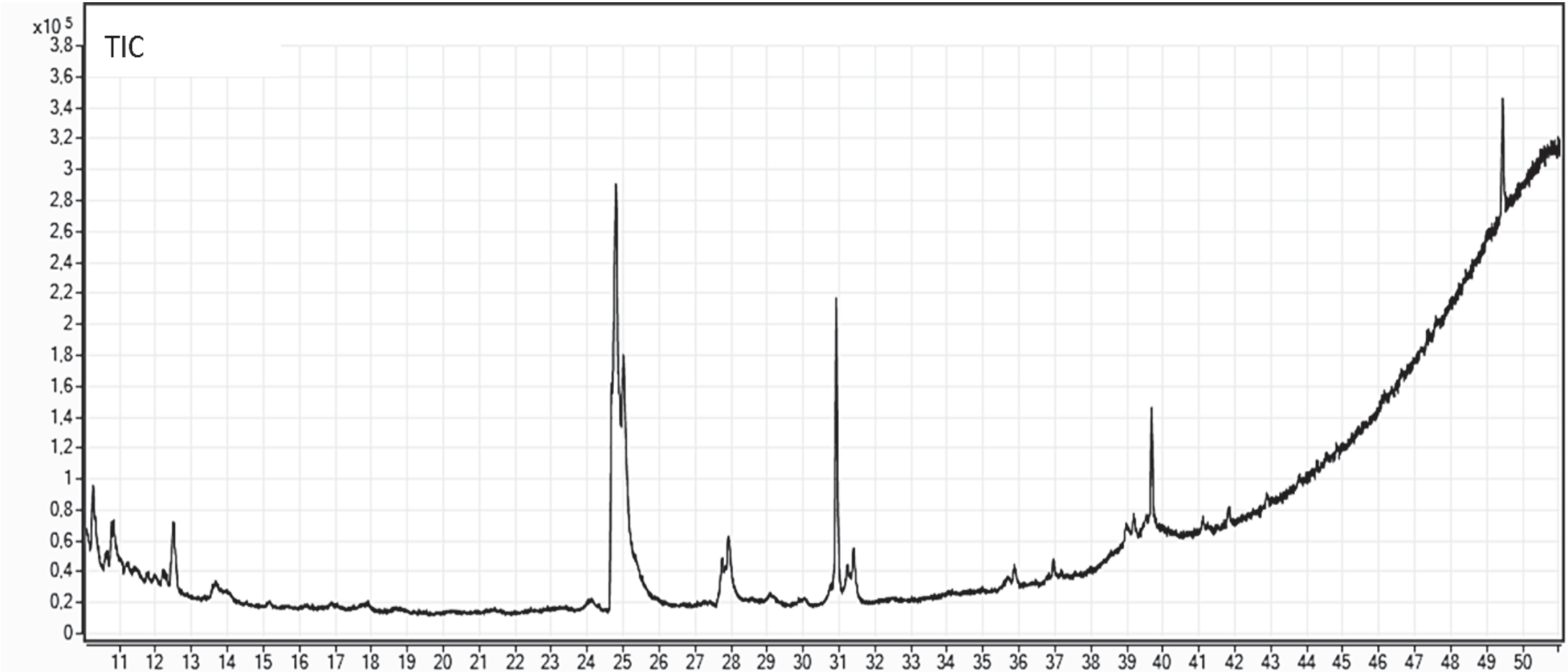


Fig. 59: Partial total ion chromatogram of the inner surface (BECS 1916) of Sample KM66 – E196 (BECS 1915)

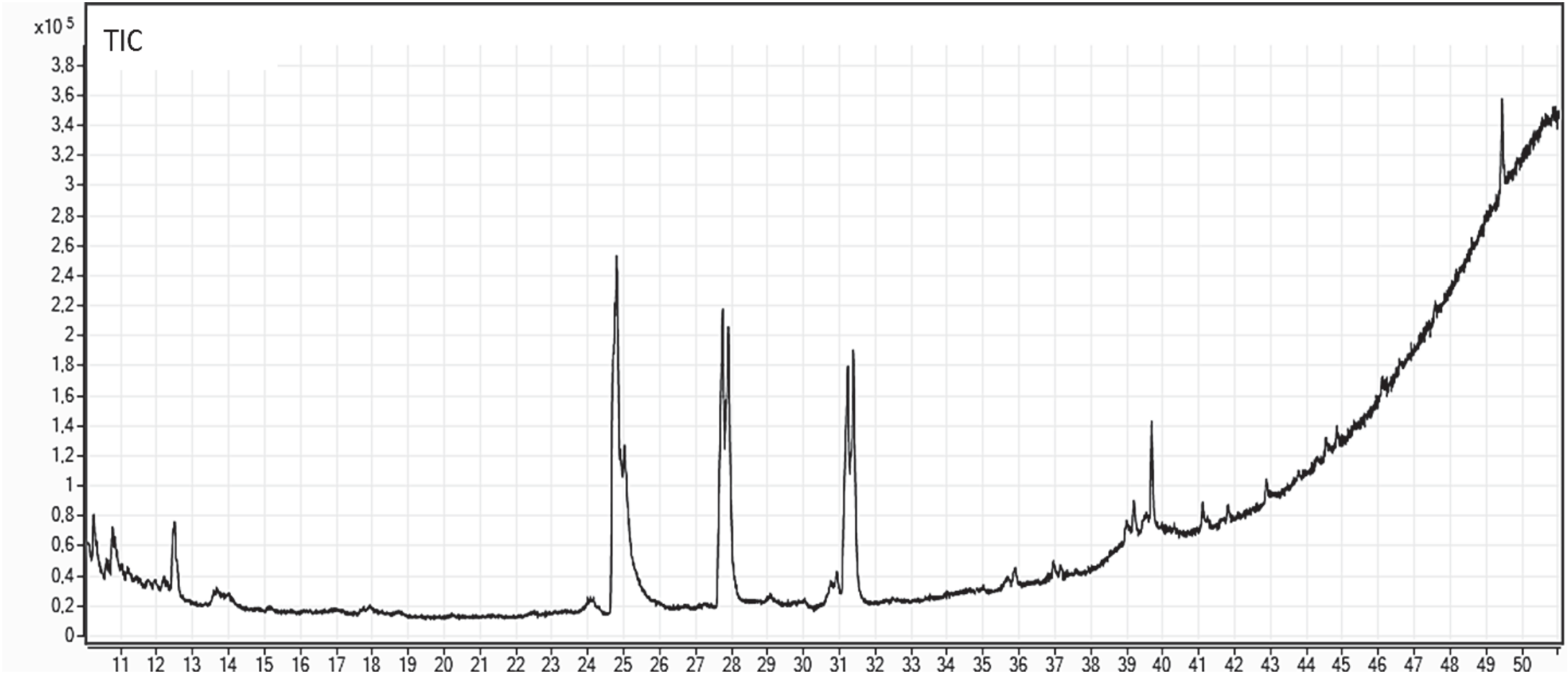


Fig. 60: Partial total ion chromatogram of the outer surface (BECS 1917) of Sample KM66 – E196 (BECS 1915)

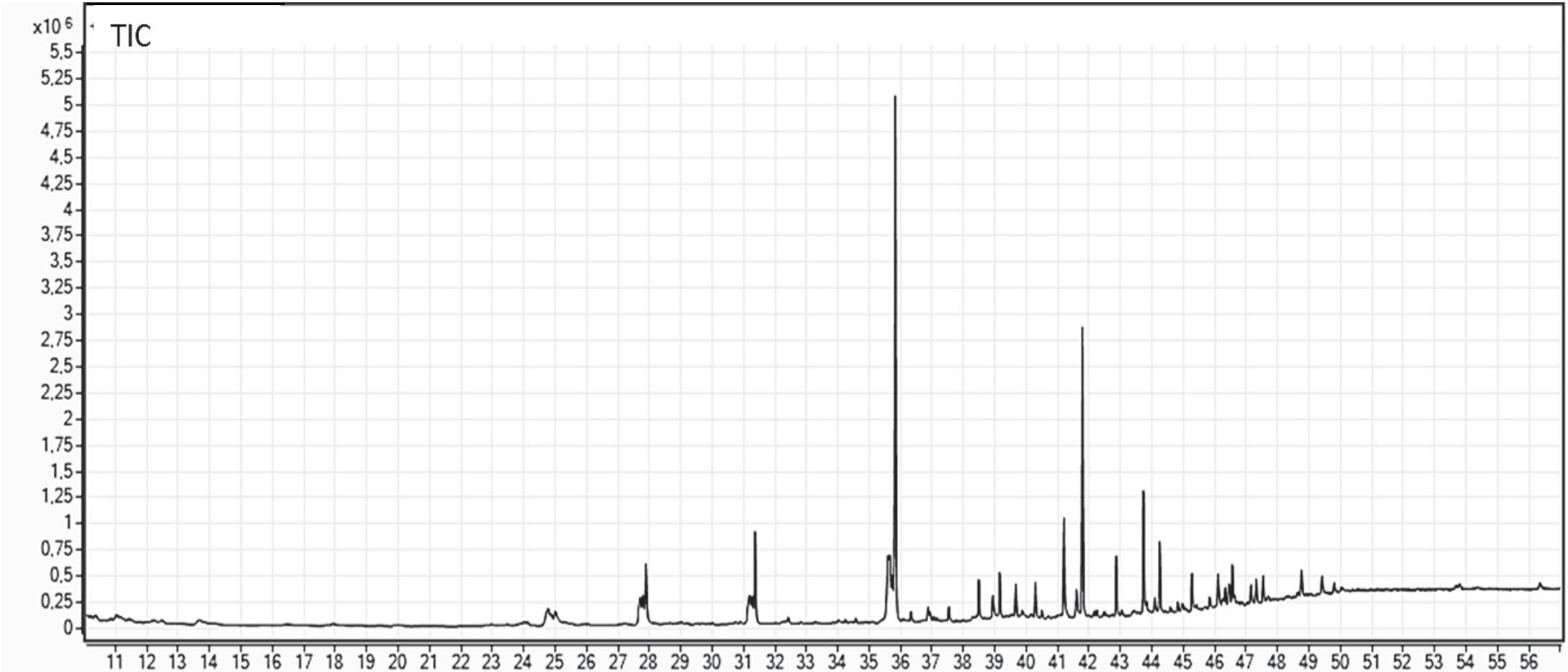


Fig. 61: Partial total ion chromatogram of the soil sample (BECS 1941) associated with Samples KM38 – E162 (BECS 1769), KM34 – E157 (BECS 1766), KM66 – E196 (BECS 1915) and KM70 – E201 (BECS 1938).

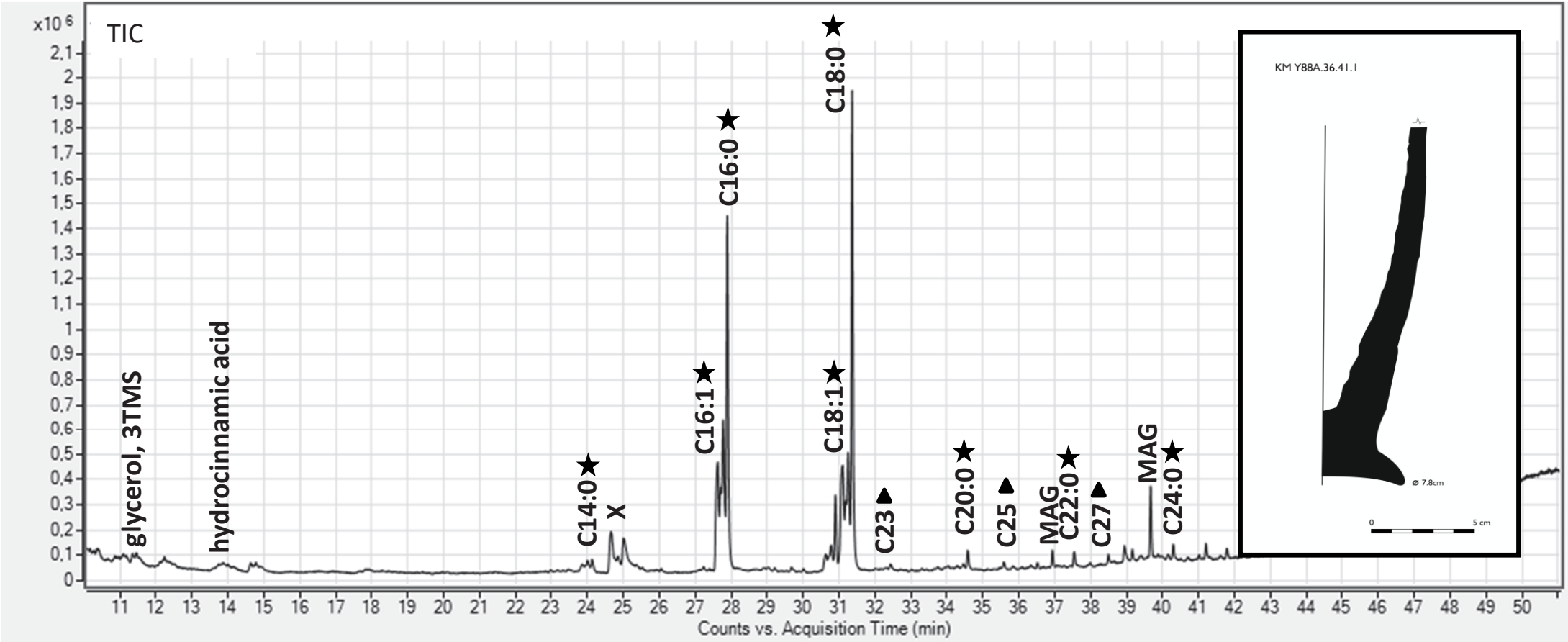


Fig. 62: Partial total ion chromatogram of Sample KM70 – E201 (BECS 1938) of a 'Kassite' Goblet discovered in Trench Y88 (Locus 36 Lot 41) : Cx:y fatty acids ★, CxOH alcohols ■ , Cx alkanes ▲ , aldehydes and amides ♦ , ketones ⬣ , **MAG** and **DAG** mono- and diacylglycerols, wax esters ● , plasticizers (cross).

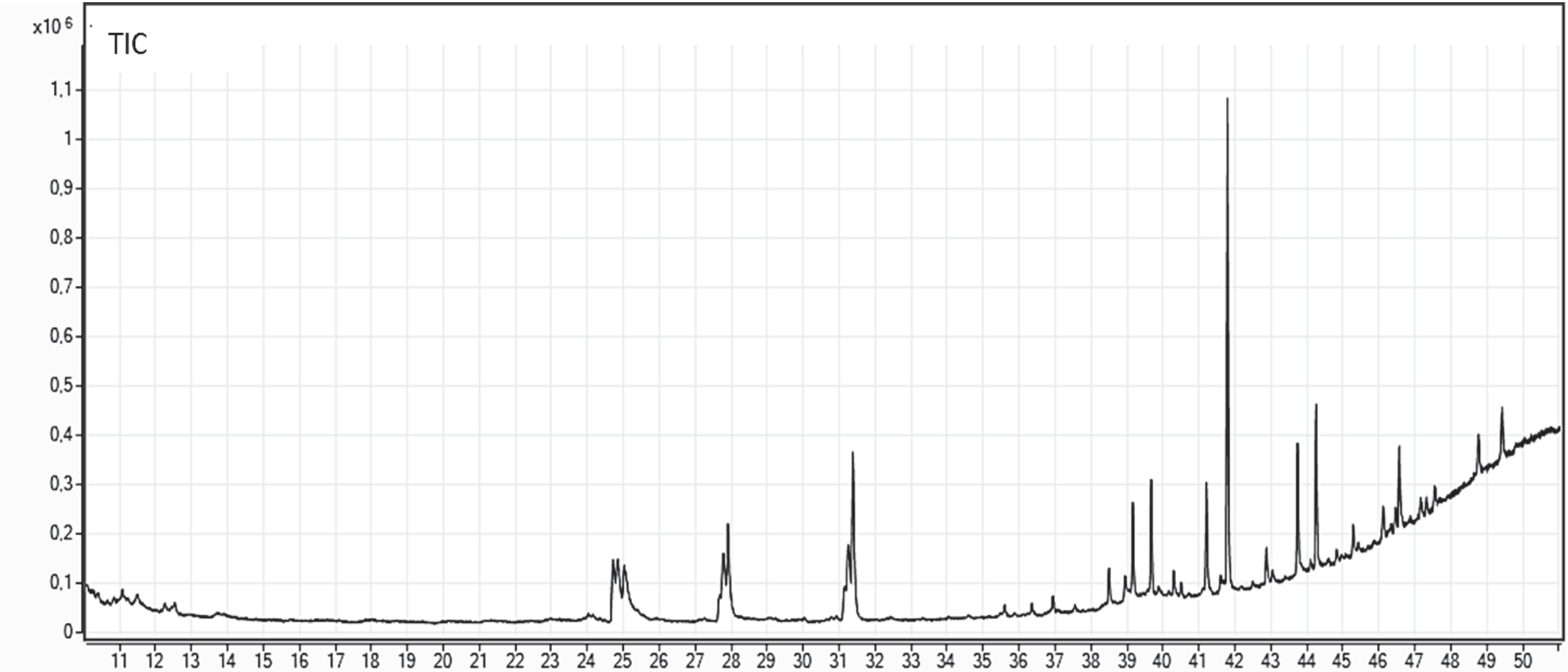


Fig. 63 : Partial total ion chromatogram of the inner surface (BECS 1939) of Sample KM70 – E201 (BECS 1938)

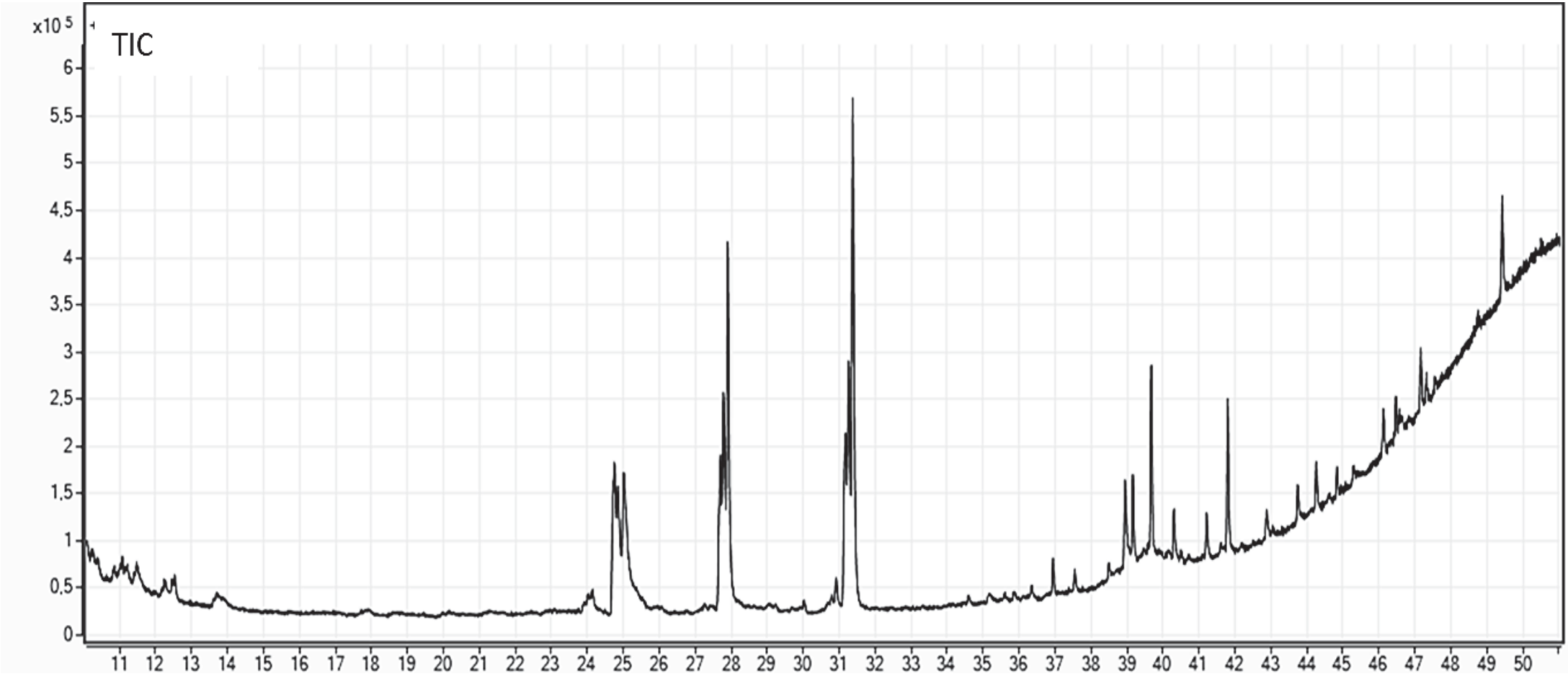


Fig. 64: Partial total ion chromatogram of the outer surface (BECS 1940) of Sample KM70 – E201 (BECS 1938)

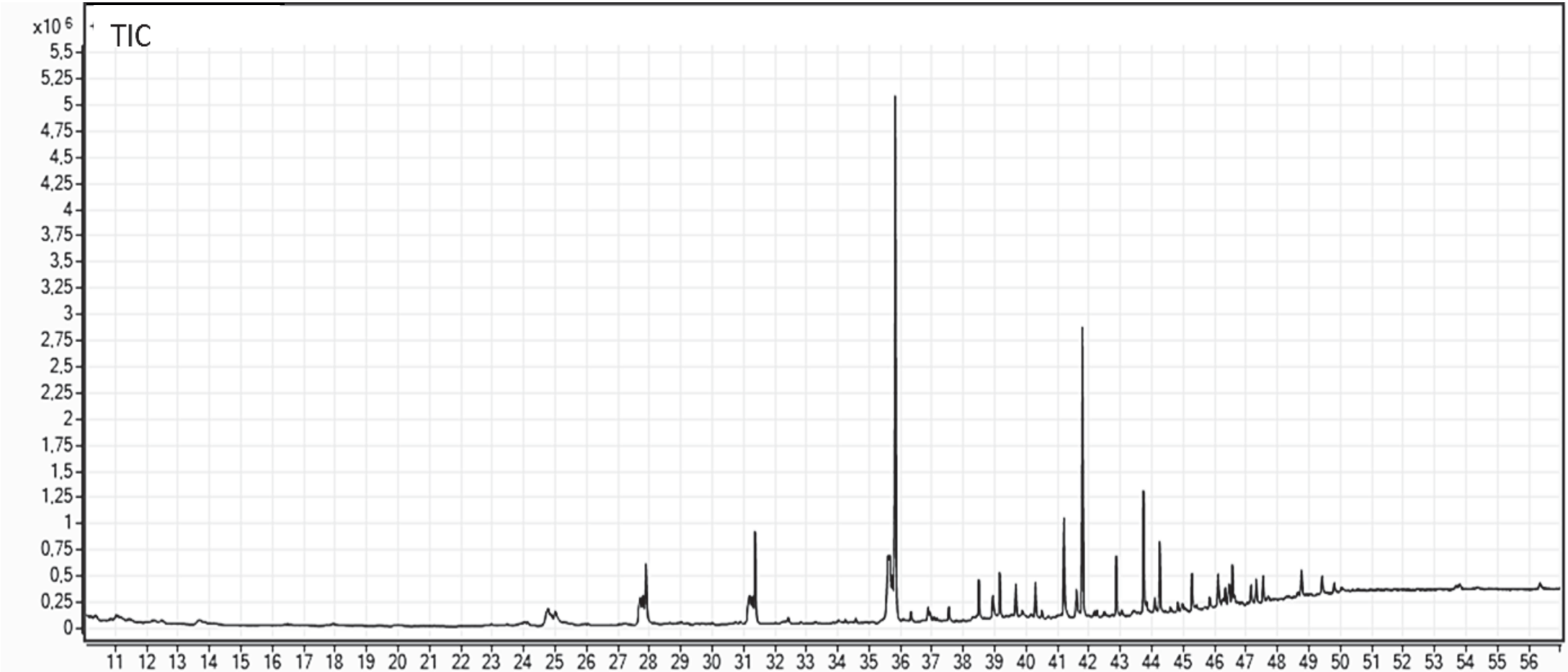


Fig. 65 : Partial total ion chromatogram of the soil sample (BECS 1941) associated with Samples KM38 – E162 (BECS 1769), KM34 – E157 (BECS 1766), KM66 – E196 (BECS 1915) and KM70 – E201 (BECS 1938).

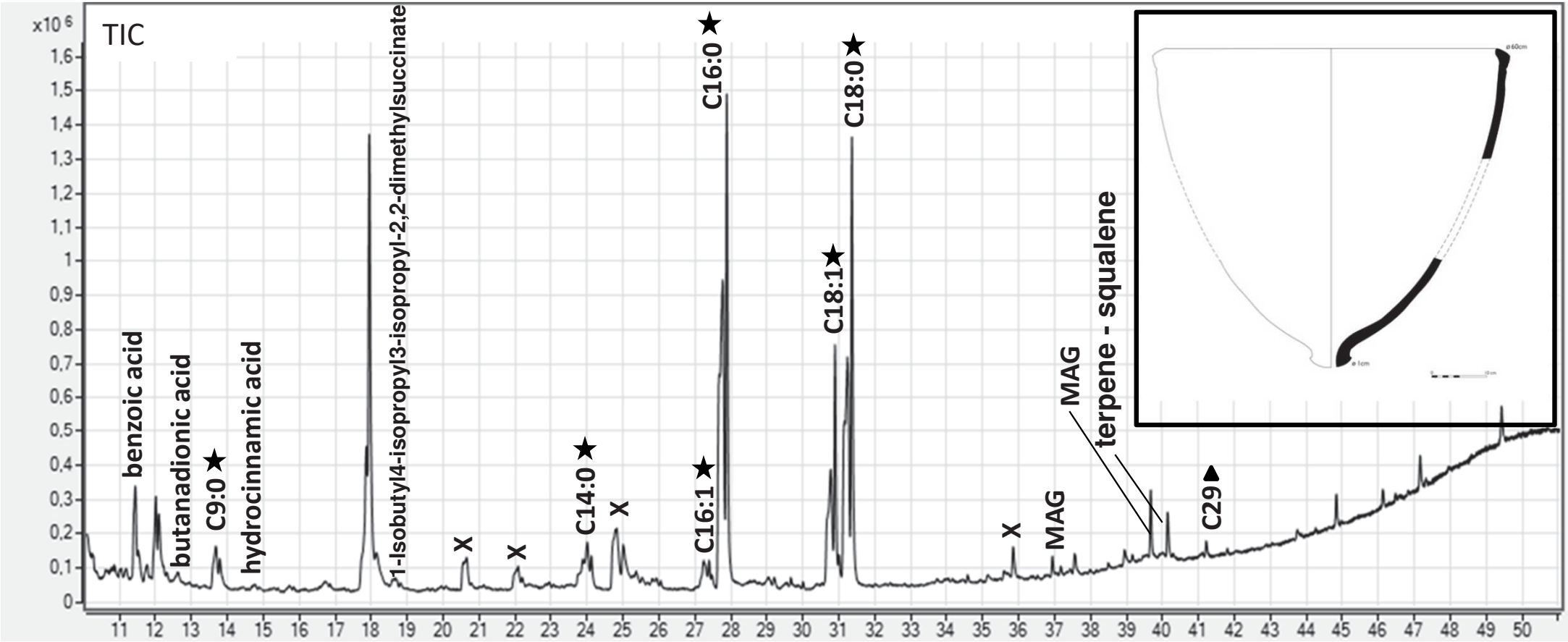


Fig. 66: Partial total ion chromatogram of Sample KM11 – E101 (BECS 1910) of a *namzitu* discovered in Trench Y88 (Locus 3 Lot 10) : Cx:y fatty acids ★, CxOH alcohols ■ , Cx alkanes ▲ , aldehydes and amides ♦ , ketones ⬟ , **MAG** and **DAG** mono- and diacylglycerols, wax esters ● , plasticizers (cross).

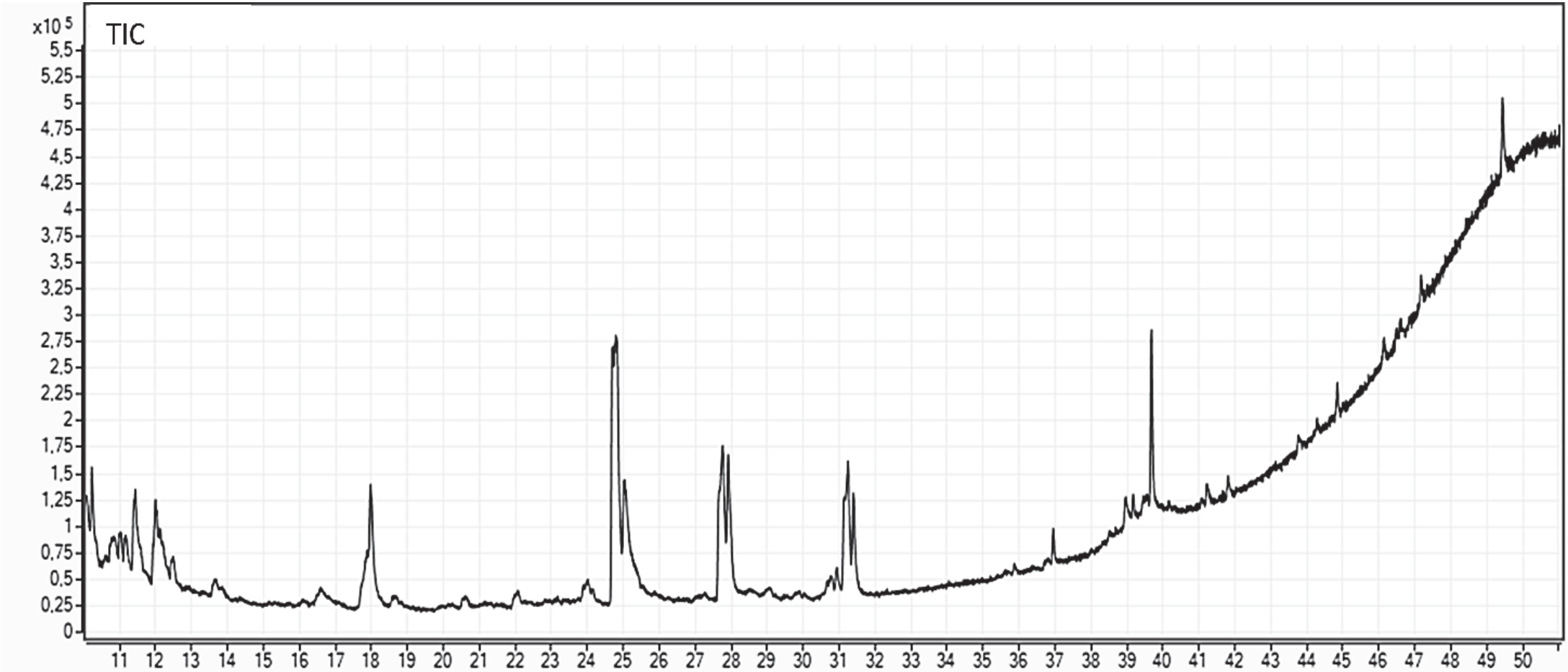


Fig. 67: Partial total ion chromatogram of the inner surface (BECS 1911) of Sample KM11 – E101 (BECS 1910)

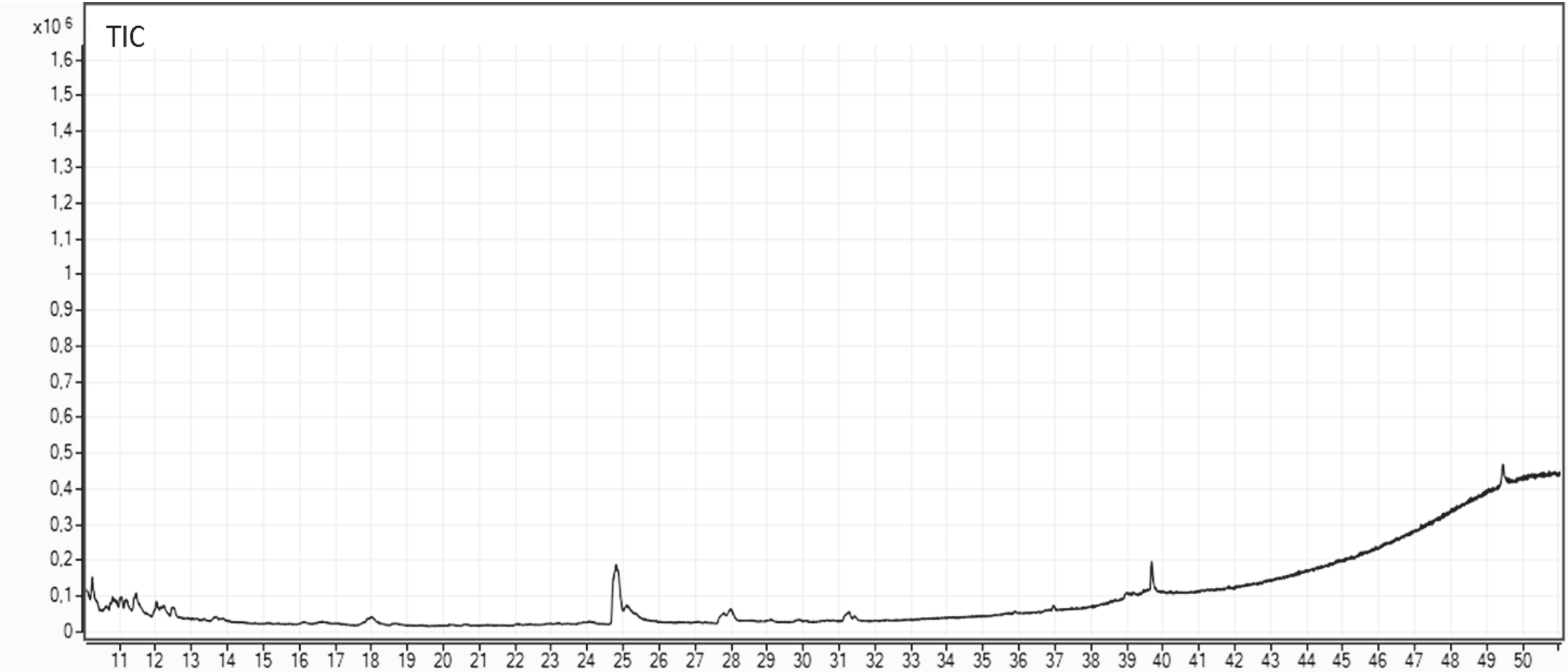


Fig. 68: Partial total ion chromatogram of the outer surface (BECS 1912) of Sample KM11 – E101 (BECS 1910)

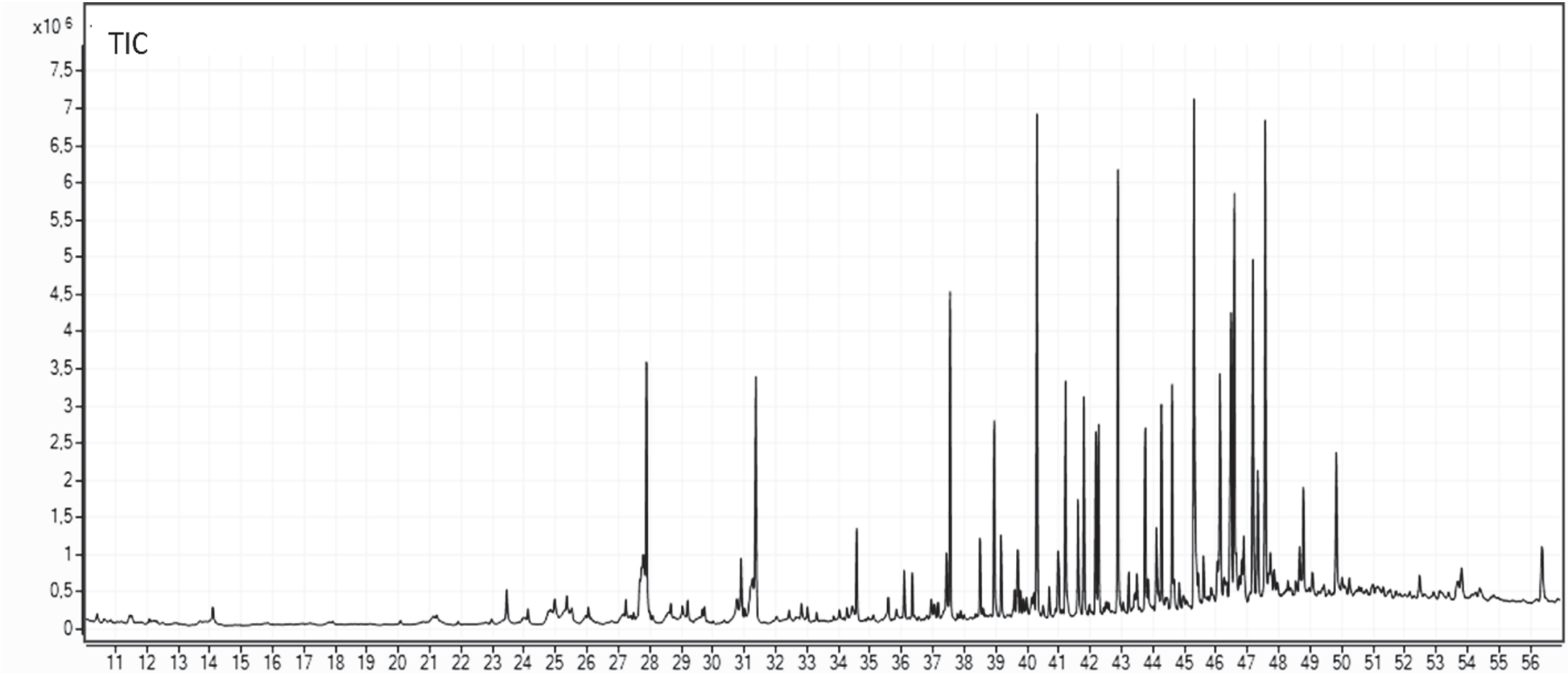


Fig. 69 : Partial total ion chromatogram of the soil sample (BECS 1913) associated with Samples KM11 – E101 (BECS 1910), KM17 – E119 (BECS 1777), KM19 – E124 (BECS 1772), and KM20 – E126 (BECS 1774).

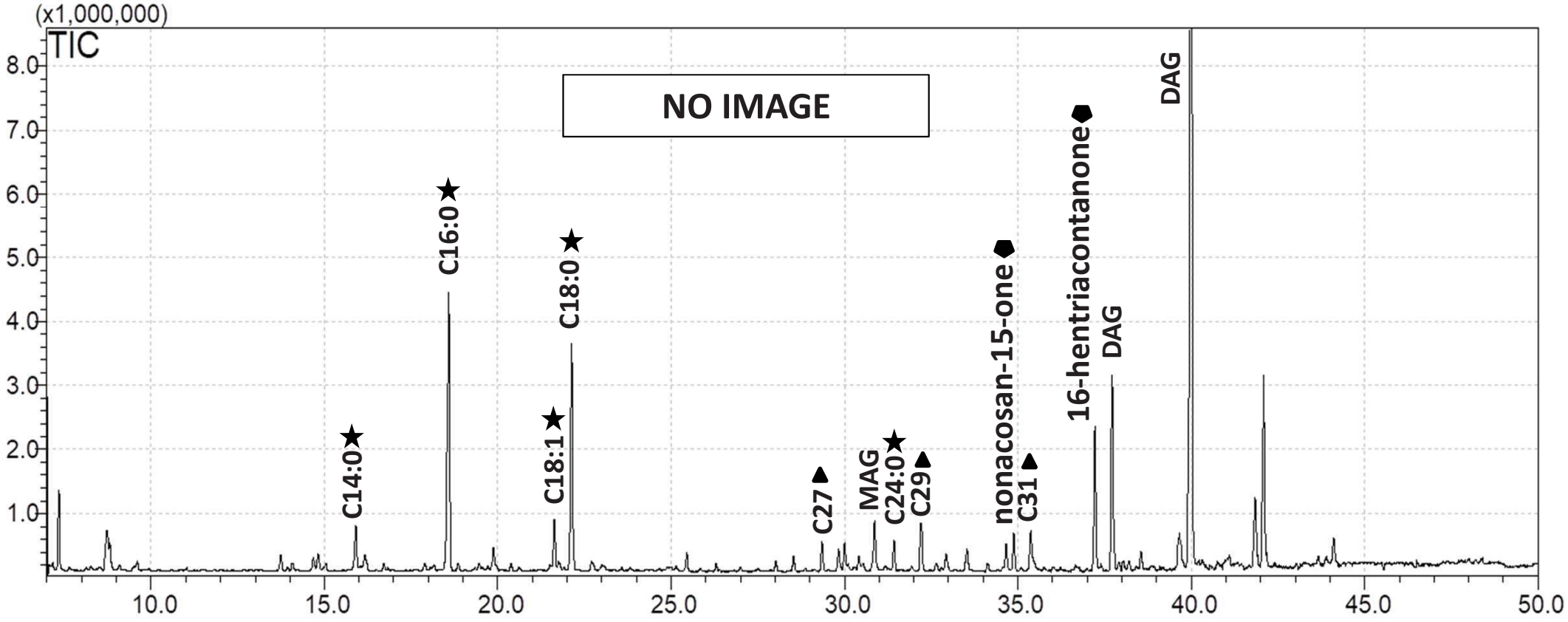


Fig. 70 : Partial total ion chromatogram of Sample KM19 – E124 (BECS 1772) of a Bowl discovered in Trench Y88 (Locus 3 Lot 9) : Cx:y fatty acids ★, CxOH alcohols ■ , Cx alkanes ▲ , aldehydes and amides ♦ , ketones ⬣ , **MAG** and **DAG** mono- and diacylglycerols, wax esters ● , plasticizers (cross).

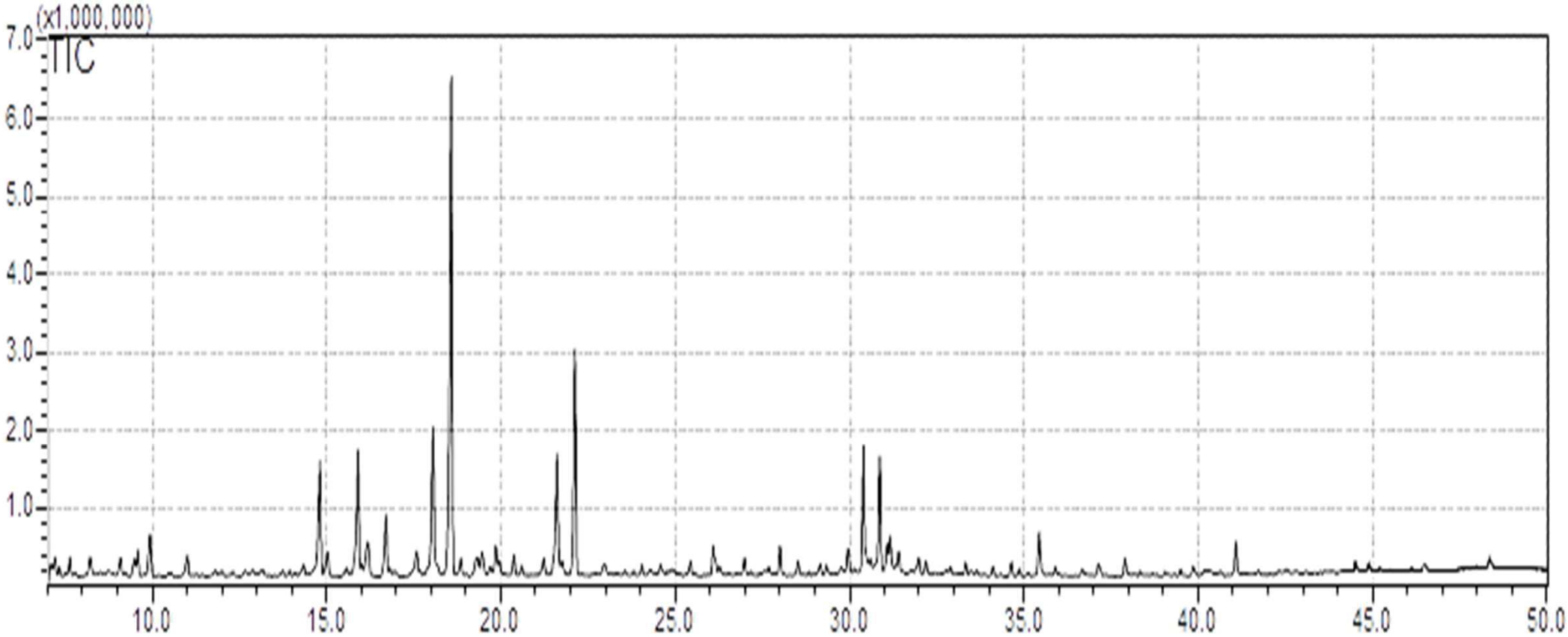


Fig.71 : Partial total ion chromatogram of the outer surface (BECS 1773) of Sample KM19 – E124 (BECS 1772)

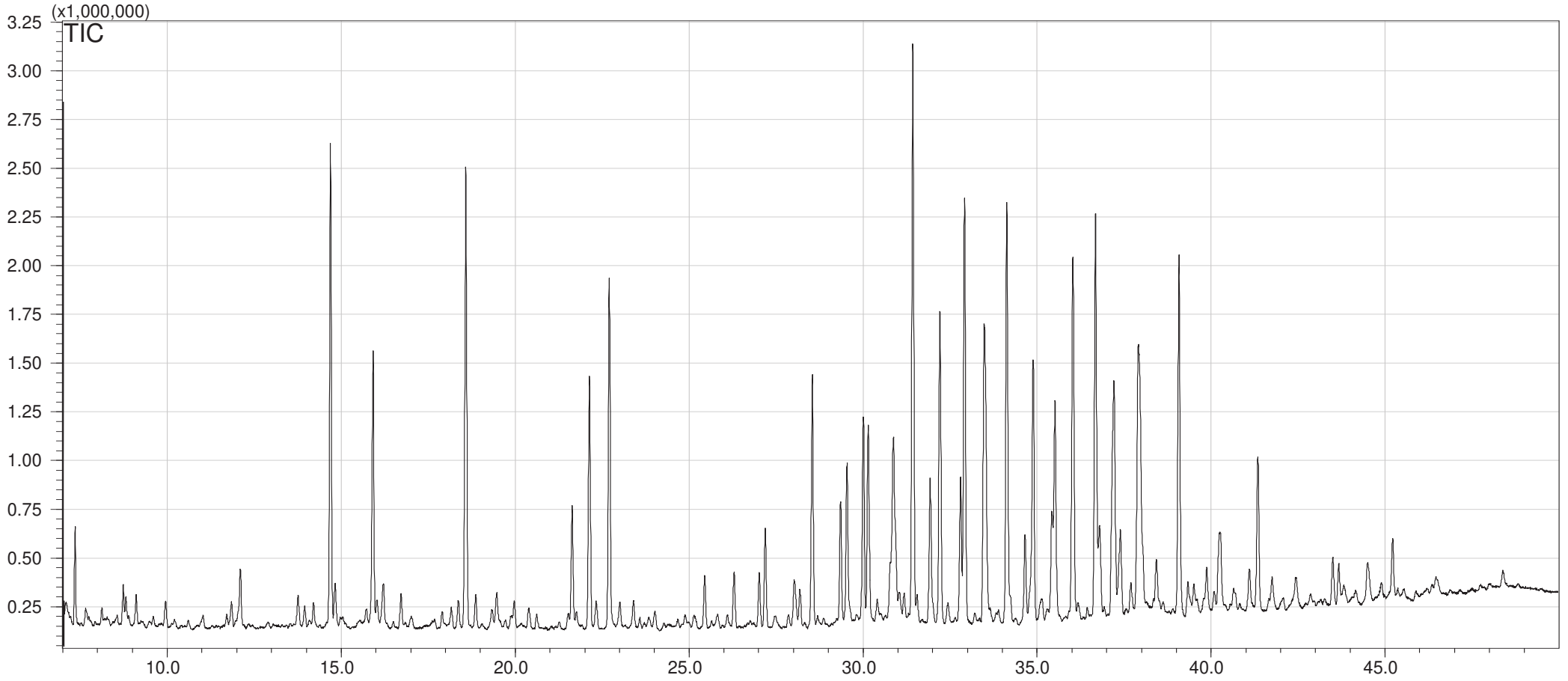


Fig.72 : Partial total ion chromatogram of the soil sample (BECS 1778) associated with Sample KM19 – E124 (BECS 1772)

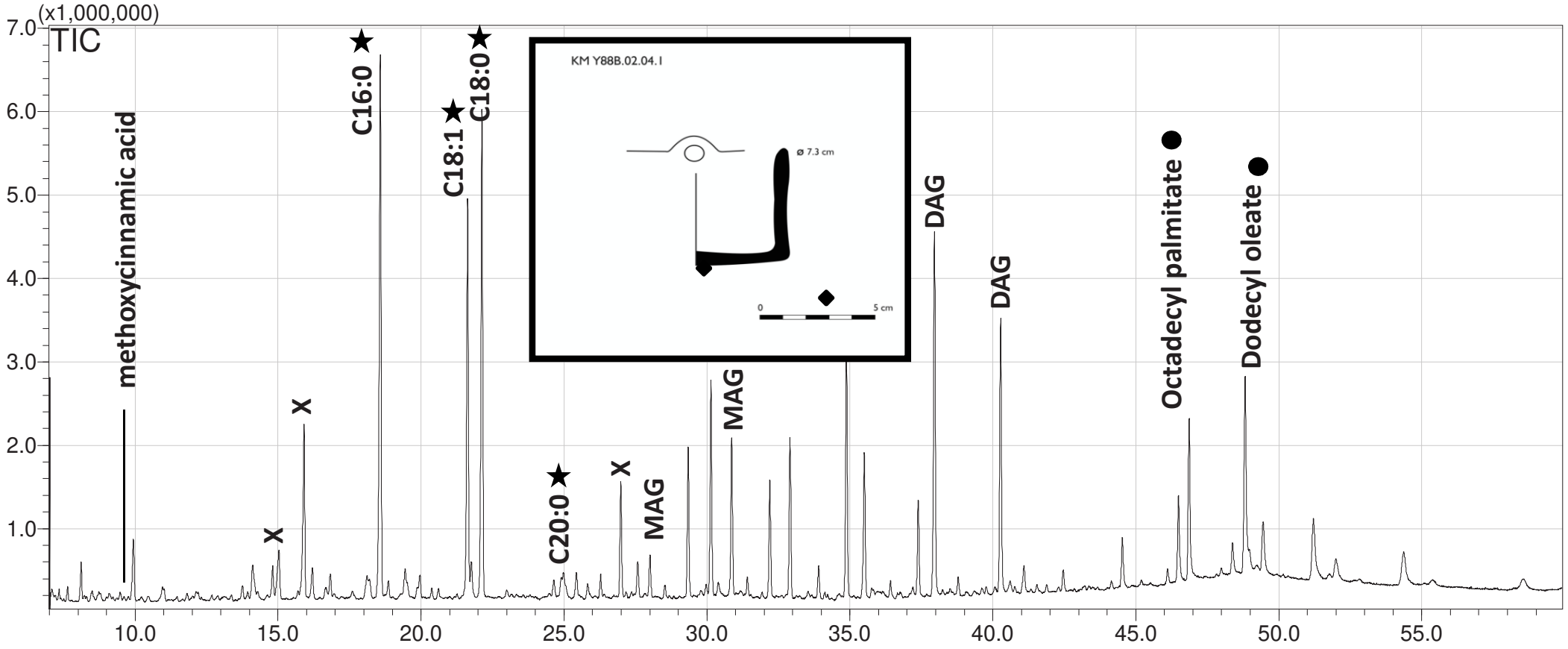


Fig. 73 : Partial total ion chromatogram of Sample KM1 – E78 (BECS 1760) of a faïence bucket discovered in Trench Y88 (Locus 2 Lot 4) : Cx:y fatty acids ★, CxOH alcohols ■ , Cx alkanes ▲ , aldehydes and amides ♦ , ketones ⬟ , **MAG** and **DAG** mono- and diacylglycerols, wax esters ● , plasticizers (cross).

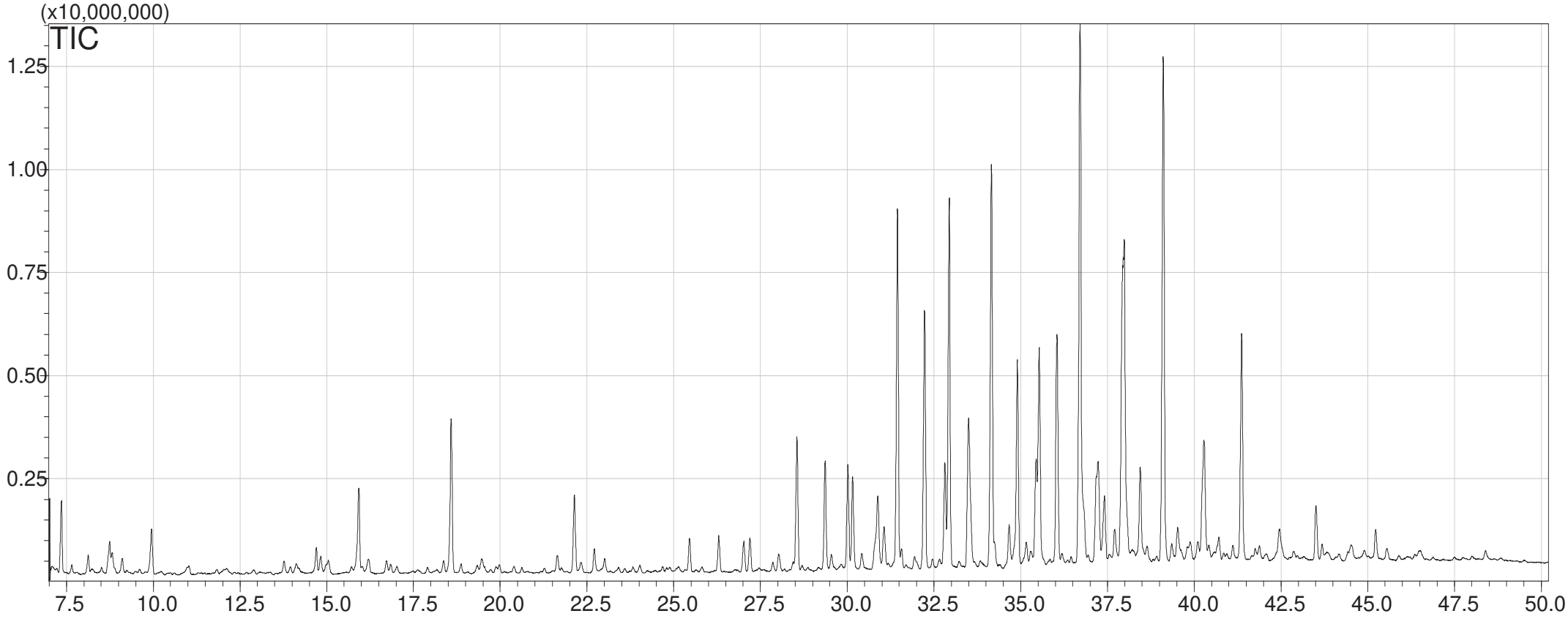


Fig. 74: Partial total ion chromatogram of the soil sample (BECS 1961) associated with Samples KM1 – E78 (BECS 1960).

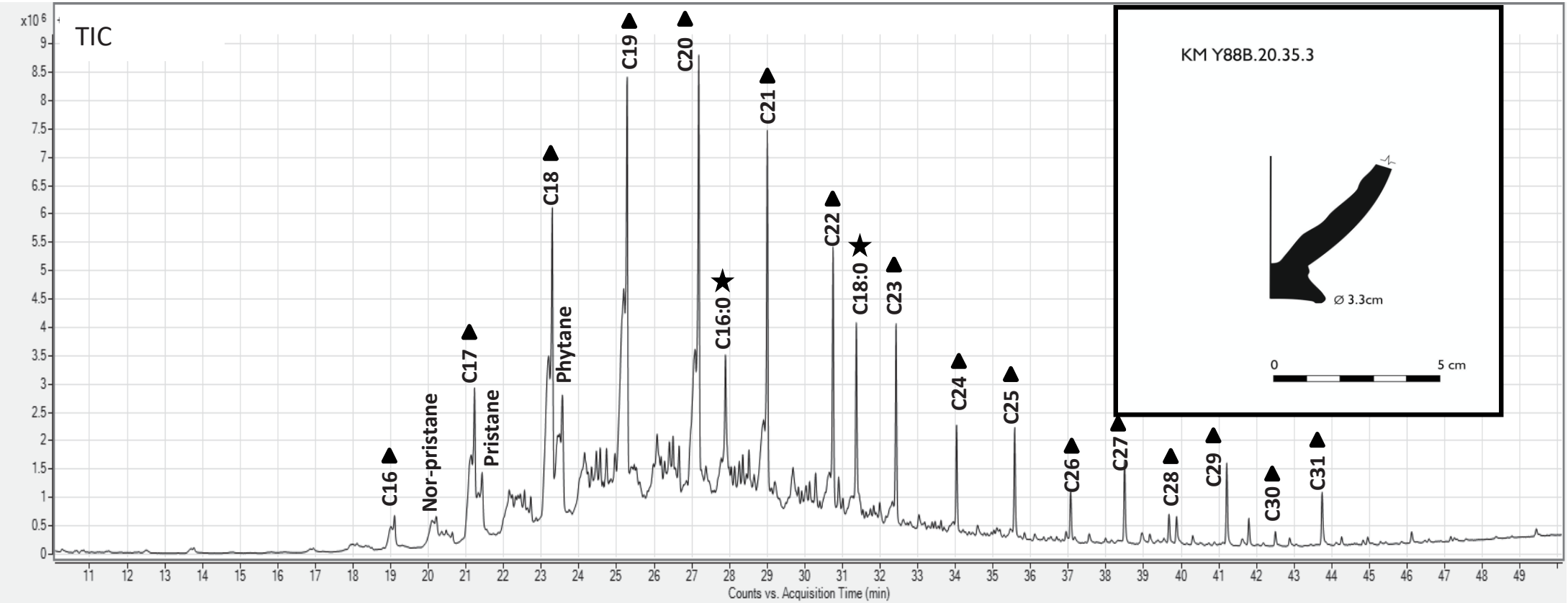


Fig. 75 : Partial total ion chromatogram of Sample KM51 – E177 (BECS 2015) of a cup discovered in Trench Y88 (Locus 20 Lot 35) : Cx:y fatty acids ★, CxOH alcohols ■ , Cx alkanes ▲ , aldehydes and amides ♦ , ketones ⬟ , **MAG** and **DAG** mono- and diacylglycerols, wax esters ● , plasticizers (cross).

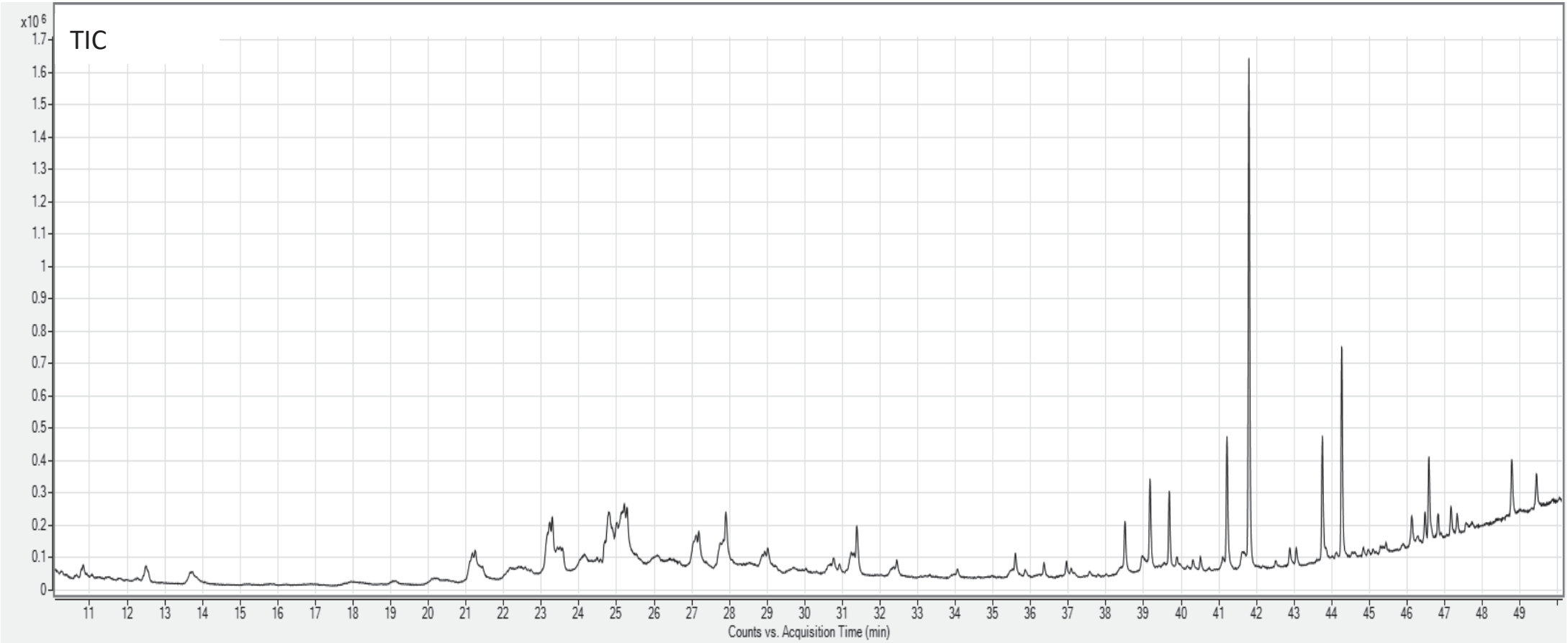


Fig. 76: Partial total ion chromatogram of the outer surface (BECS 2016) of Sample KM51 – E177 (BECS 2015)

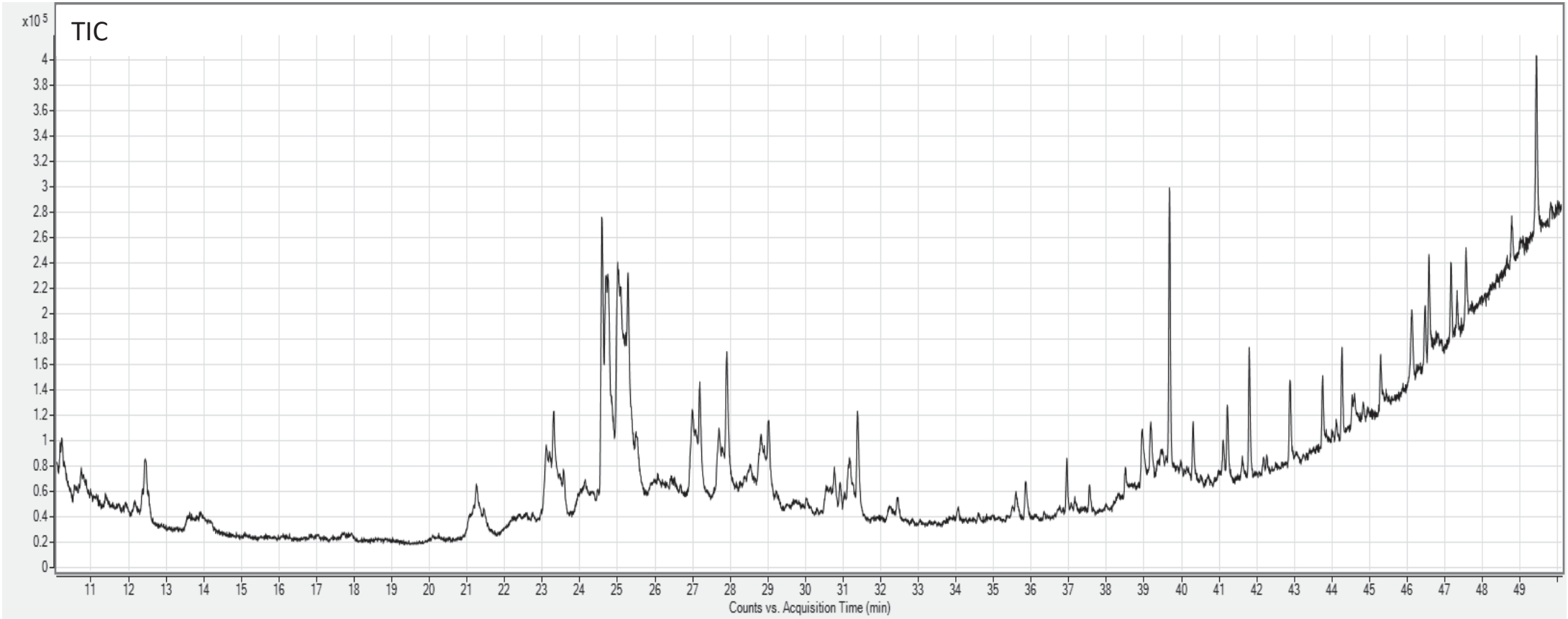


Fig.77 : Partial total ion chromatogram of the outer surface (BECS 2017) of Sample KM51 – E177 (BECS 2015)

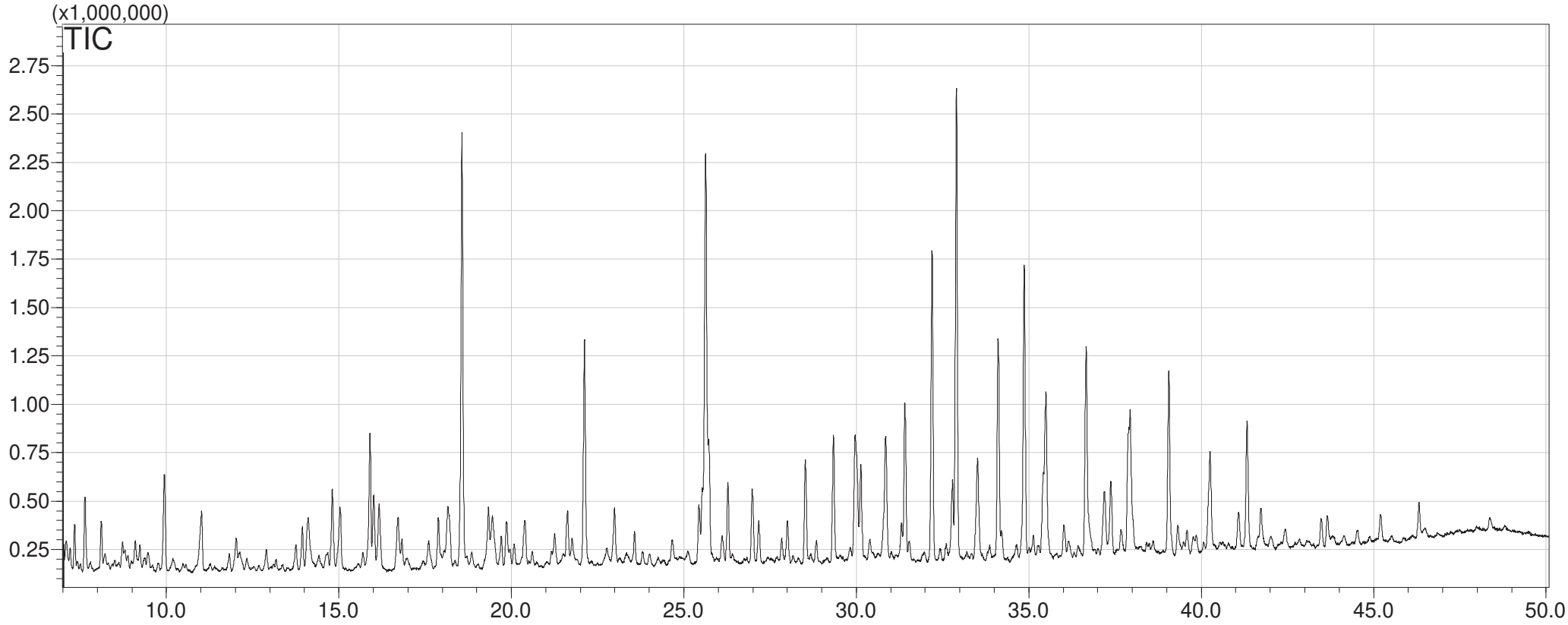


Fig. 78: Partial total ion chromatogram of the soil sample (BECS 1765) associated with Samples KM49 – E175 (BECS 1747), KM56 – E184 (BECS 1756), KM55 – E182 (BECS 1757), KM51 – E177 (BECS 2015), KM48 – E174 (BECS 2018) and KM54 – E181 (BECS 1935).

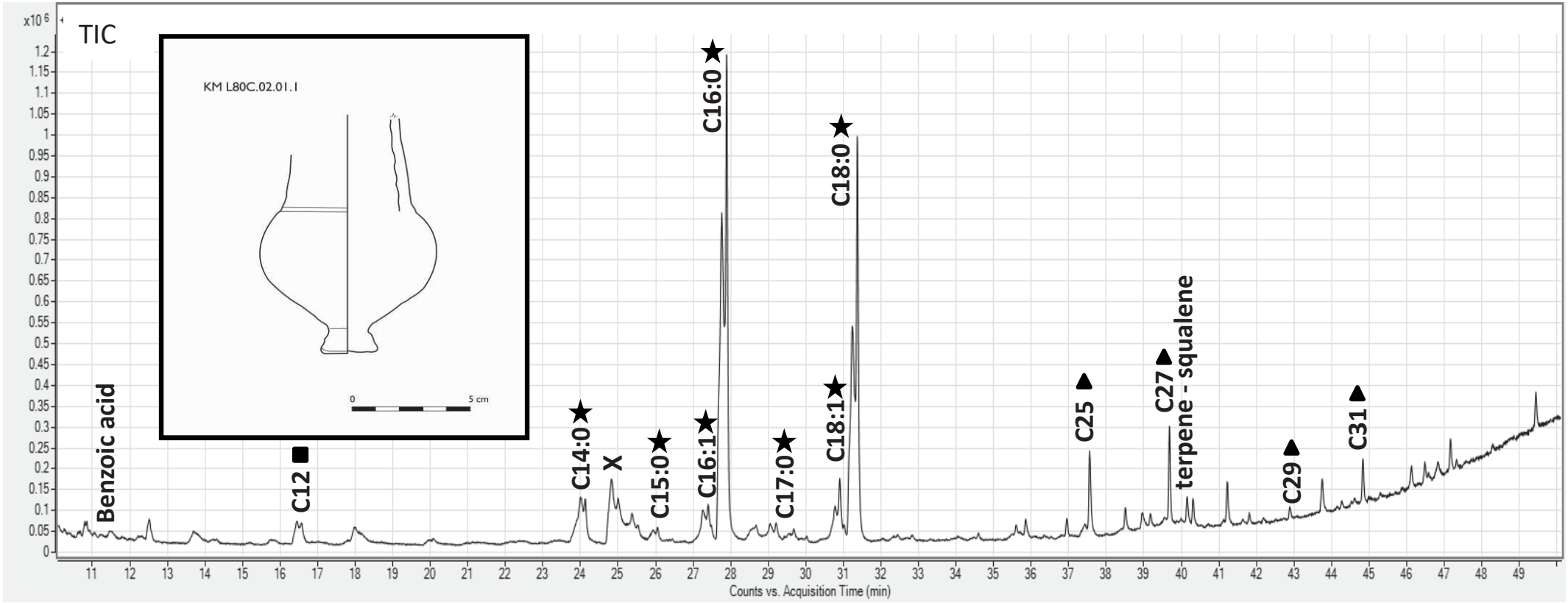


Fig. 79 : Partial total ion chromatogram of Sample KM22 – E131 (BECS 1922) of a cup discovered in Trench L80C (Locus 2 Lot 1) : Cx:y fatty acids ★, CxOH alcohols ■ , Cx alkanes ▲ , aldehydes and amides ♦ , ketones ⬟ , **MAG** and **DAG** mono- and diacylglycerols, wax esters ● , plasticizers (cross).

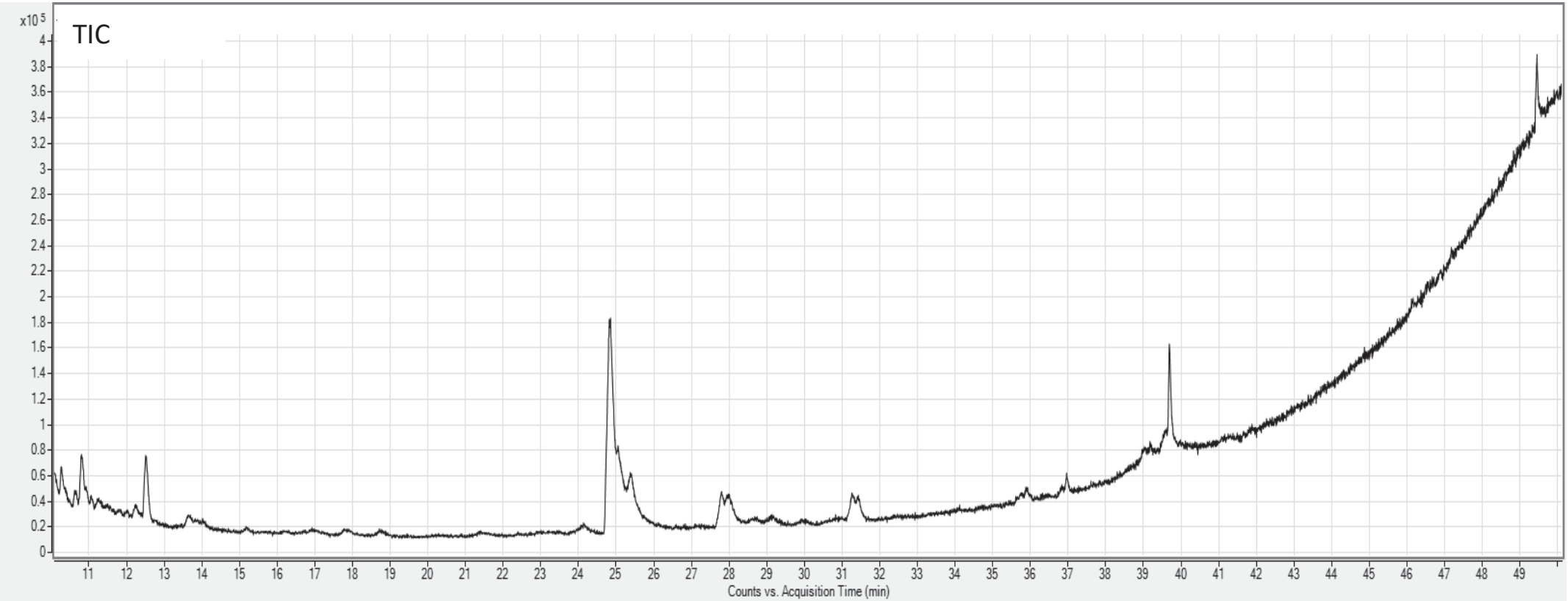


Fig.80 : Partial total ion chromatogram of the inner surface (BECS 1923) of Sample KM22 – E131 (BECS 1922)

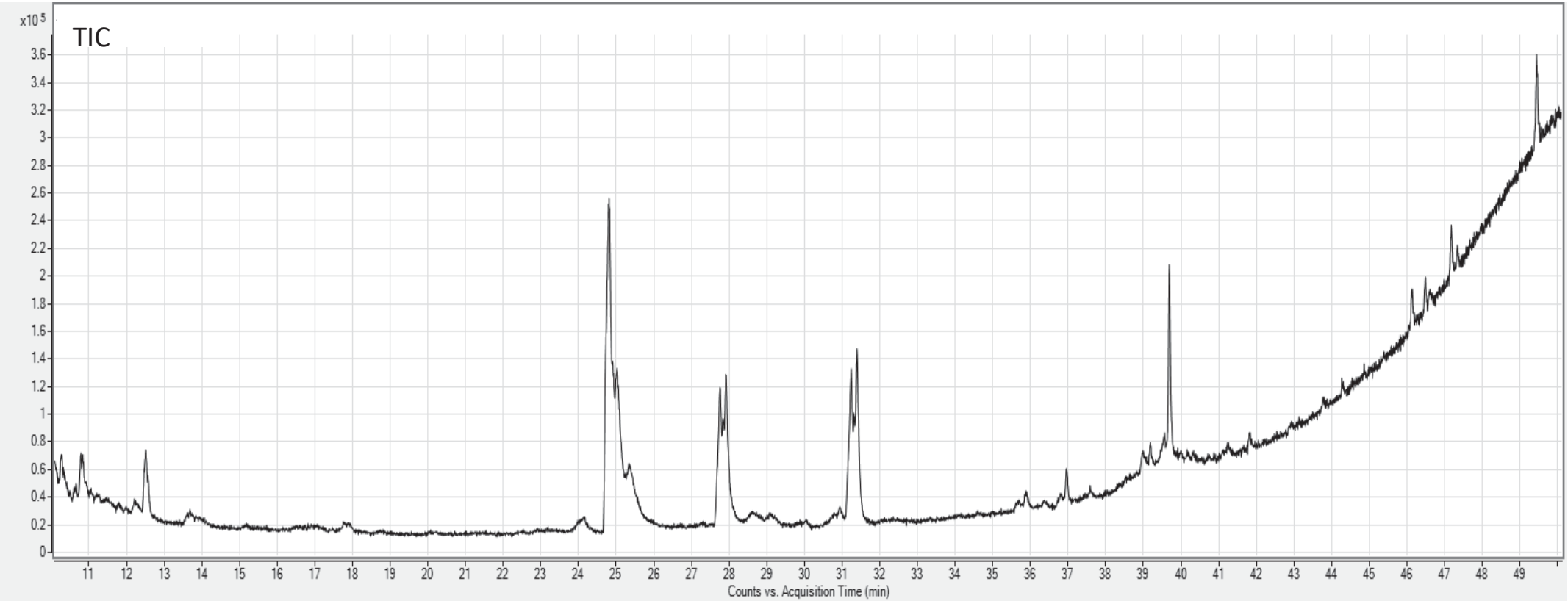


Fig. 81: Partial total ion chromatogram of the outer surface (BECS 1924) of Sample KM22 – E131 (BECS 1922)

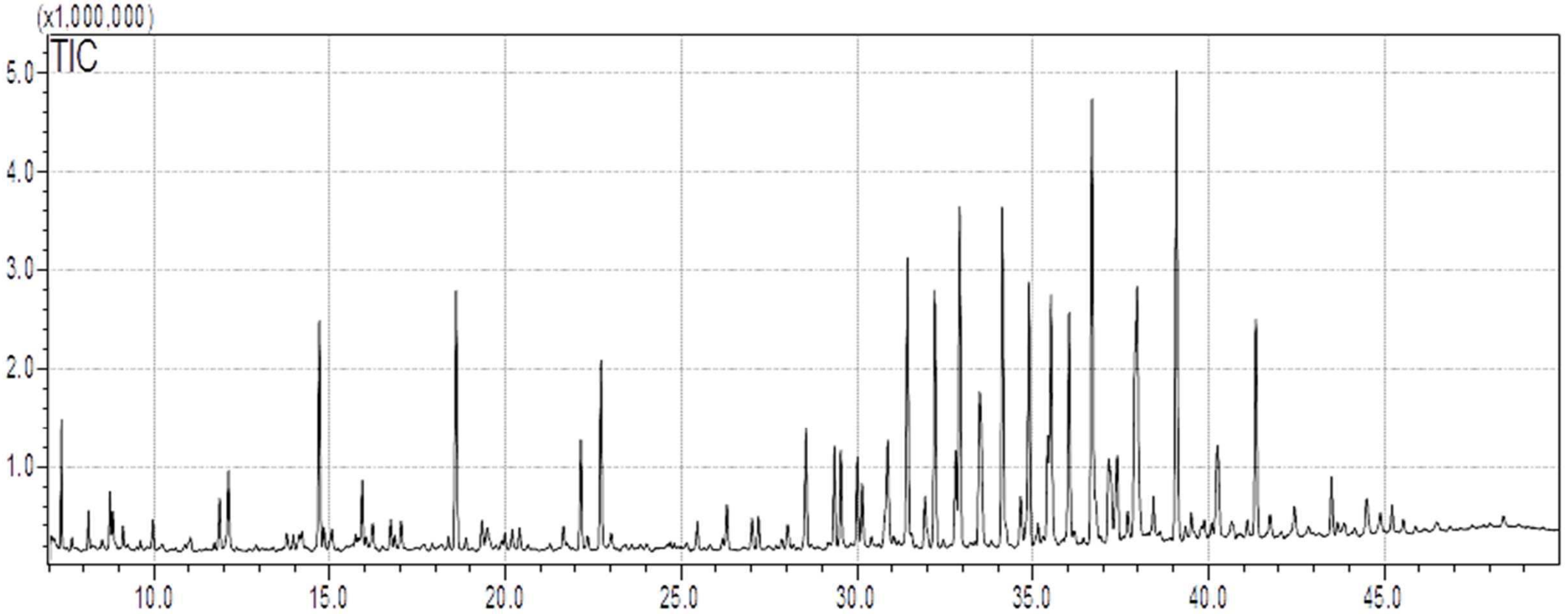


Fig. 82 : Partial total ion chromatogram of the soil sample (BECS 1763) associated with Samples KM22 – E131 (BECS 1922).

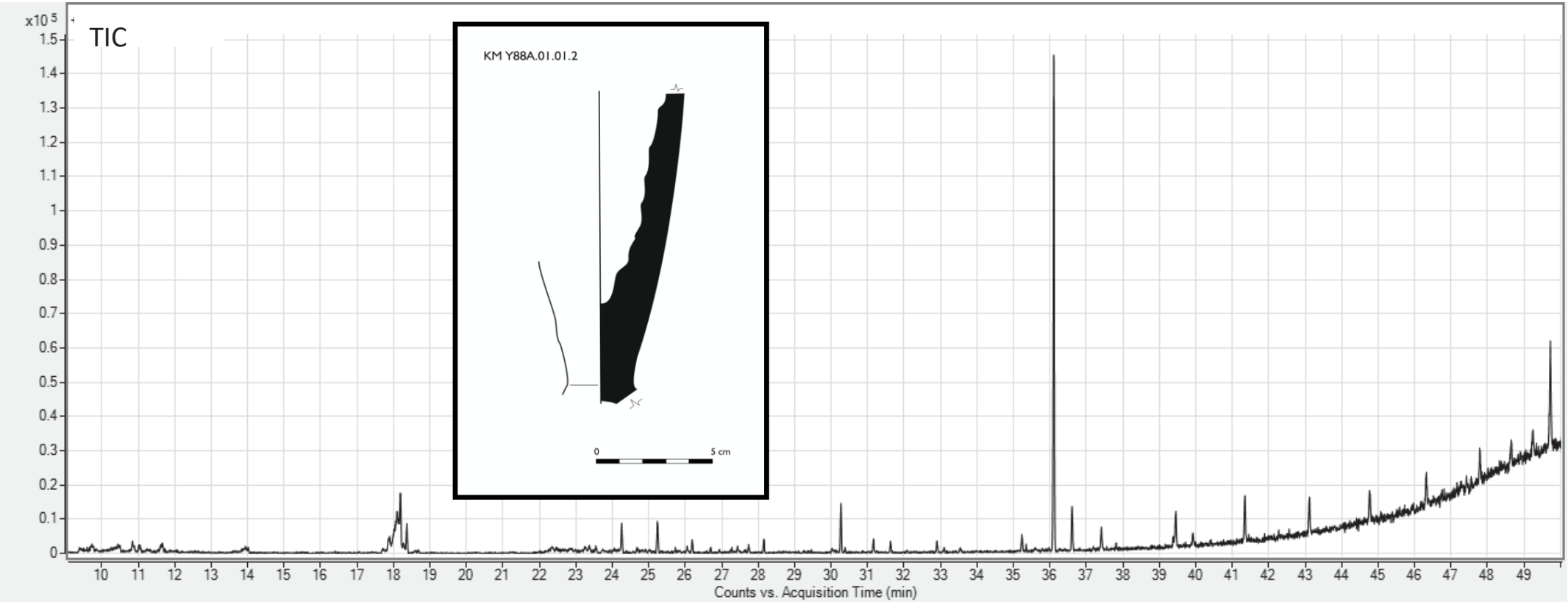


Fig. 83 : Partial total ion chromatogram of Sample KM30– E151 (BECS 2218) of a 'Kassite' Goblet discovered in Trench Y88 (Locus 1 Lot 1): Cx:y fatty acids ★, CxOH alcohols ■ , Cx alkanes ▲ , aldehydes and amides ♦ , ketones ⬣ , **MAG** and **DAG** mono- and diacylglycerols, wax esters ● , plasticizers (cross).

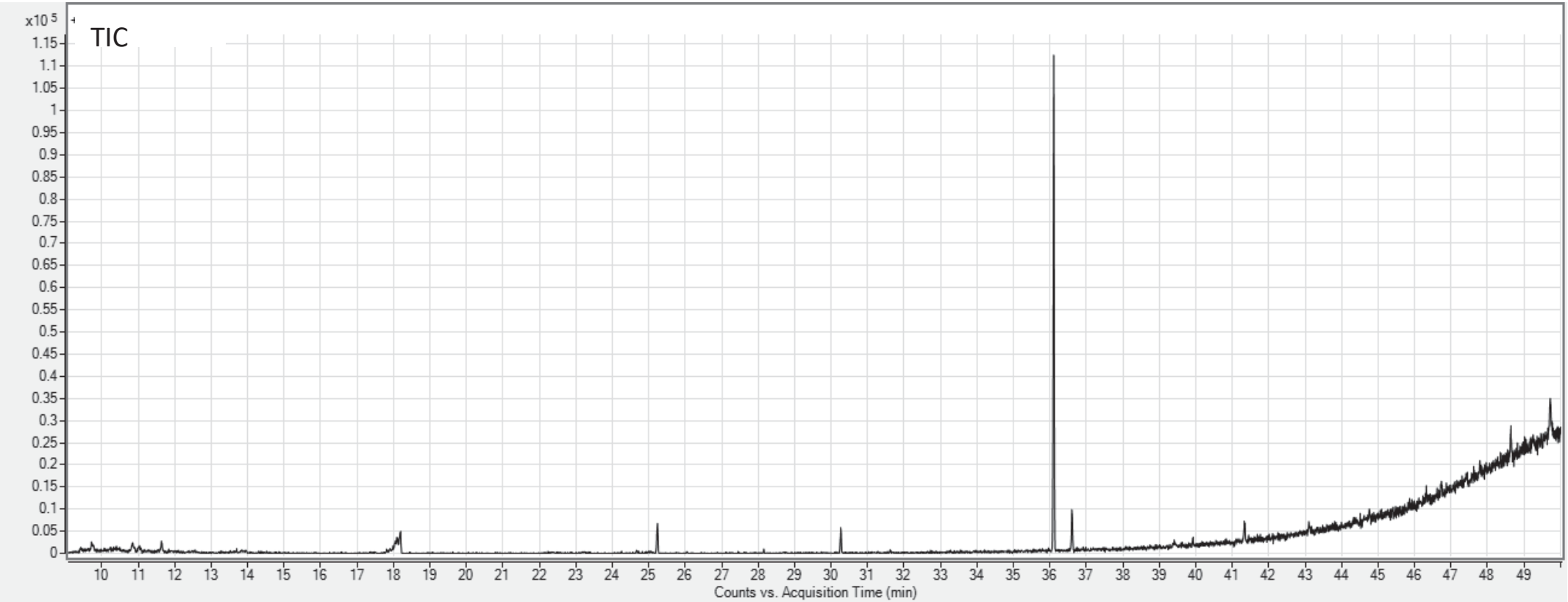


Fig. 84: Partial total ion chromatogram of the inner surface (BECS 2219) of Sample KM30 – E151 (BECS 2218)

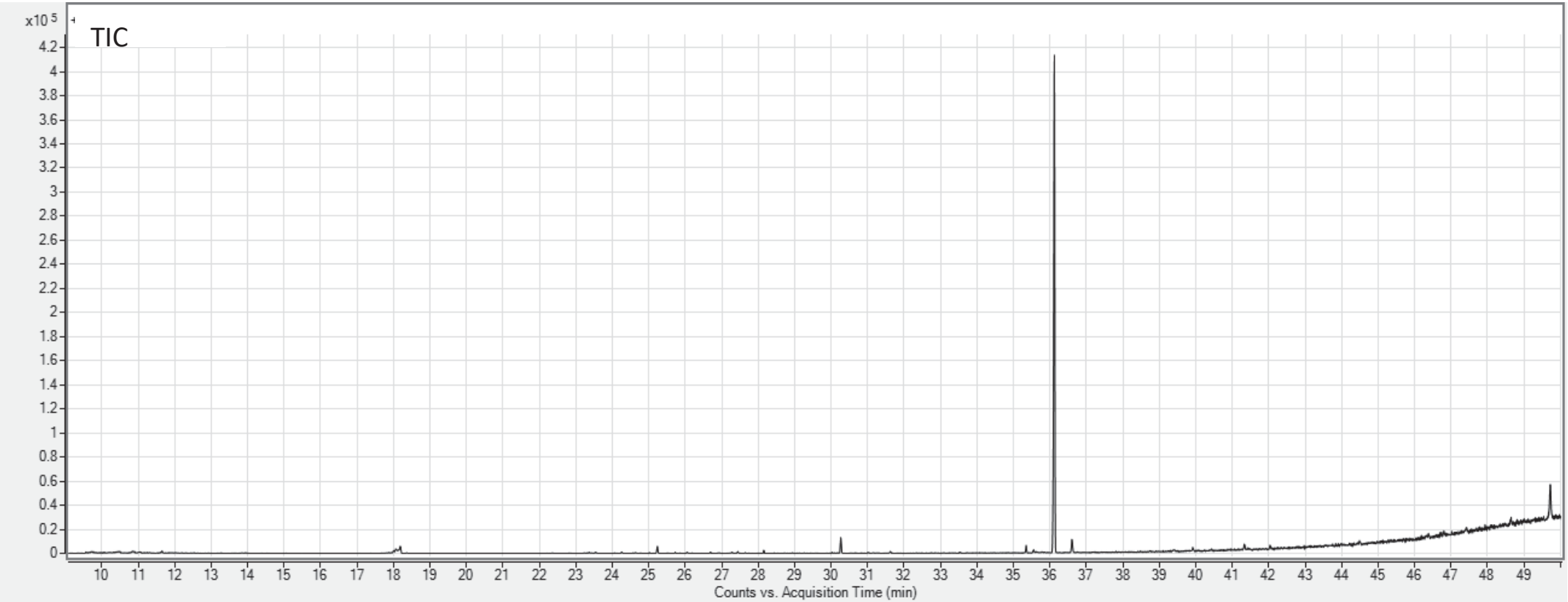


Fig.85 : Partial total ion chromatogram of the inner surface (BECS 2220) of Sample KM30 – E151 (BECS 2218)

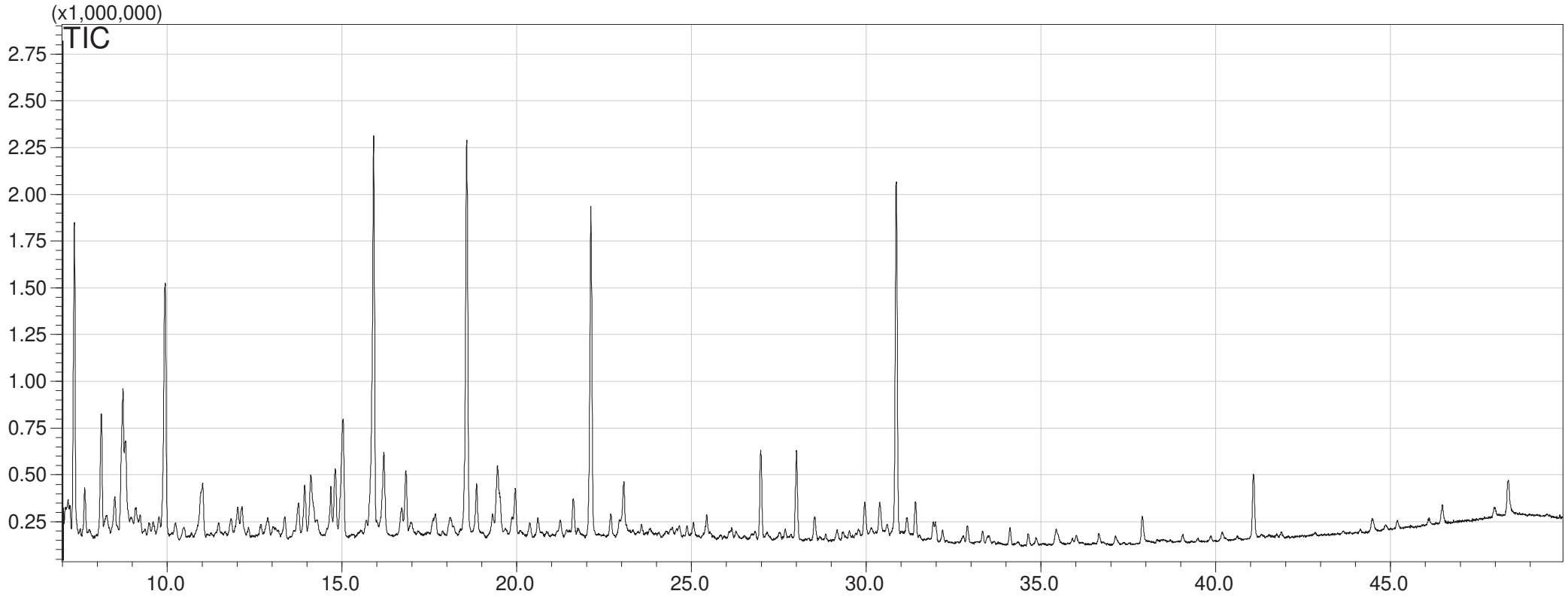


Fig. 86 : Partial total ion chromatogram of the soil sample (BECS 1762) associated with Samples KM2 – E83 (BECS 1750), KM30 – E151 (BECS 2218), KM41 – E167 (BECS 2223) and KM42 – E168 (BECS 2215).

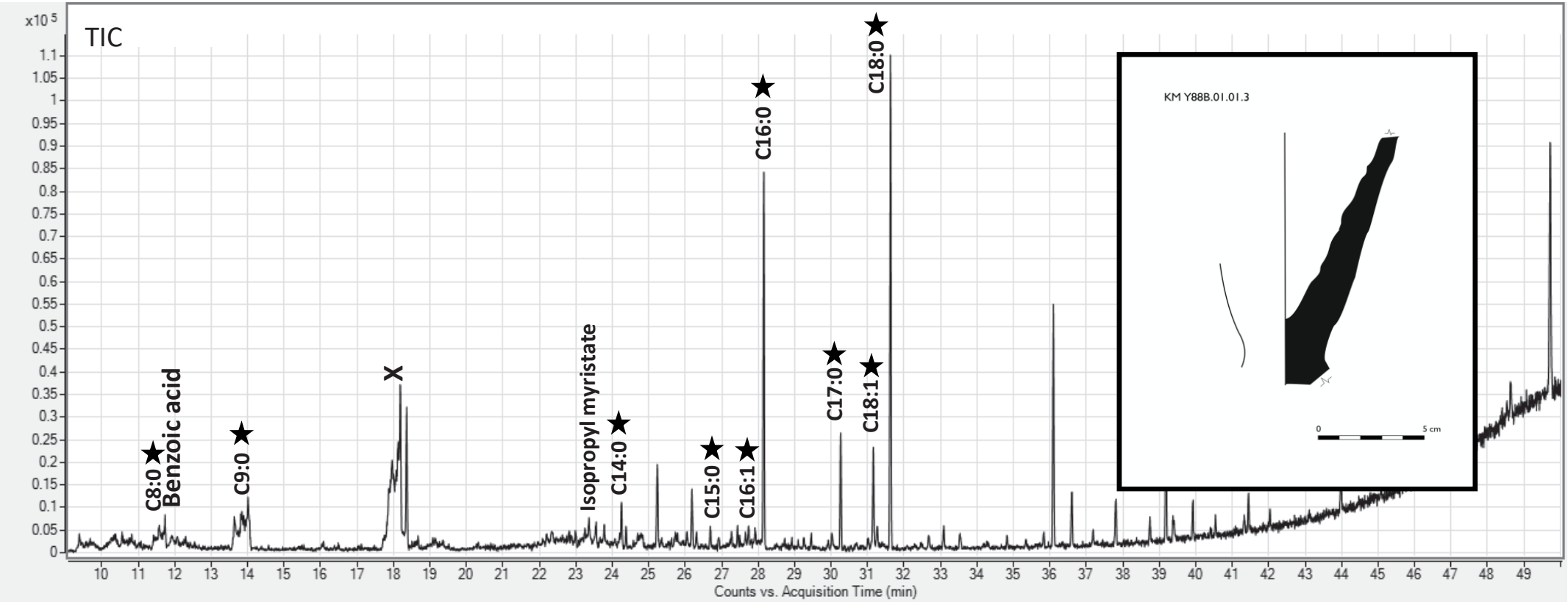


Fig. 87: Partial total ion chromatogram of Sample KM41– E167 (BECS 2223) of a 'Kassite' Goblet discovered in Trench Y88 (Locus 1 Lot 1): Cx:y fatty acids ★, CxOH alcohols ■ , Cx alkanes ▲ , aldehydes and amides ♦ , ketones ⬣ , **MAG** and **DAG** mono- and diacylglycerols, wax esters ● , plasticizers (cross).

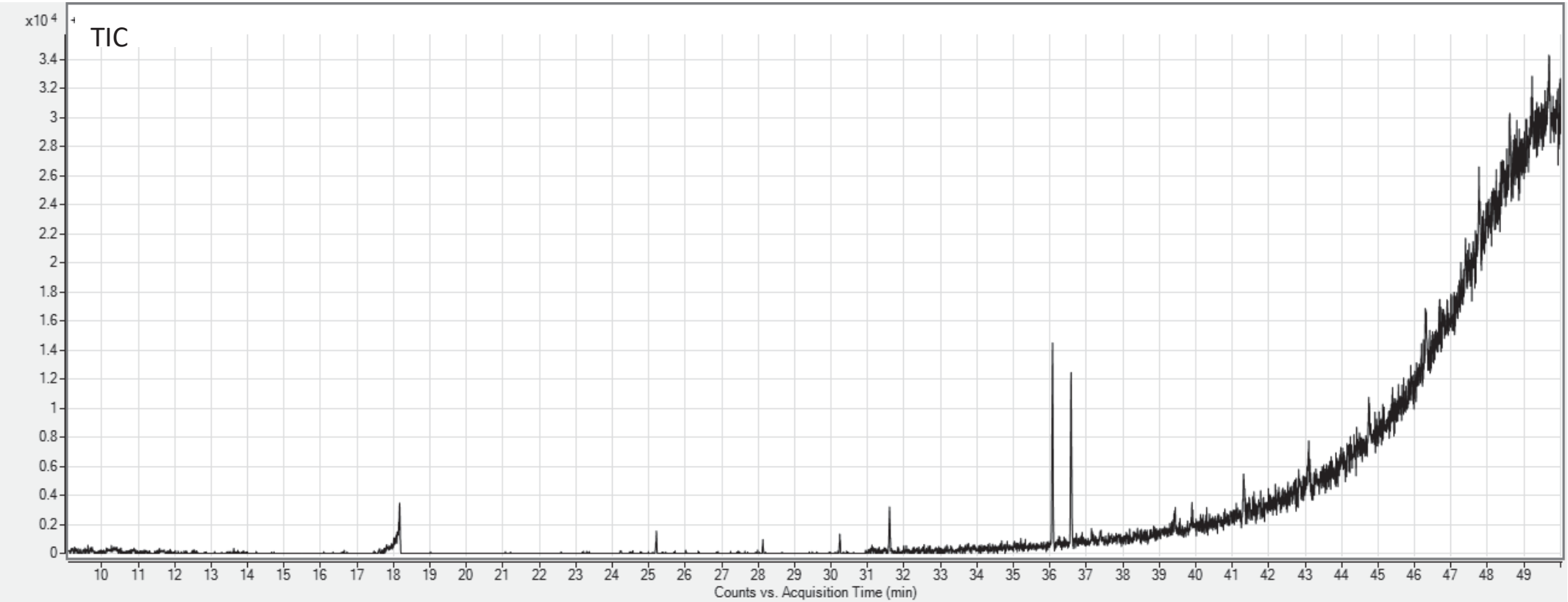


Fig. 88: Partial total ion chromatogram of the inner surface (BECS 2224) of Sample KM41– E167 (BECS 2223)

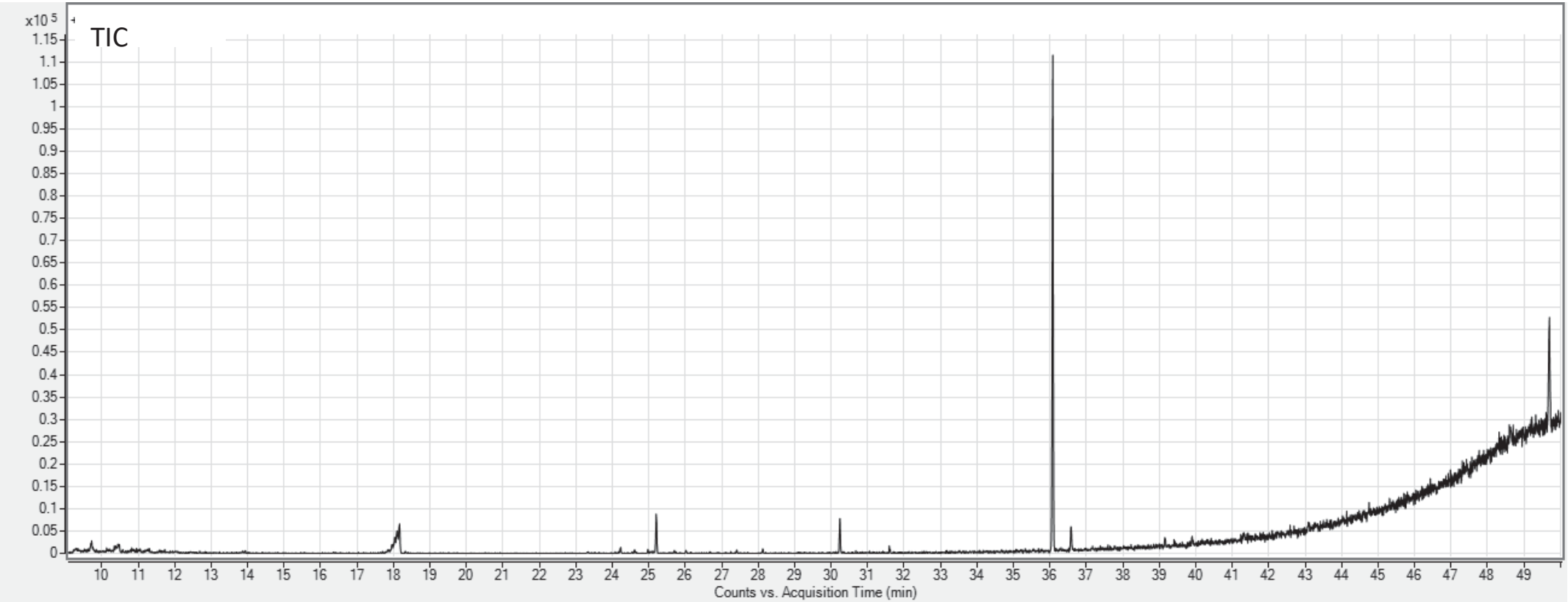


Fig.89 : Partial total ion chromatogram of the outer surface (BECS 2225) of Sample KM41– E167 (BECS 2223)

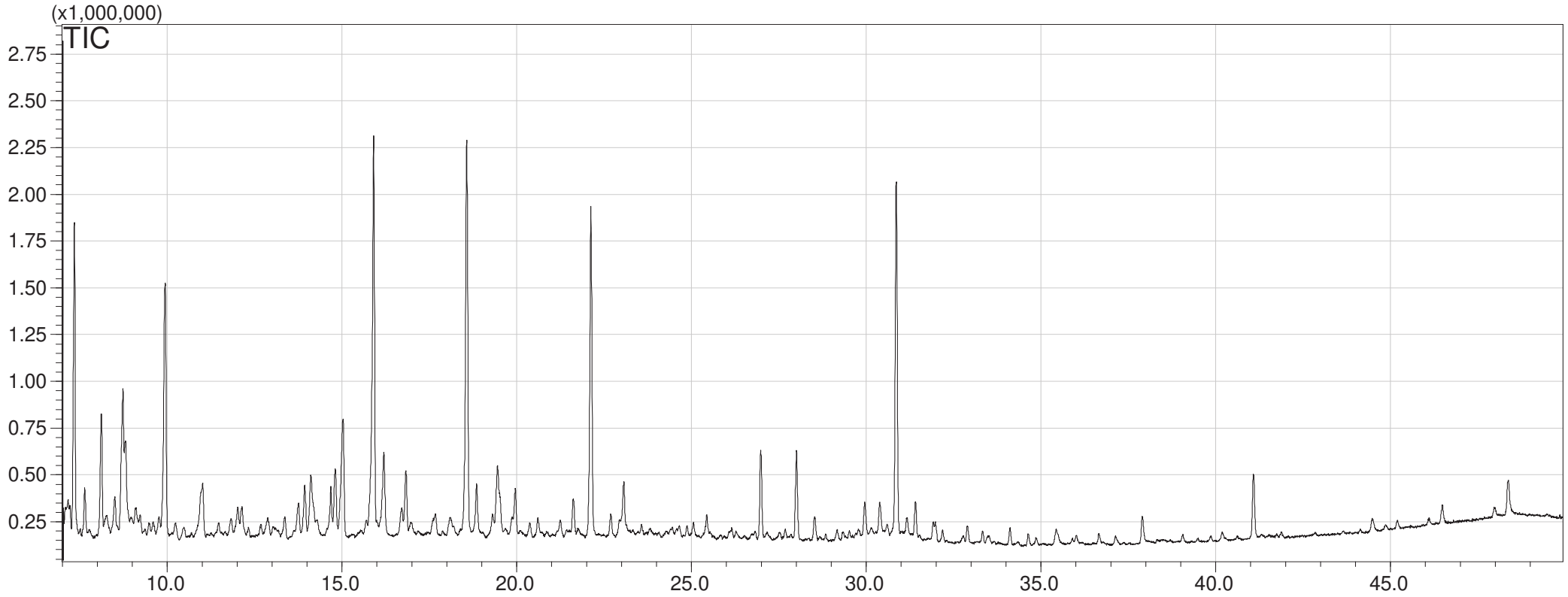


Fig. 90: Partial total ion chromatogram of the soil sample (BECS 1762) associated with Samples KM2 – E83 (BECS 1750), KM30 – E151 (BECS 2218), KM41 – E167 (BECS 2223) and KM42 – E168 (BECS 2215).

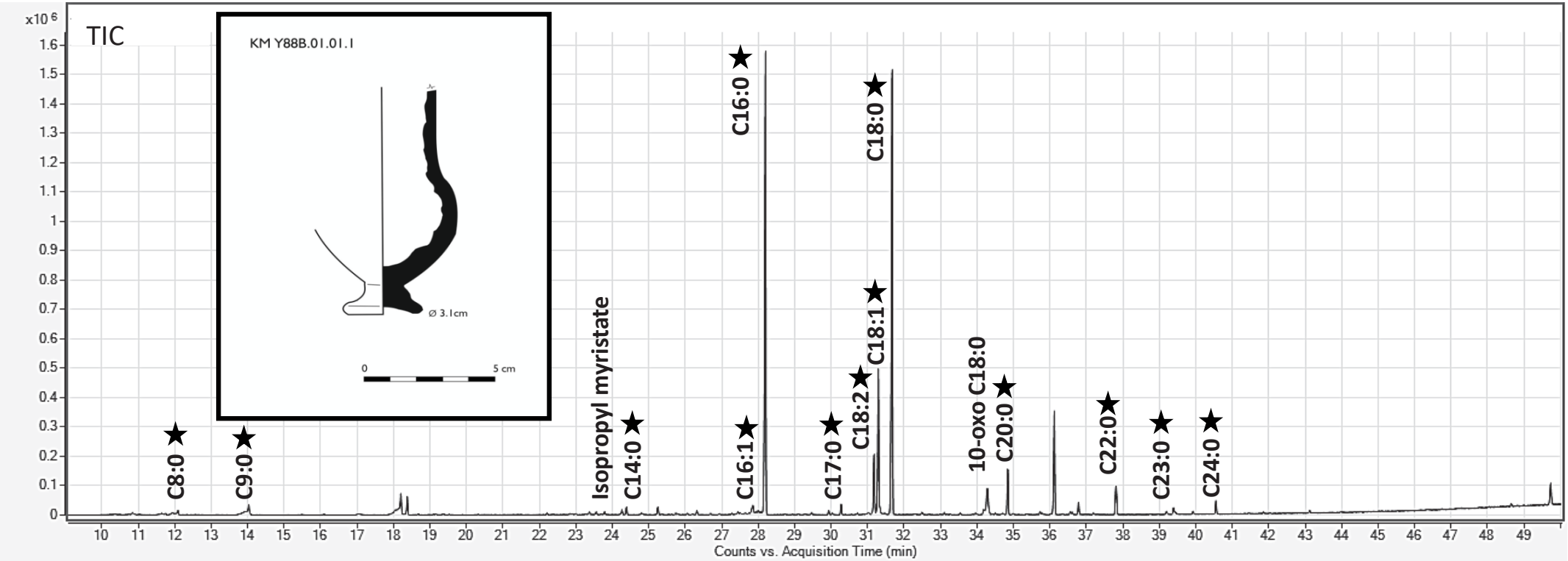


Fig. 100: Partial total ion chromatogram of Sample KM42– E168 (BECS 2215) of a footed cup discovered in Trench Y88 (Locus 1 Lot 1): Cx:y fatty acids ★, CxOH alcohols ■ , Cx alkanes ▲ , aldehydes and amides ♦ , ketones ⬢ , **MAG** and **DAG** mono- and diacylglycerols, wax esters ● , plasticizers (cross).

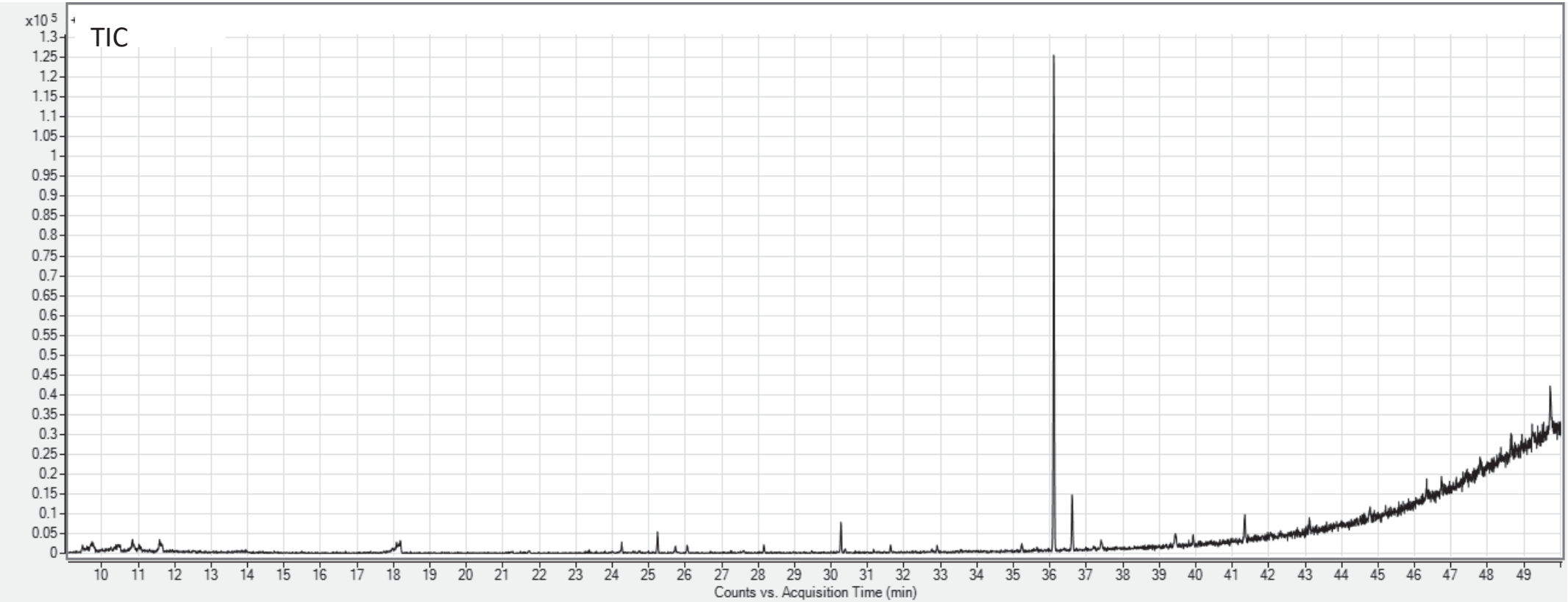


Fig. 101: Partial total ion chromatogram of the inner surface (BECS 2216) of Sample KM42– E168 (BECS 2215)

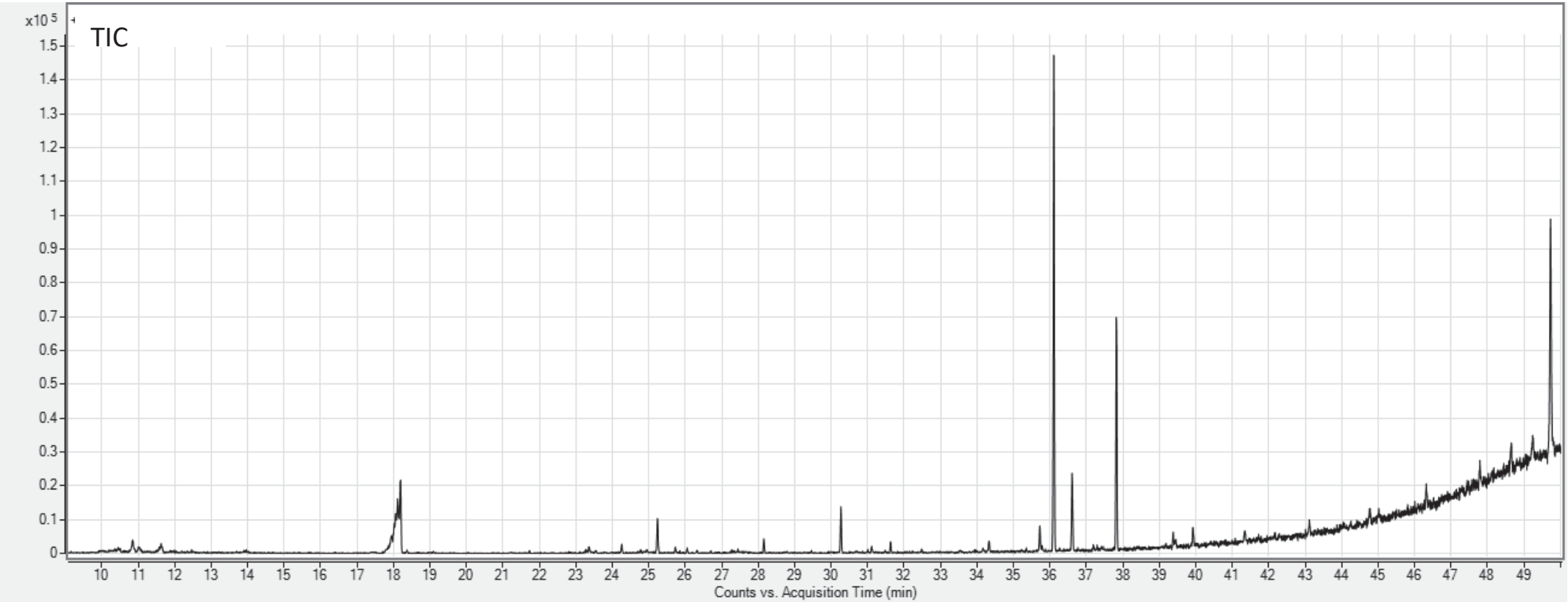


Fig. 102 : Partial total ion chromatogram of the outer surface (BECS 2217) of Sample KM42– E168 (BECS 2215)

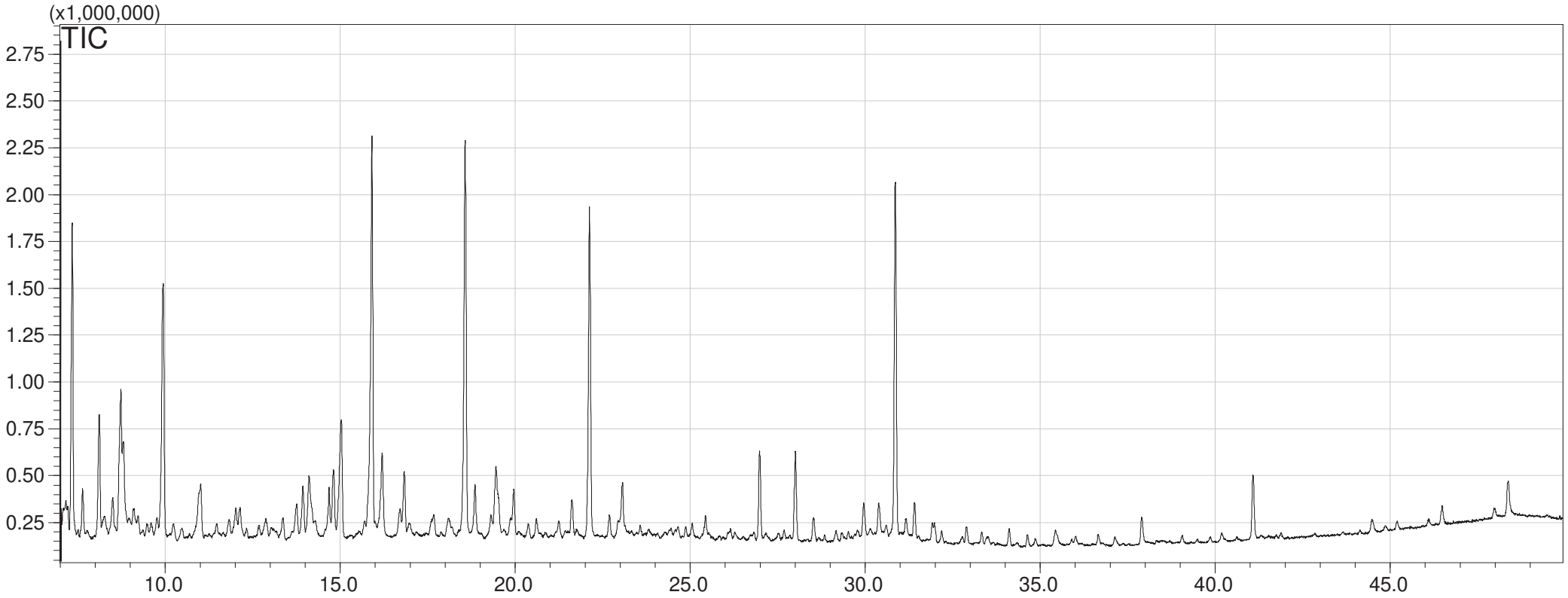


Fig. 103 : Partial total ion chromatogram of the soil sample (BECS 1762) associated with Samples KM2 – E83 (BECS 1750), KM30 – E151 (BECS 2218), KM41 – E167 (BECS 2223) and KM42 – E168 (BECS 2215).

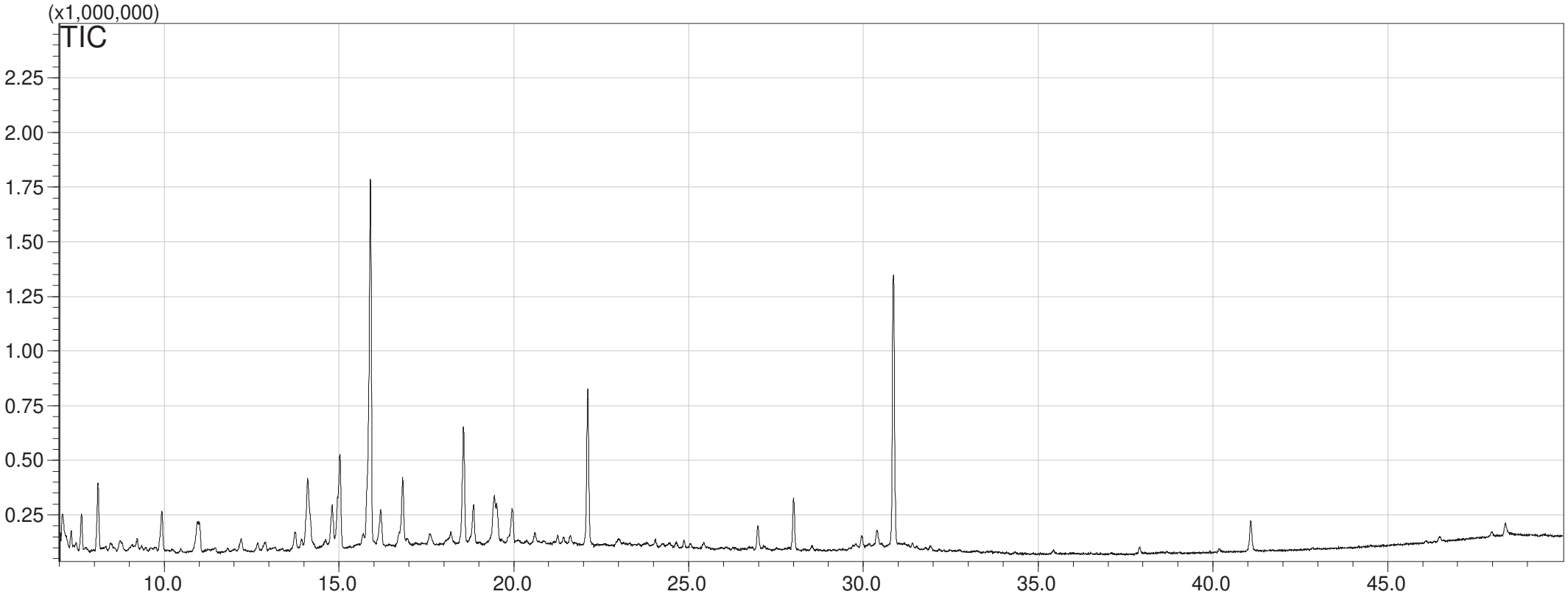


Fig. 104 : Partial total ion chromatogram of a blank sample 1 associated with Samples BECS 1747, 1750, 1781, 1769, 1766, 1777, 1774, 1756, 1757, 1772, 1760.

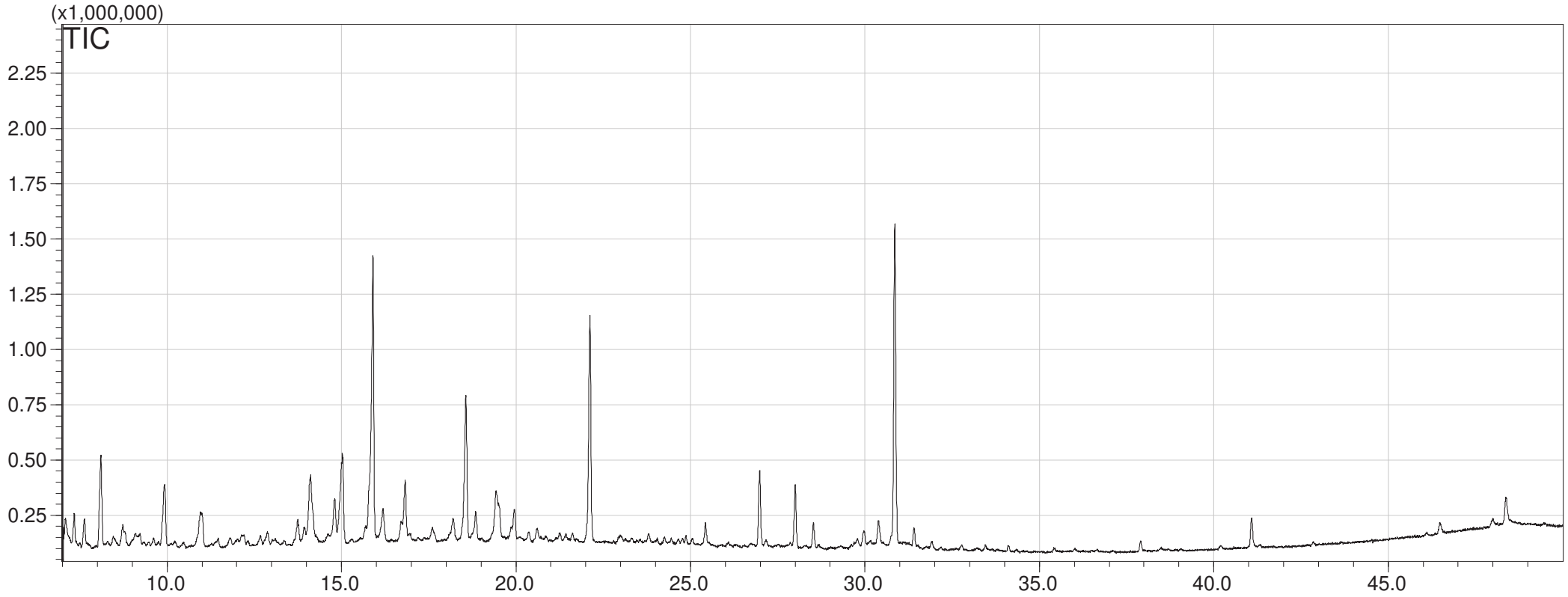


Fig. 105 : Partial total ion chromatogram of a blank sample 2 associated with Samples BECS 1747, 1750, 1781, 1769, 1766, 1777, 1774, 1756, 1757, 1772, 1760.

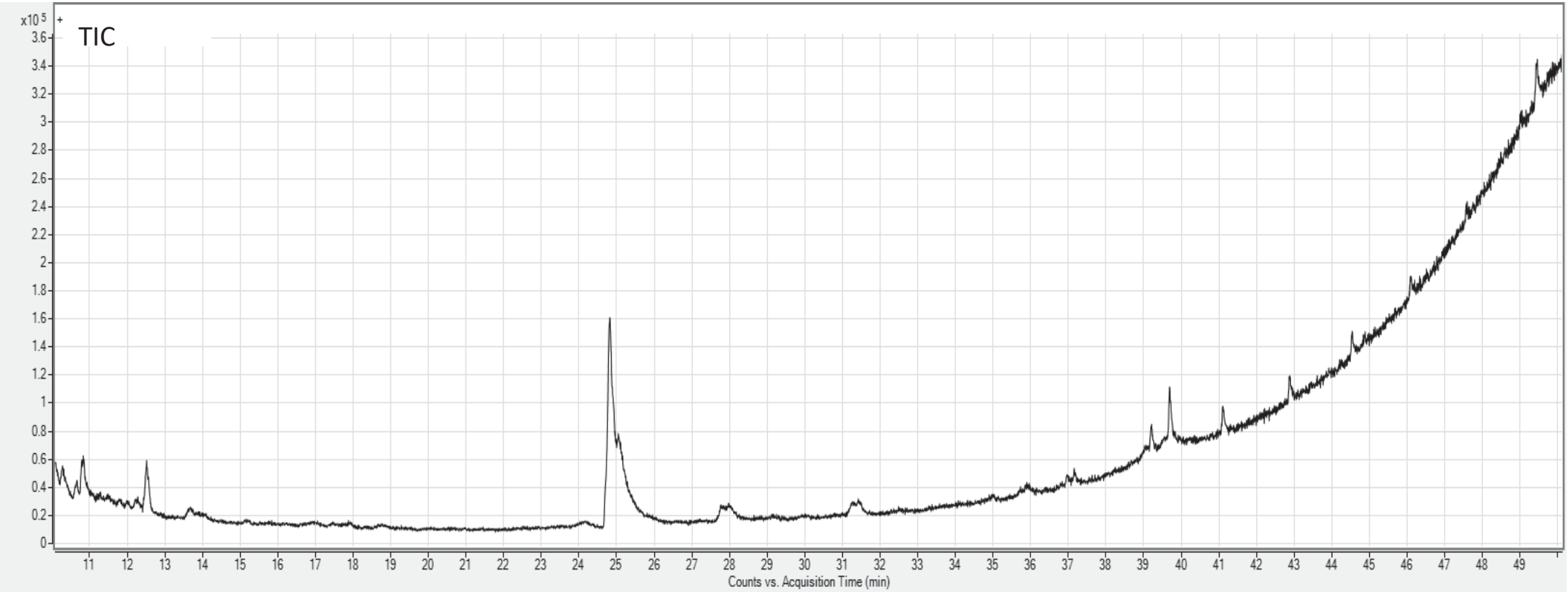


Fig. 106 : Partial total ion chromatogram of a blank sample 1 associated with Samples BECS 1918, 1935, 1915, 1938, 1910, 2015, 1922, 2218, 2223, 2215, 2018.

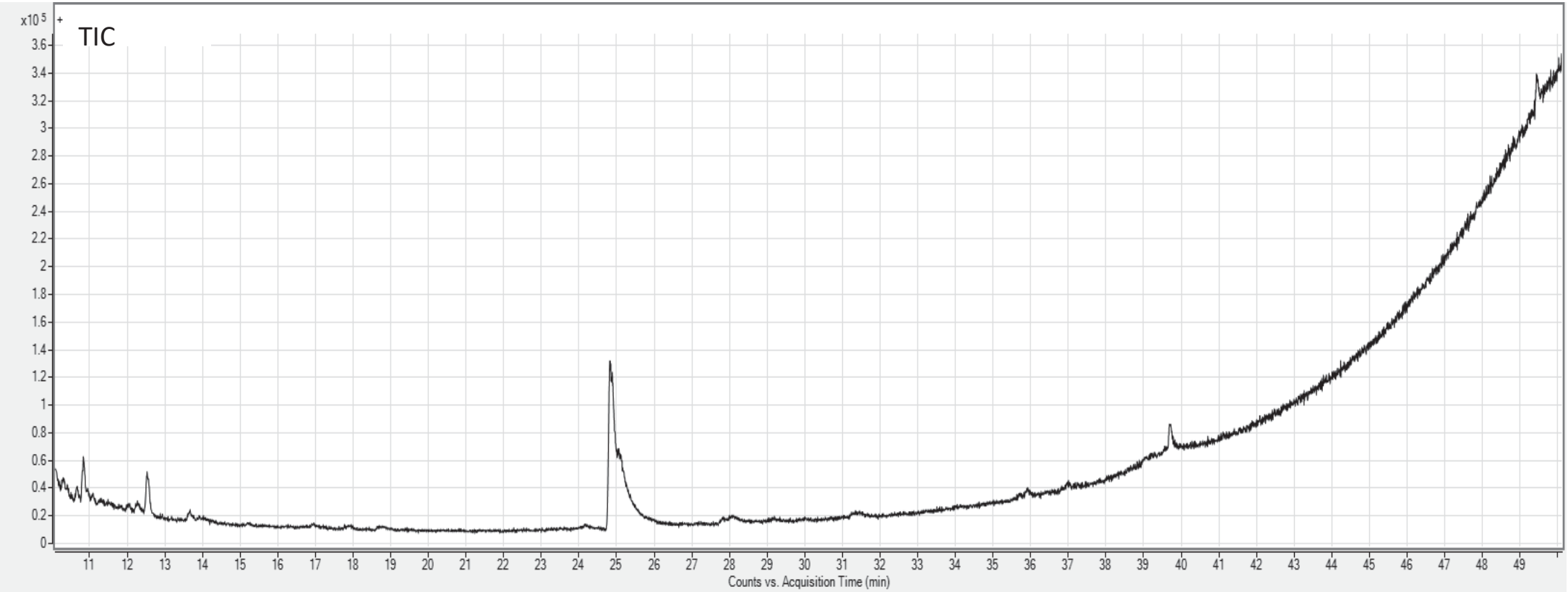


Fig. 107 : Partial total ion chromatogram of a blank sample 2 associated with Samples BECS 1918, 1935, 1915, 1938, 1910, 2015, 1922, 2218, 2223, 2215, 2018.

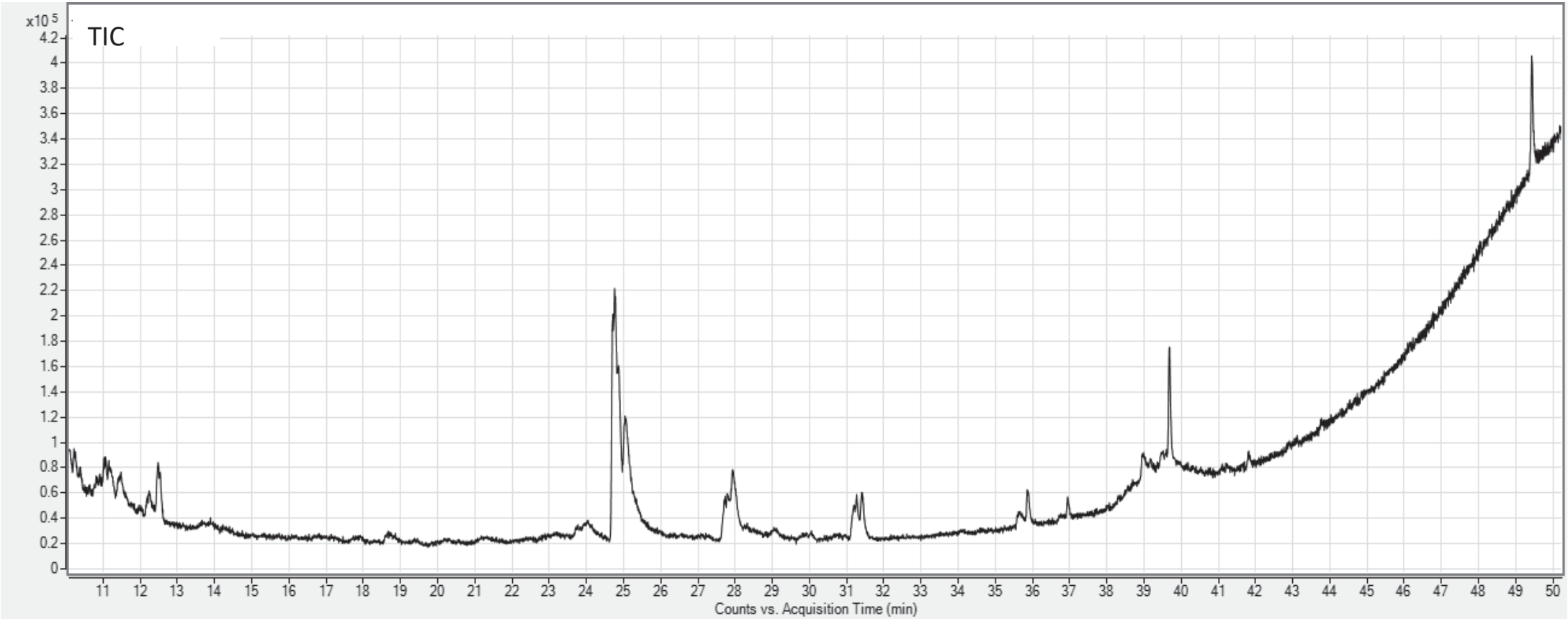


Fig. 108 : Partial total ion chromatogram of a blank sample 3 associated with Samples BECS 1918, 1935, 1915, 1938, 1910, 2015, 1922, 2218, 2223, 2215, 2018.

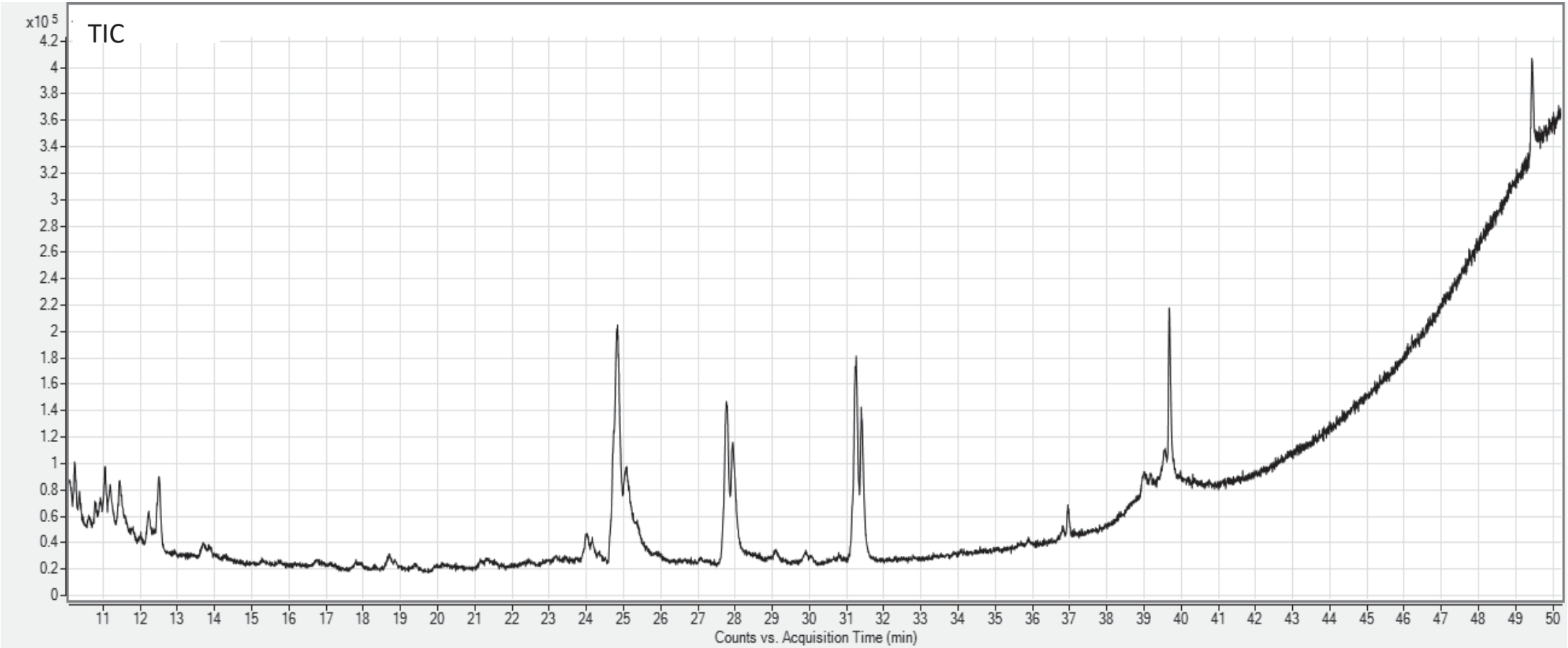


Fig. 109 : Partial total ion chromatogram of a blank sample 4 associated with Samples BECS 1918, 1935, 1915, 1938, 1910, 2015, 1922, 2218, 2223, 2215, 2018.

APPENDIX D
Chromatograms 2017-2018

This appendix contains the chromatograms of sample analysed in 2017-2018 and presented in this thesis, as well as control samples (soil samples, inner and outer surfaces samples and laboratory blanks).

The chromatogram is a two-dimensional plot with the ordinate axis giving average concentration in terms of detector response and the abscissa represents the retention time of each compound represented by a peak.

Major compounds and archaeologically significant compounds found exclusively in the sherd samples have been identified and labelled.

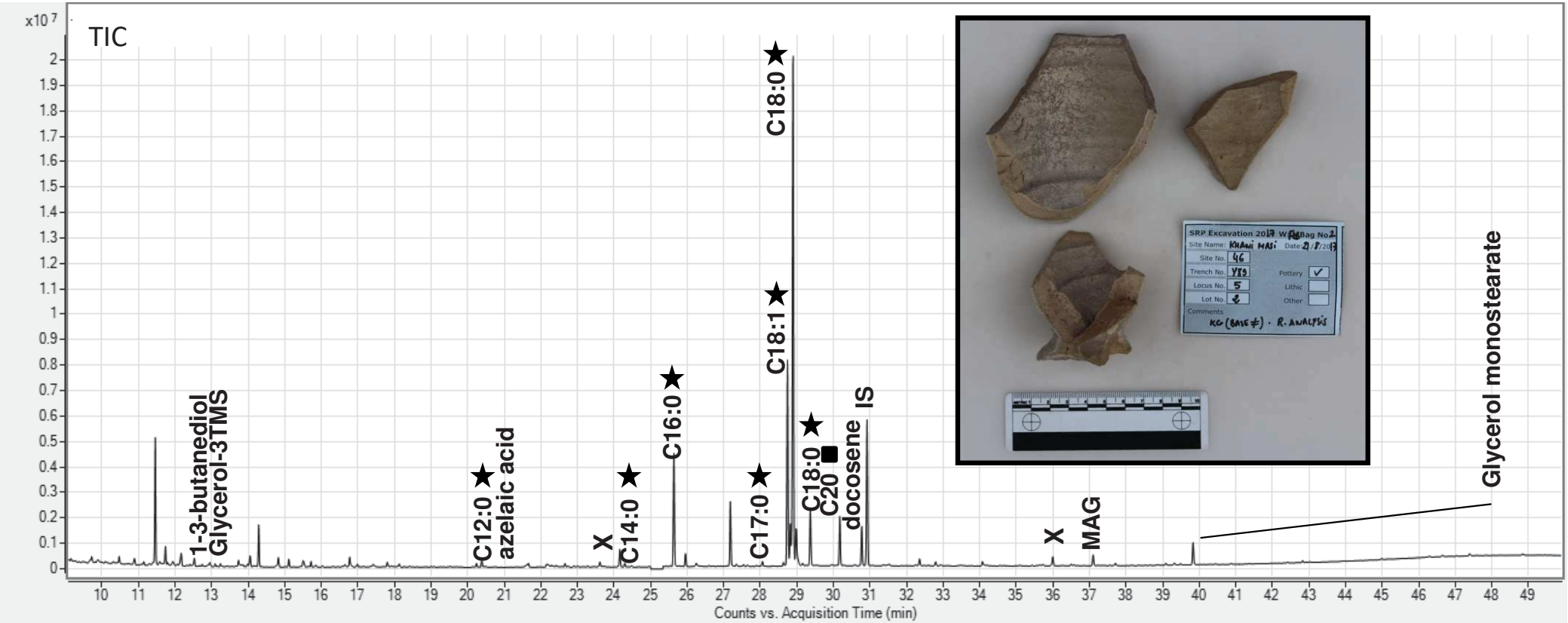


Fig. 110: Partial total ion chromatogram of Sample KM147– E147 (BECS 2306) of a 'Kassite' Goblet discovered in Trench Y89 (Locus 5 Lot 2): Cx:y fatty acids ★, CxOH alcohols ■ , Cx alkanes ▲ , aldehydes and amides ♦ , ketones ⬟ , **MAG** and **DAG** mono- and diacylglycerols, wax esters ● , plasticizers (cross).

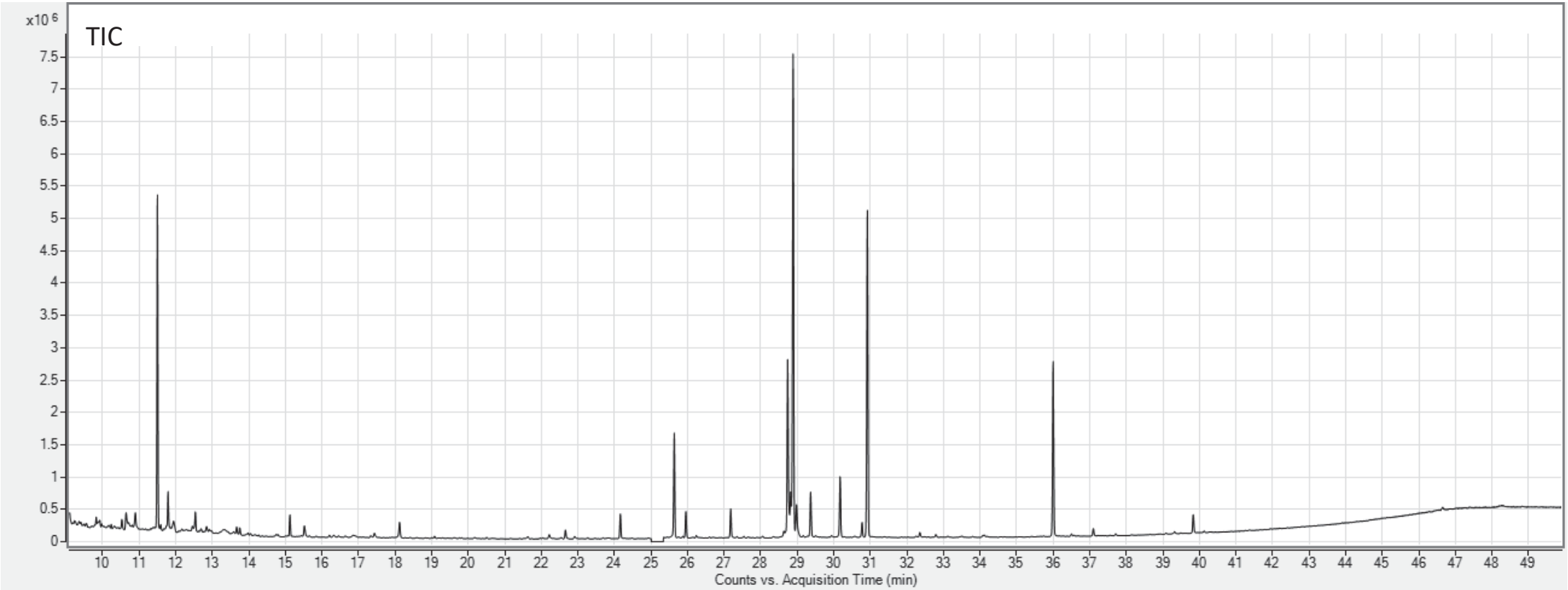


Fig. 111 : Partial total ion chromatogram of the inner surface (BECS 2307) of Sample KM147– E147 (BECS 2306)

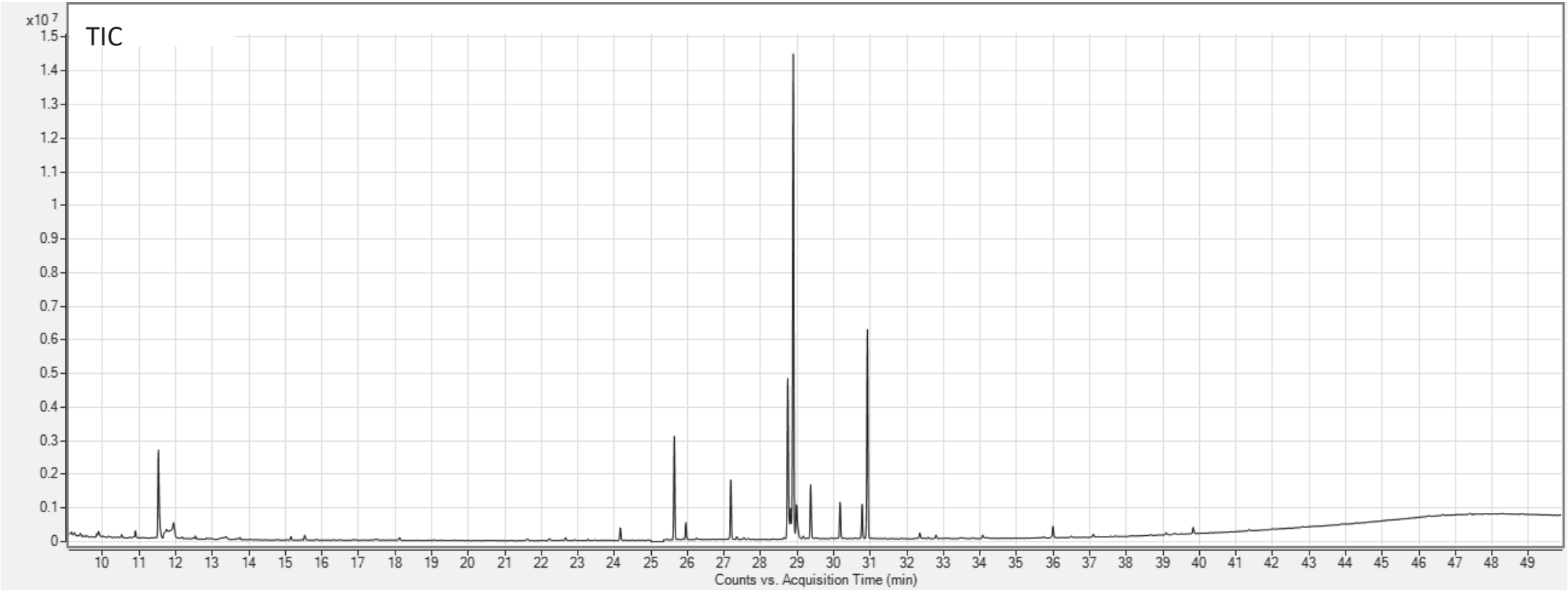


Fig. 112: Partial total ion chromatogram of the outer surface (BECS 2308) of Sample KM147– E147 (BECS 2306)

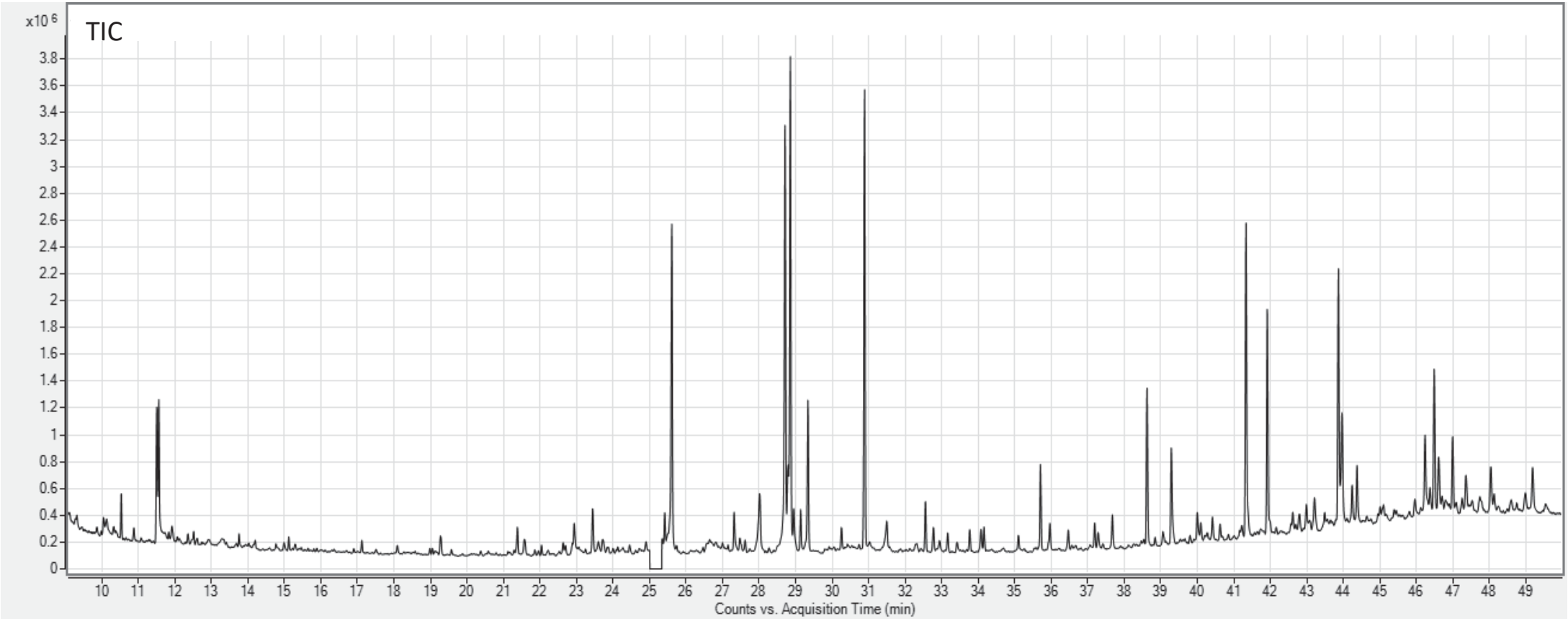


Fig. 113 : Partial total ion chromatogram of the soil sample (BECS 2819) associated with Sample KM147– E147 (BECS 2306)

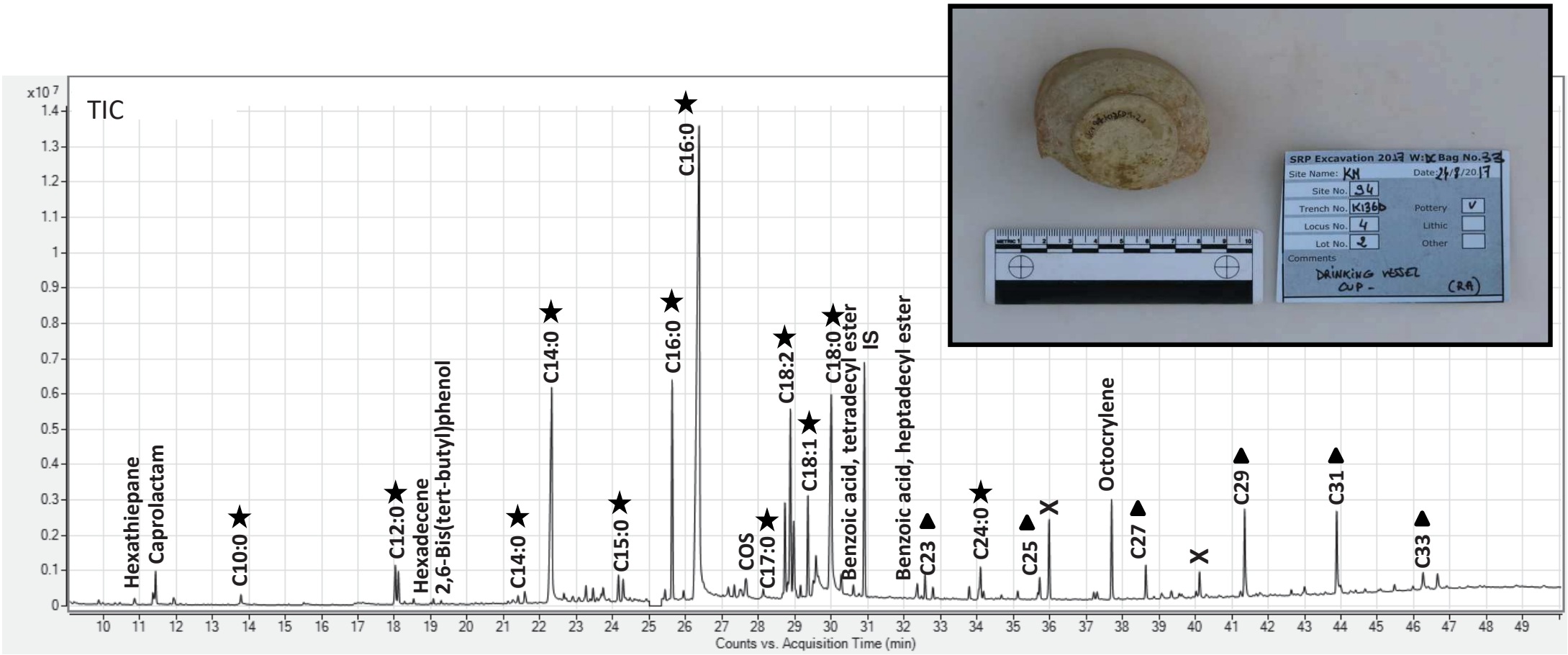


Fig. 114: Partial total ion chromatogram of Sample KM178– E178 (BECS 2736) of a cup discovered in SRP 94 Trench K136D (Locus 4 Lot 2): Cx:y fatty acids ★, CxOH alcohols ■ , Cx alkanes ▲ , aldehydes and amides ♦ , ketones ⬣ , **MAG** and **DAG** mono- and diacylglycerols, wax esters ● , plasticizers (cross).

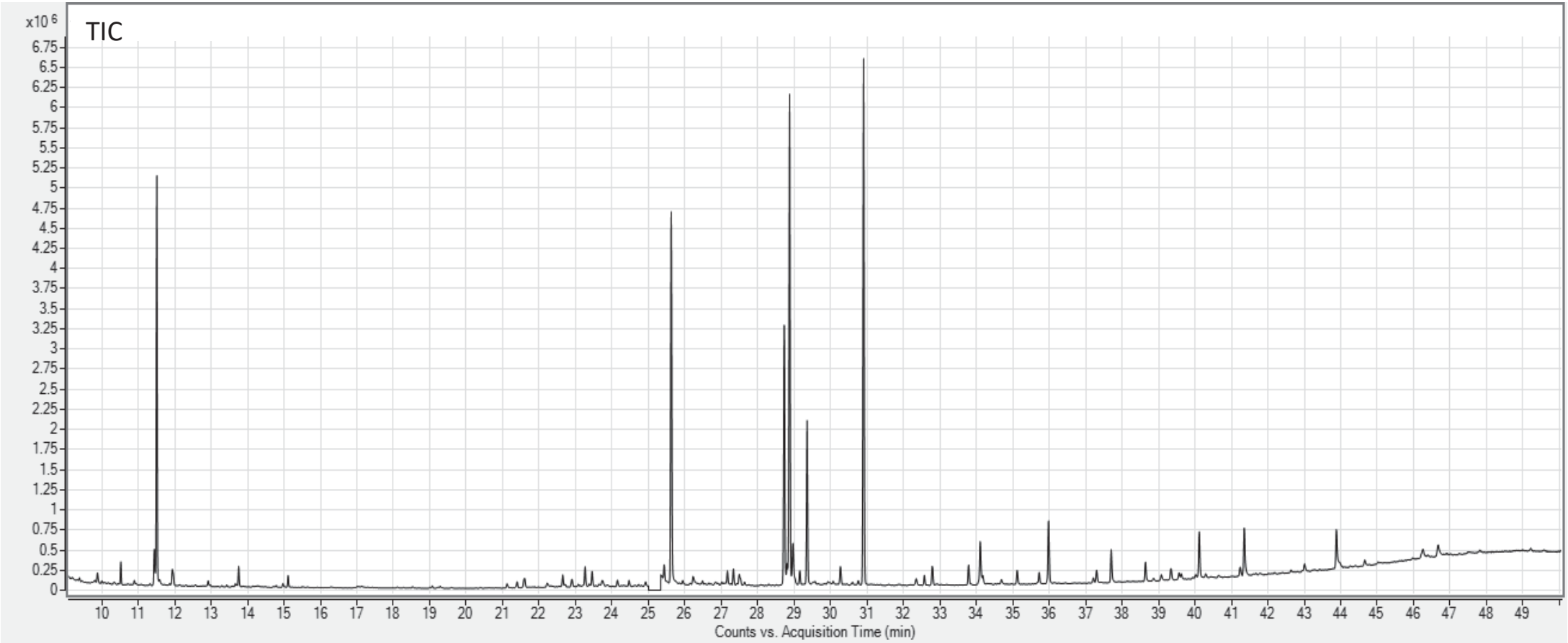


Fig. 115 : Partial total ion chromatogram of the inner surface (BECS 2737) of Sample KM178– E178 (BECS 2736)

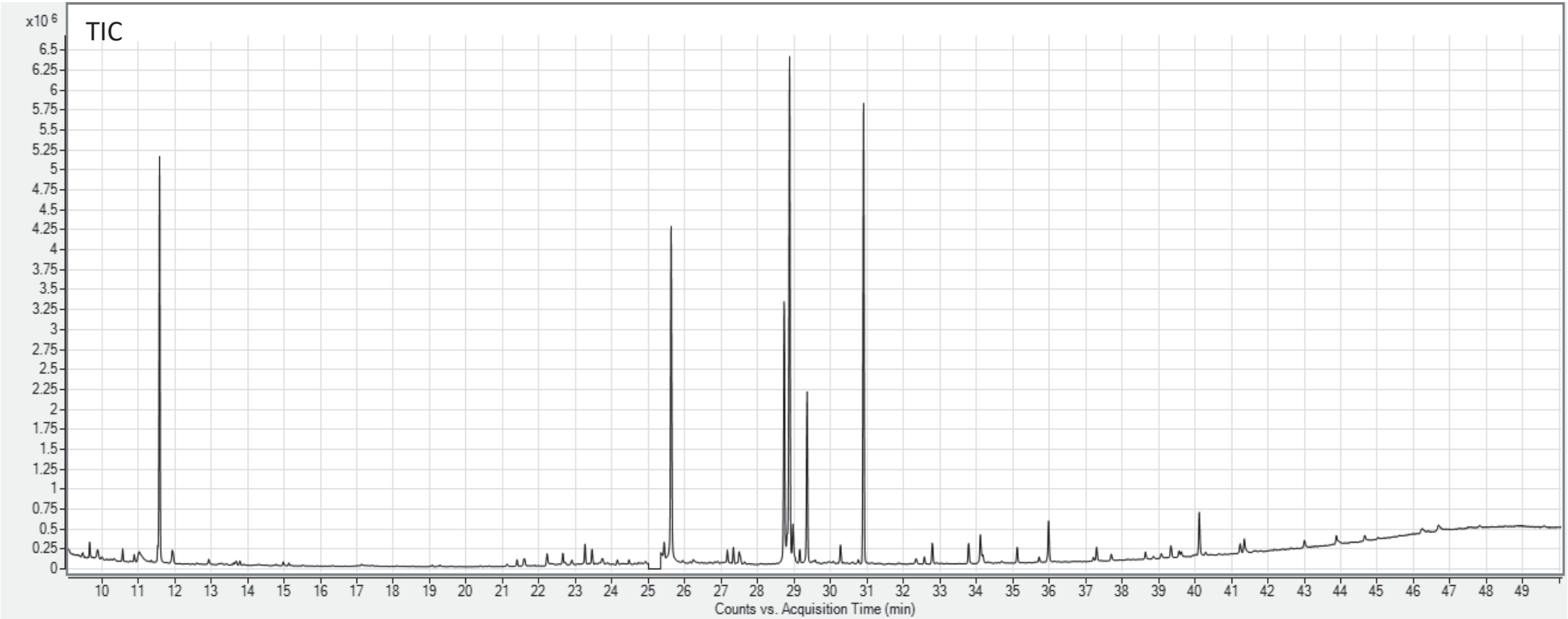


Fig. 116: Partial total ion chromatogram of the outer surface (BECS 2738) of Sample KM178– E178 (BECS 2736)

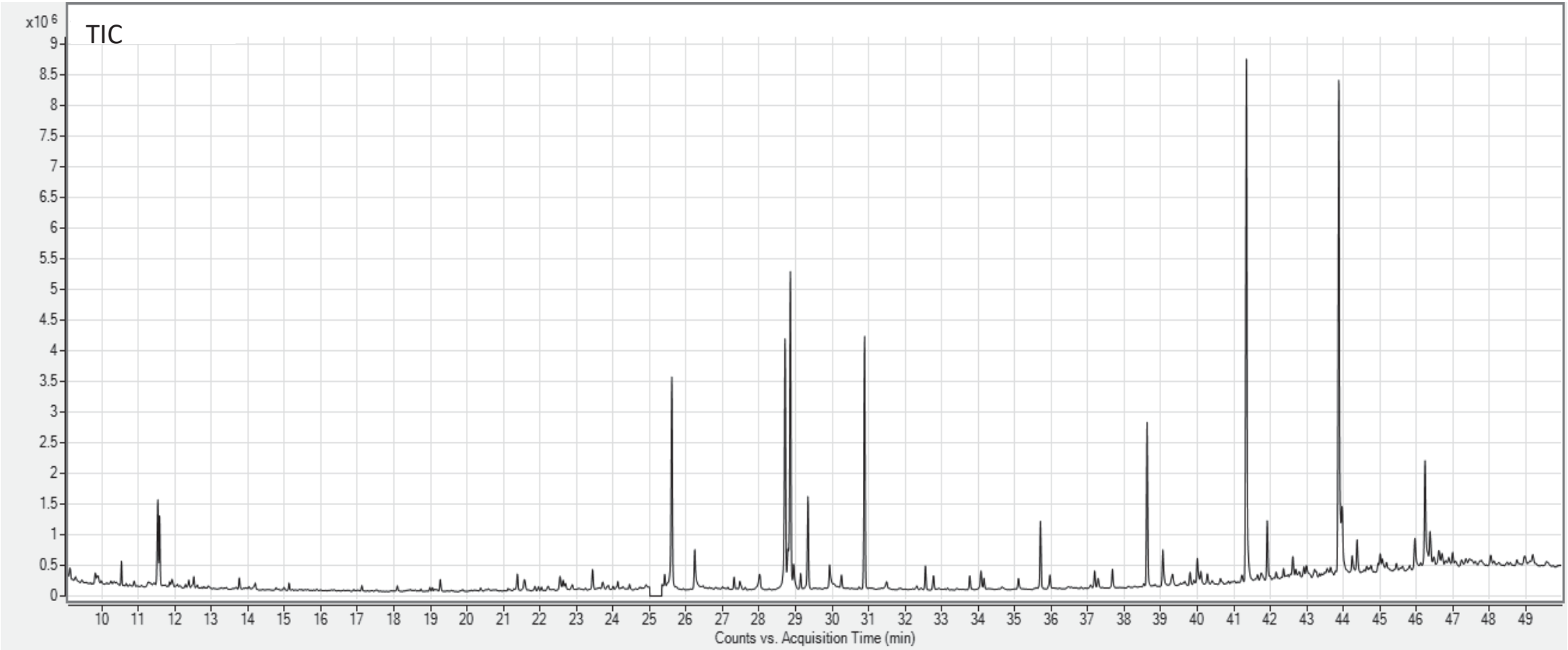


Fig. 117: Partial total ion chromatogram of the soil sample (BECS 2818) associated with Sample KM178– E178 (BECS 2736).

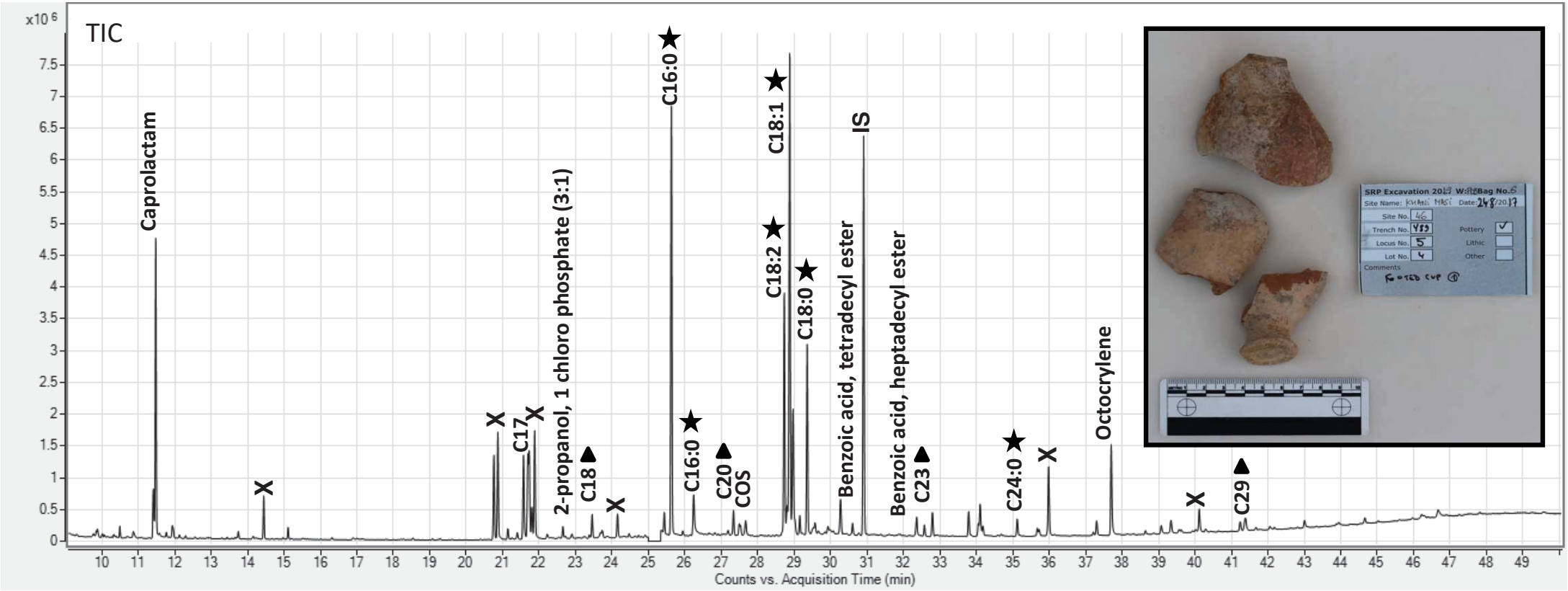


Fig. 118: Partial total ion chromatogram of Sample KM135– E135 (BECS 2749) of a cup discovered in Trench Y89 (Locus 5 Lot 4): Cx:y fatty acids ★, CxOH alcohols ■ , Cx alkanes ▲ , aldehydes and amides ♦ , ketones ⬣ , **MAG** and **DAG** mono- and diacylglycerols, wax esters ● , plasticizers (cross).

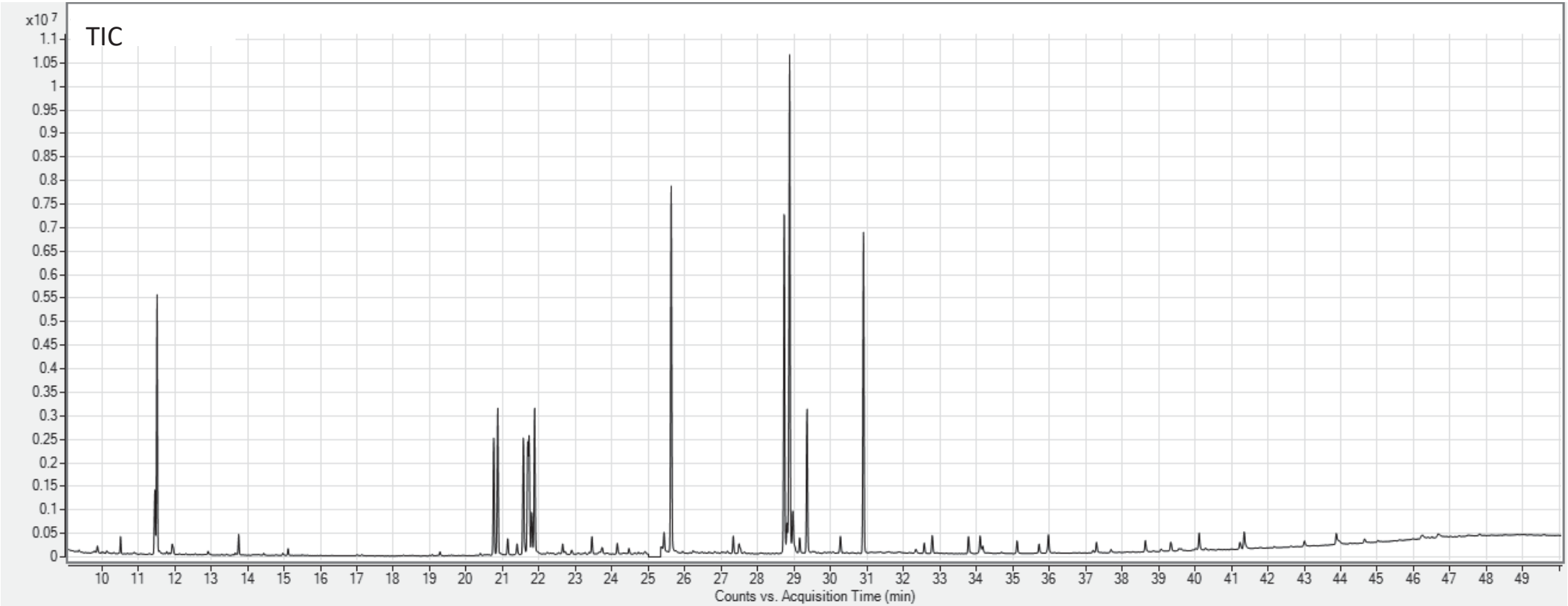


Fig. 119: Partial total ion chromatogram of the inner surface (BECS 2750) of Sample KM135– E135 (BECS 2749)

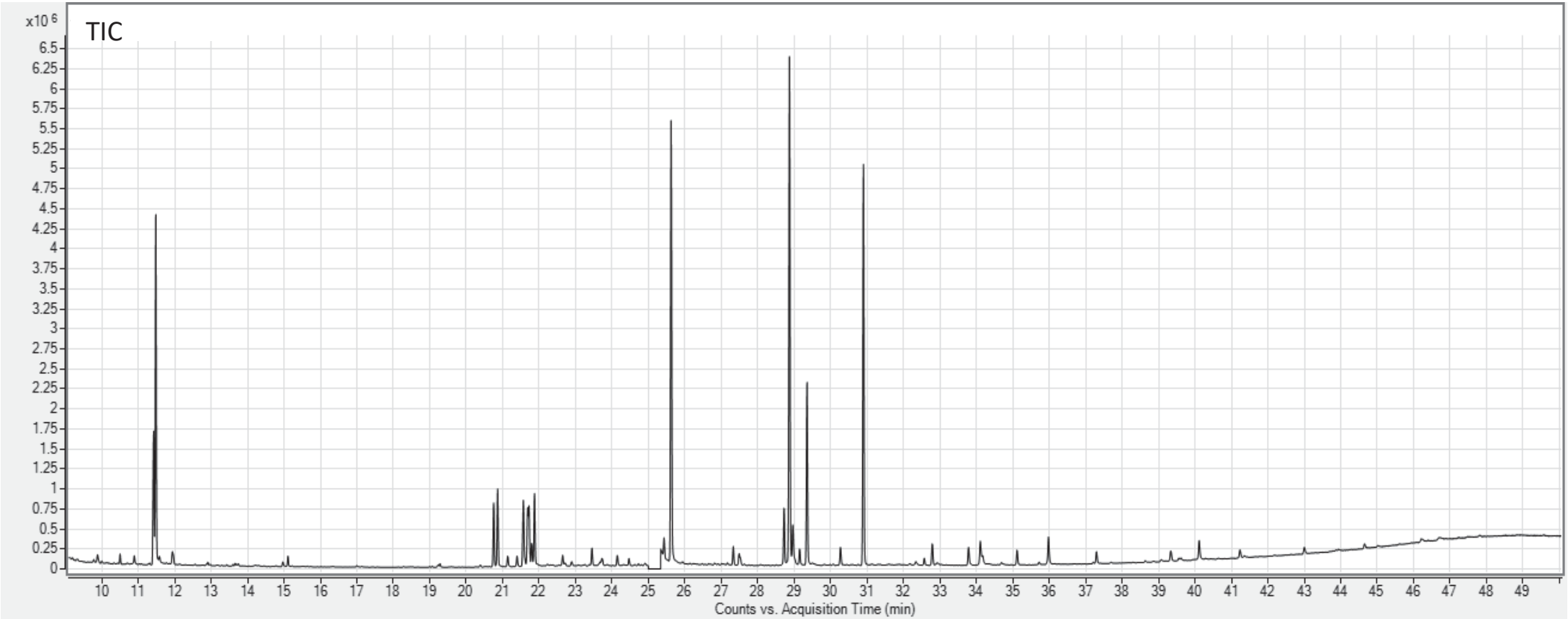


Fig. 120: Partial total ion chromatogram of the outer surface (BECS 2751) of Sample KM135– E135 (BECS 2749)

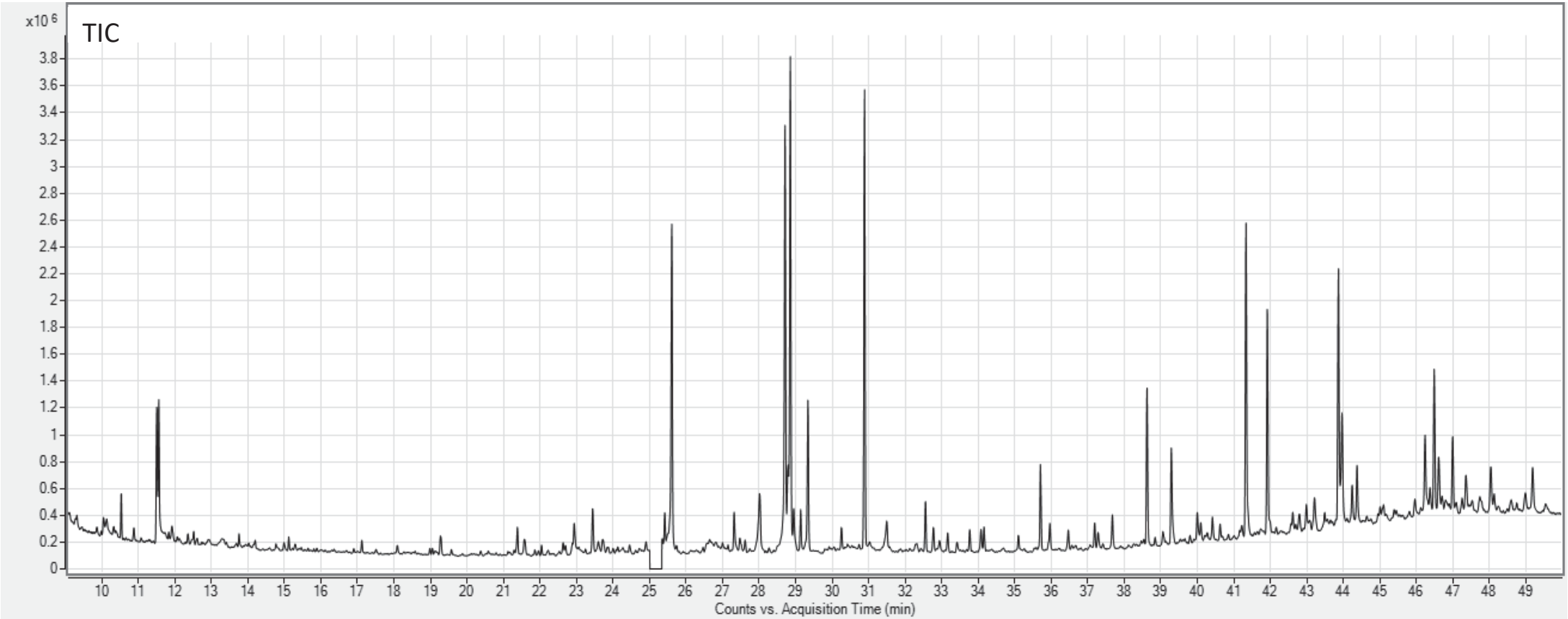


Fig. 121 : Partial total ion chromatogram of the soil sample (BECS 2819) associated with Sample KM135– E135 (BECS 2749)

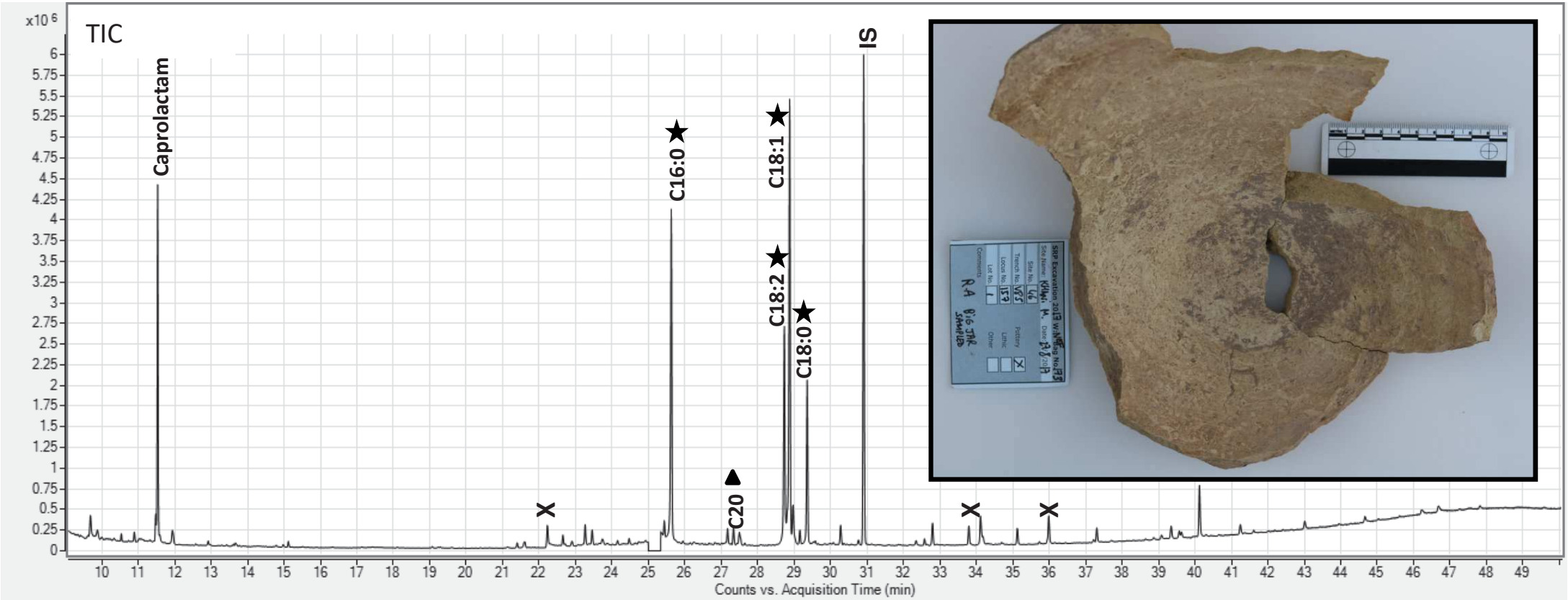


Fig. 122: Partial total ion chromatogram of Sample KM129– E129 (BECS 2324) of a large vessel discovered in Trench V85 (Locus 157 Lot 1): Cx:y fatty acids ★, CxOH alcohols ■ , Cx alkanes ▲ , aldehydes and amides ♦ , ketones ⬣ , **MAG** and **DAG** mono- and diacylglycerols, wax esters ● , plasticizers (cross).

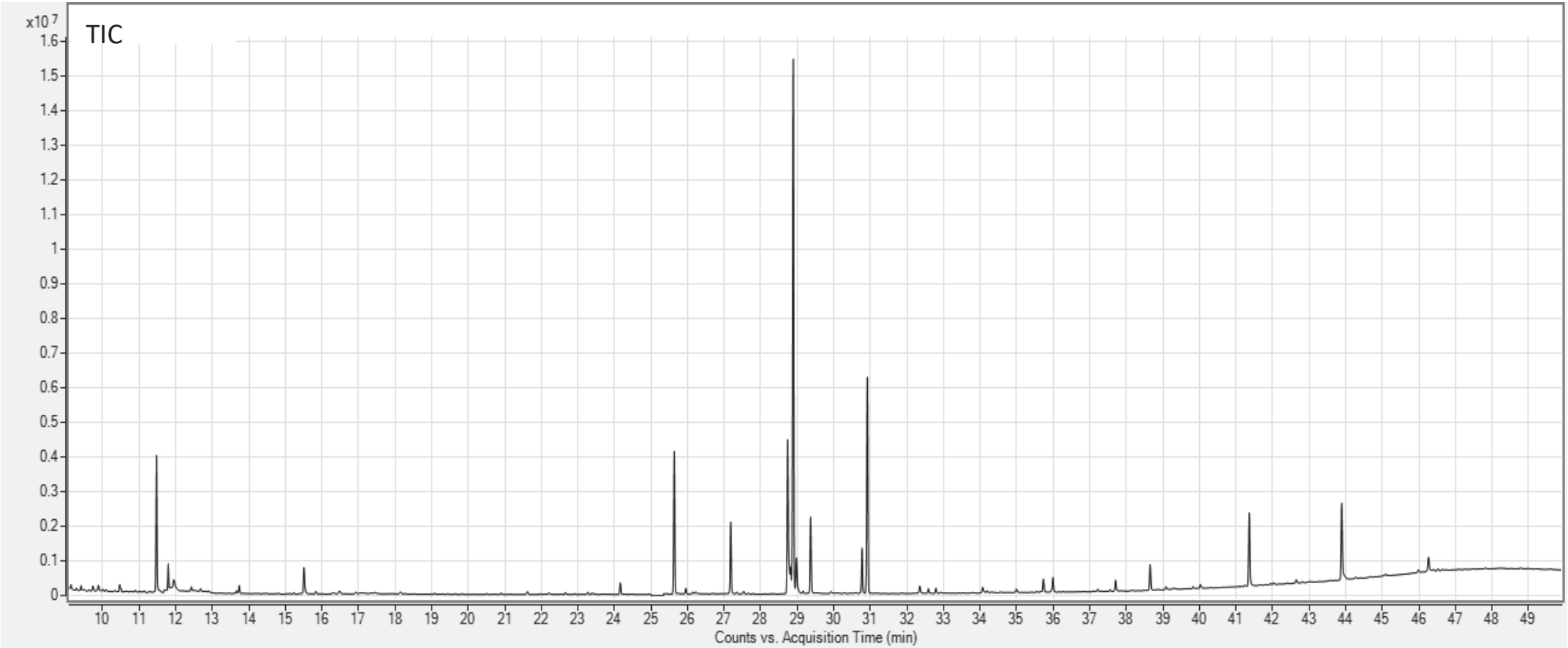


Fig. 123: Partial total ion chromatogram of the inner surface (BECS 2325) of Sample KM129– E129 (BECS 2324)

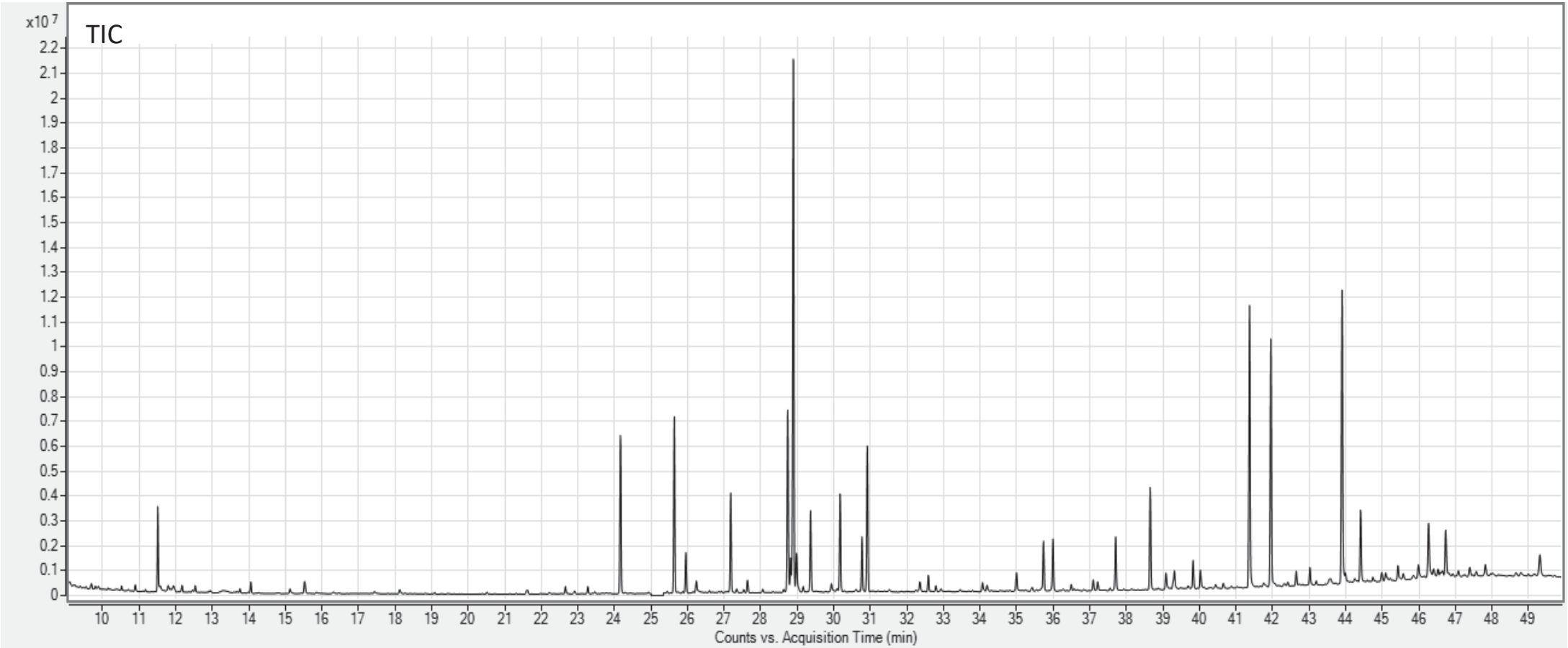


Fig. 124 : Partial total ion chromatogram of the inner surface (BECS 2326) of Sample KM129– E129 (BECS 2324)

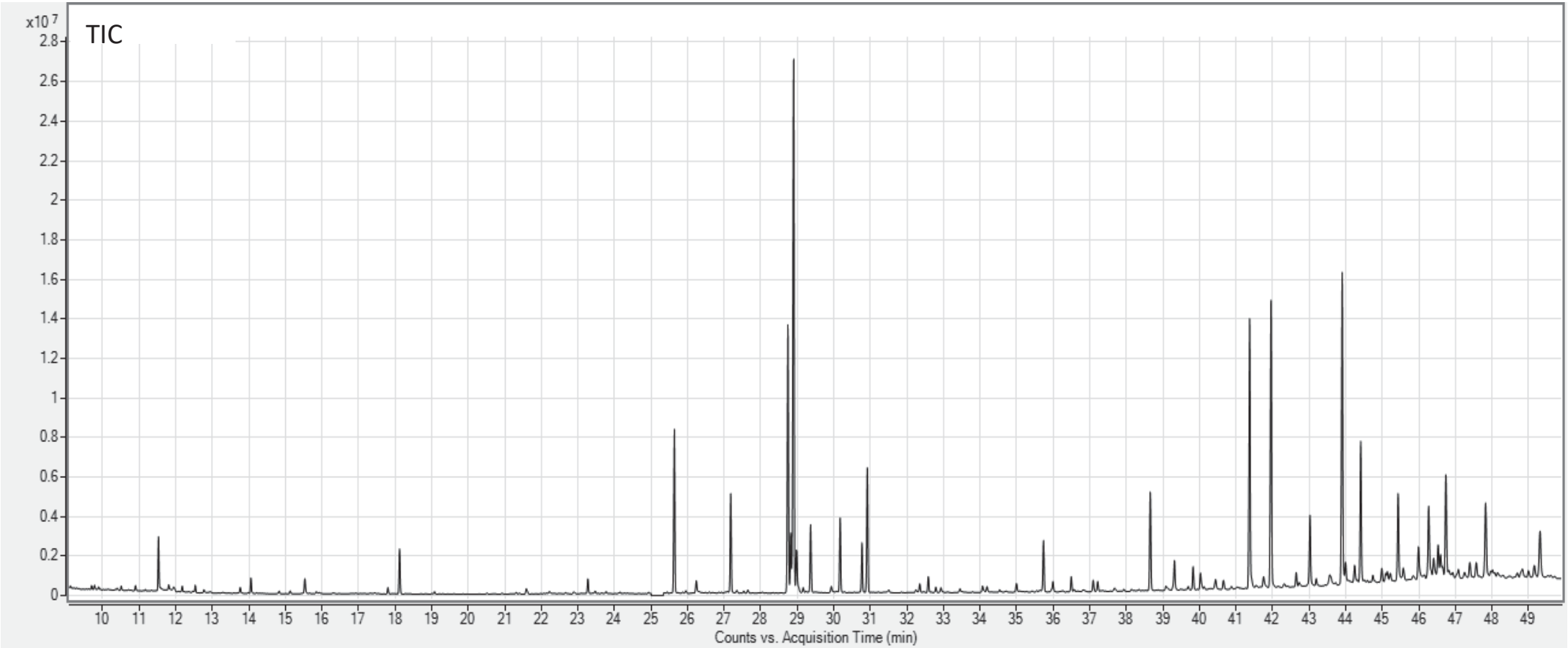


Fig. 125 : Partial total ion chromatogram of the soil sample (BECS 2327) associated with Sample KM129– E129 (BECS 2324)

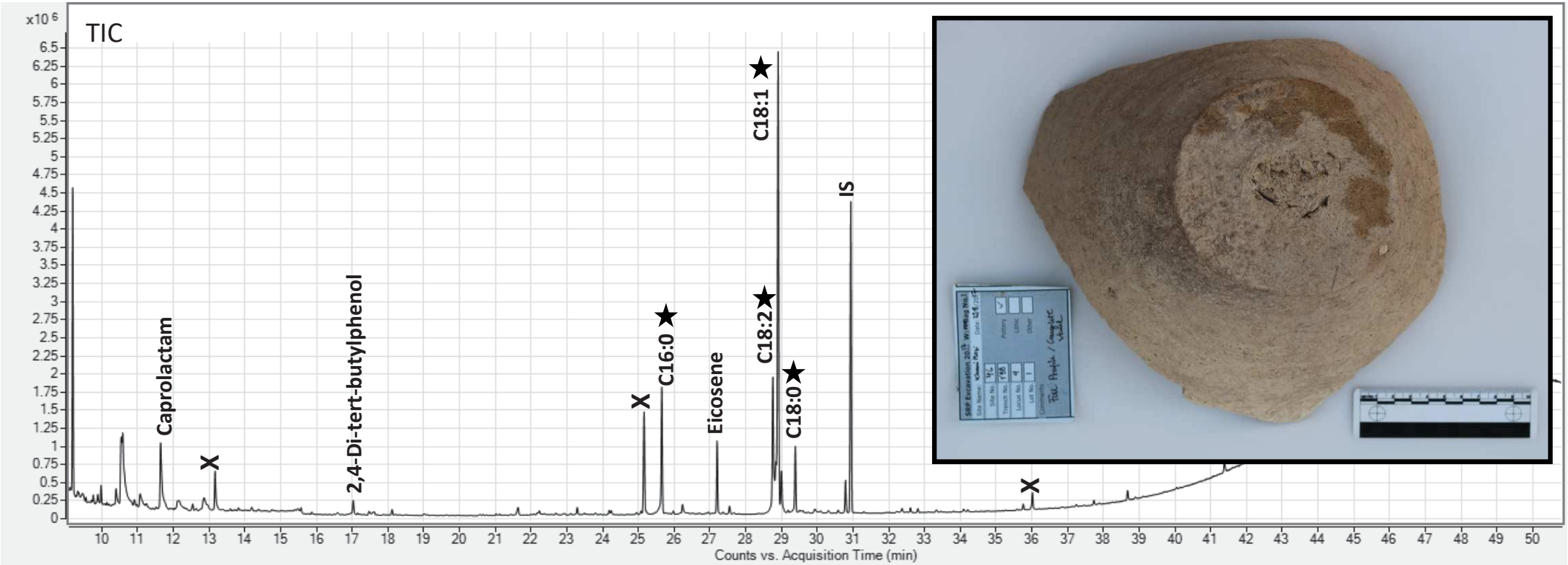


Fig. 126: Partial total ion chromatogram of Sample KM115– E115 (BECS 2320) of a large vessel discovered in Trench Y88 (Locus 104 Lot 1): Cx:y fatty acids ★, CxOH alcohols ■ , Cx alkanes ▲ , aldehydes and amides ♦ , ketones ⬣ , **MAG** and **DAG** mono- and diacylglycerols, wax esters ● , plasticizers (cross).

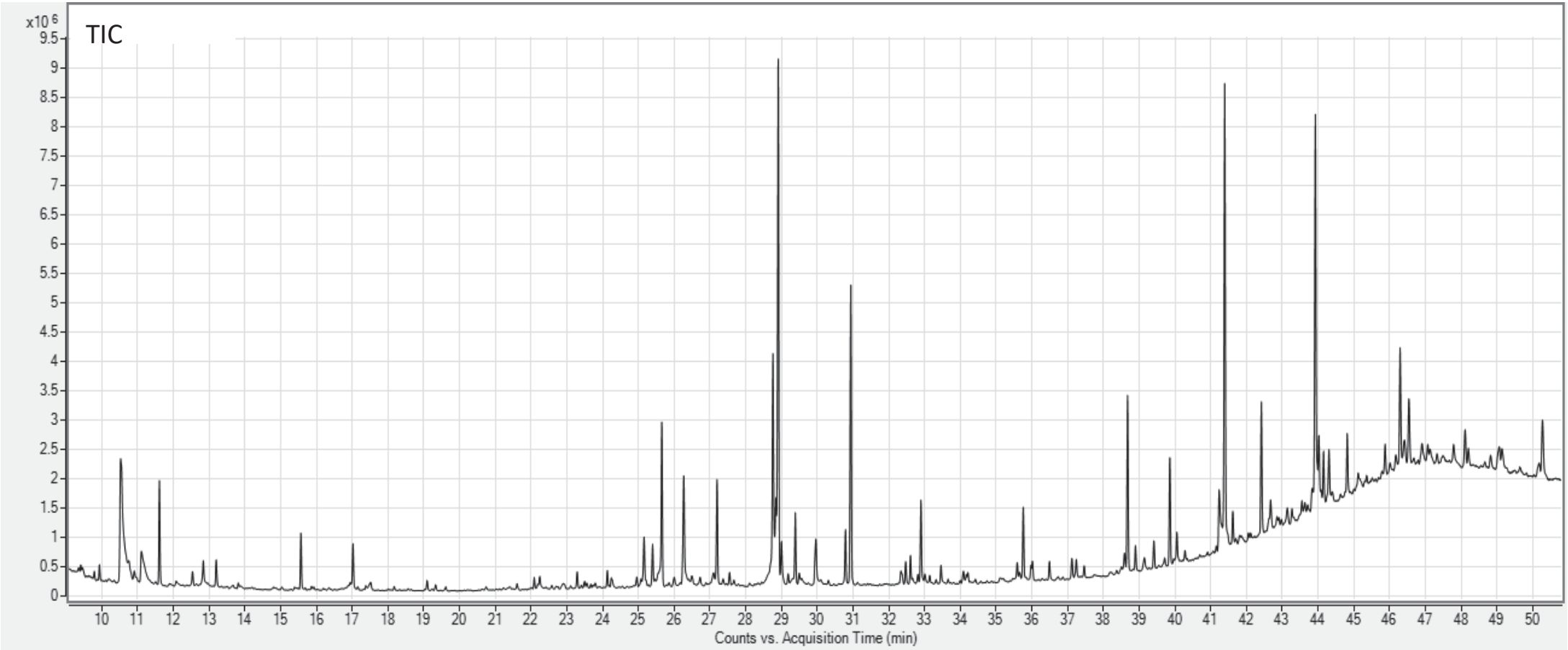


Fig. 127: Partial total ion chromatogram of the inner surface (BECS 2321) of Sample KM115– E115 (BECS 2320)

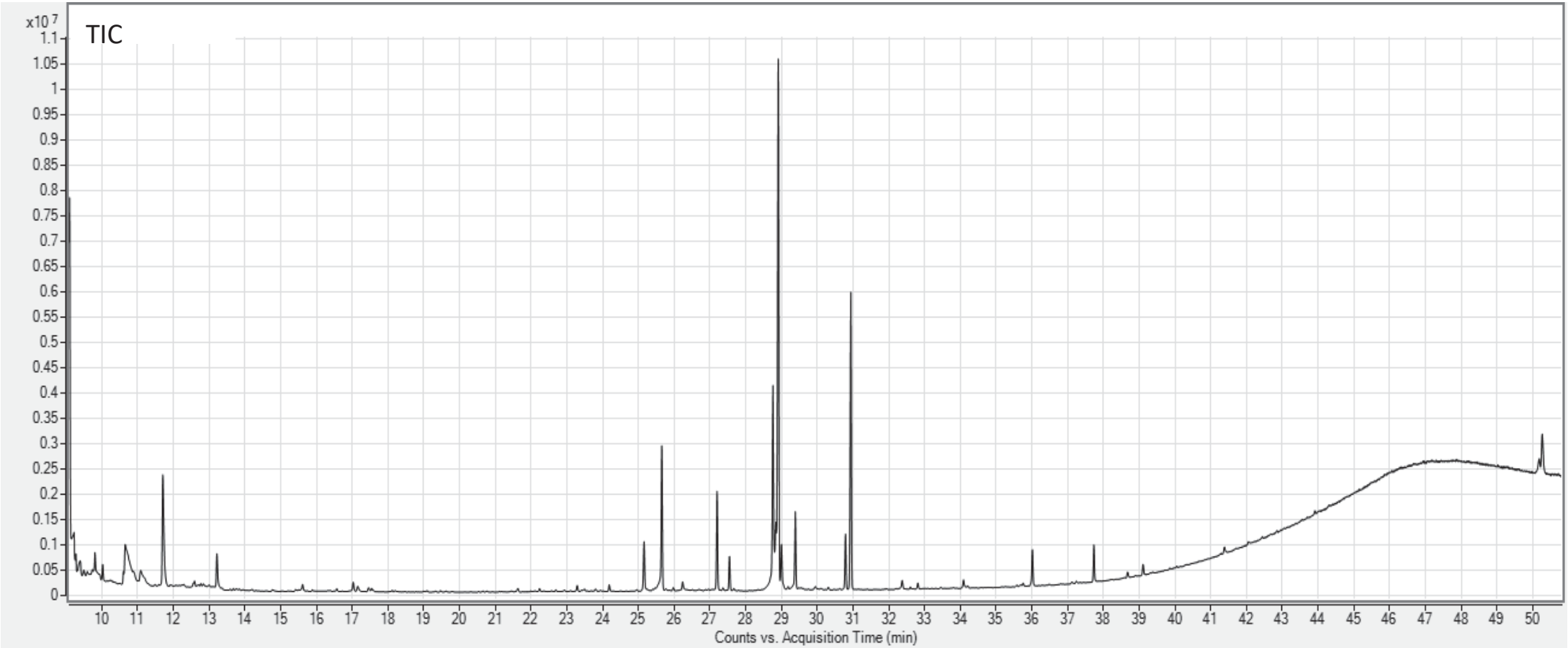


Fig. 128: Partial total ion chromatogram of the outer surface (BECS 2322) of Sample KM115– E115 (BECS 2320)

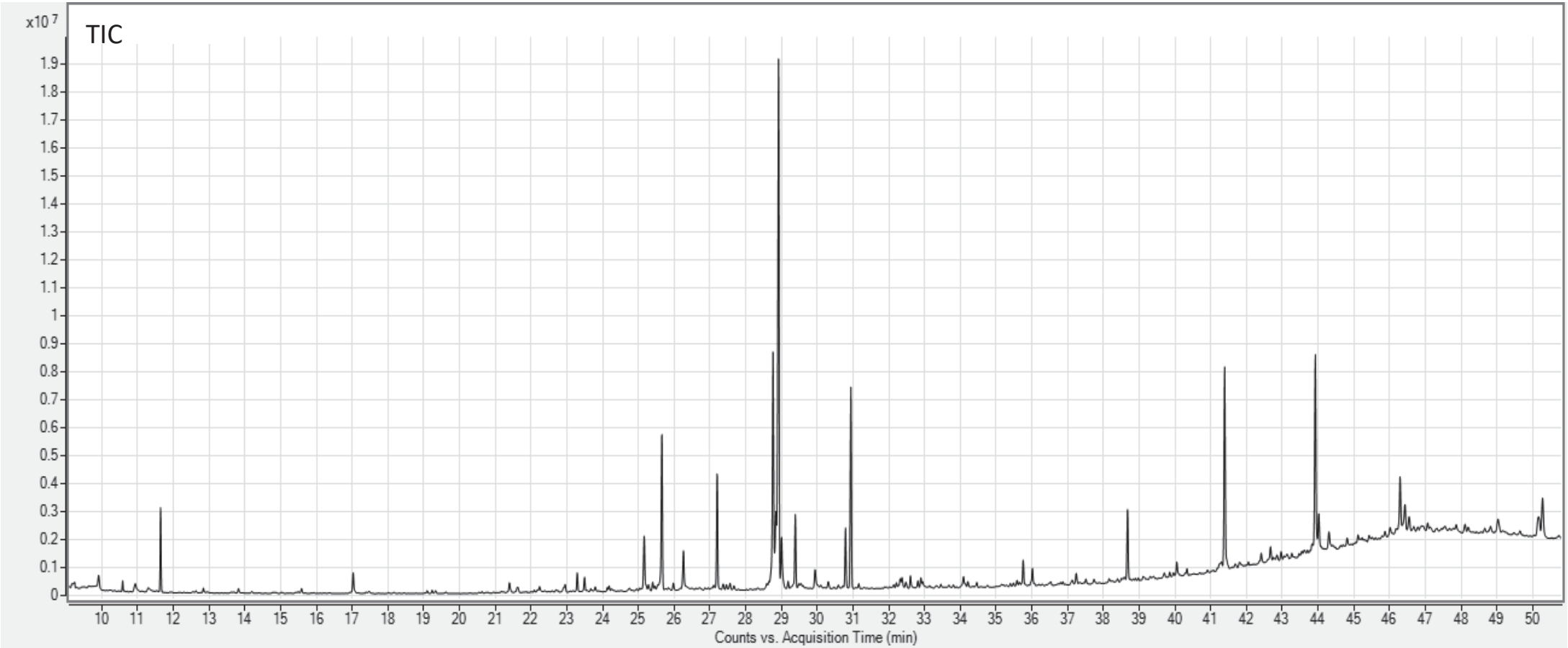


Fig. 129 : Partial total ion chromatogram of the soil sample (BECS 2323) associated with Sample KM115– E115 (BECS 2320)

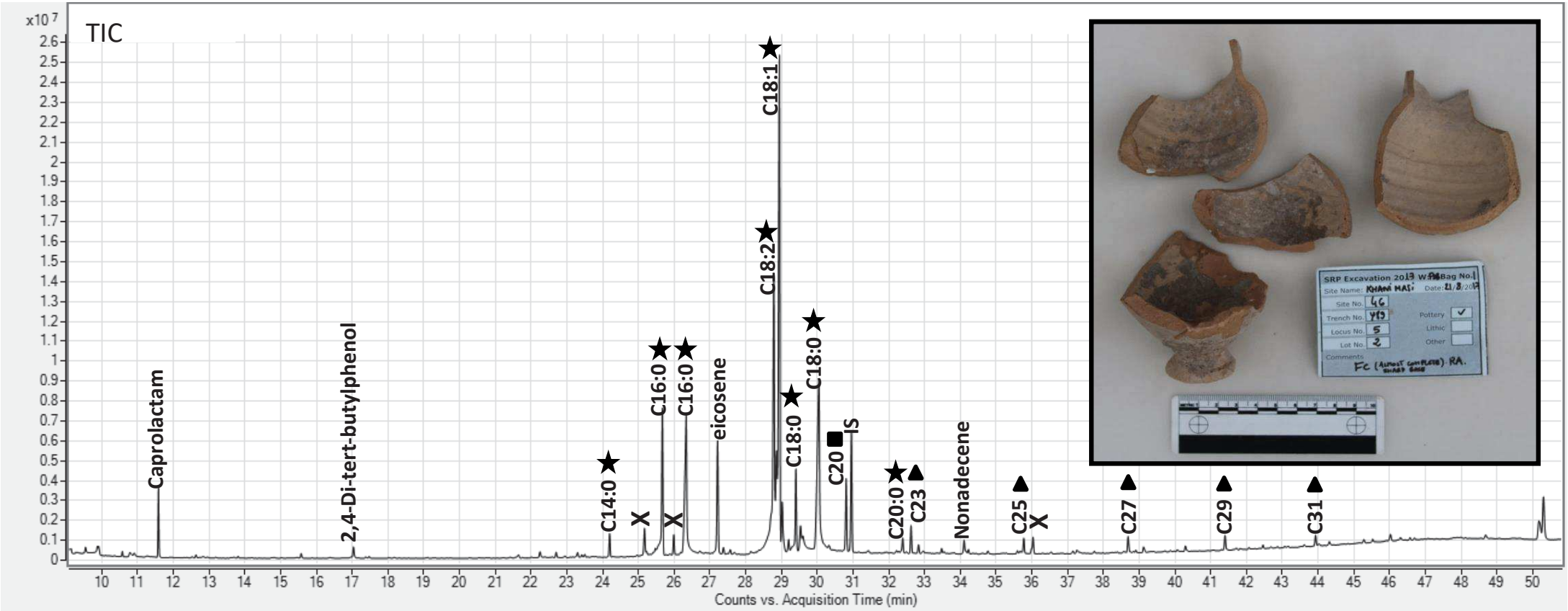


Fig. 130 : Partial total ion chromatogram of Sample KM150– E150 (BECS 2303) of a cup in Trench Y89 (Locus 5 Lot 2): Cx:y fatty acids ★, CxOH alcohols ■ , Cx alkanes ▲ , aldehydes and amides ♦ , ketones ⬣ , **MAG** and **DAG** mono- and diacylglycerols, wax esters ● , plasticizers (cross).

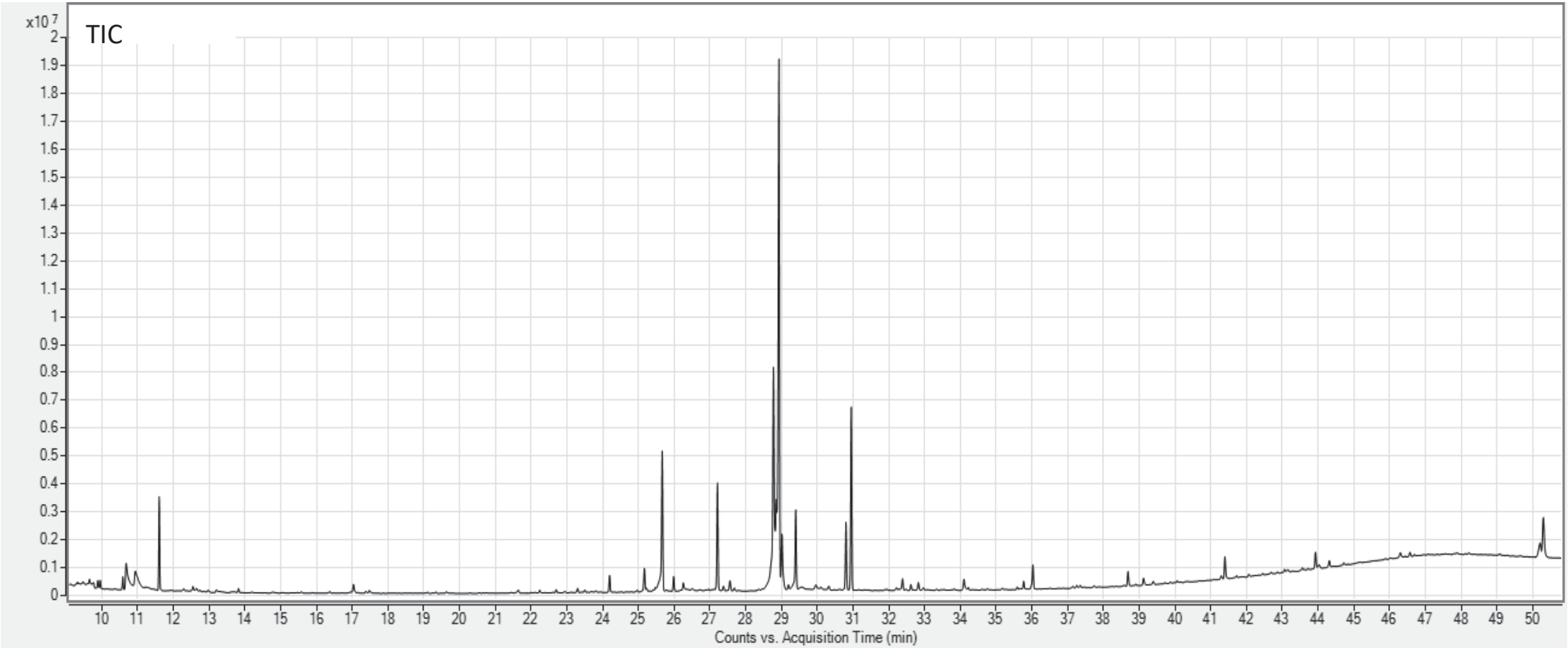


Fig. 131 : Partial total ion chromatogram of the inner surface (BECS 2304) of Sample KM150– E150 (BECS 2303)

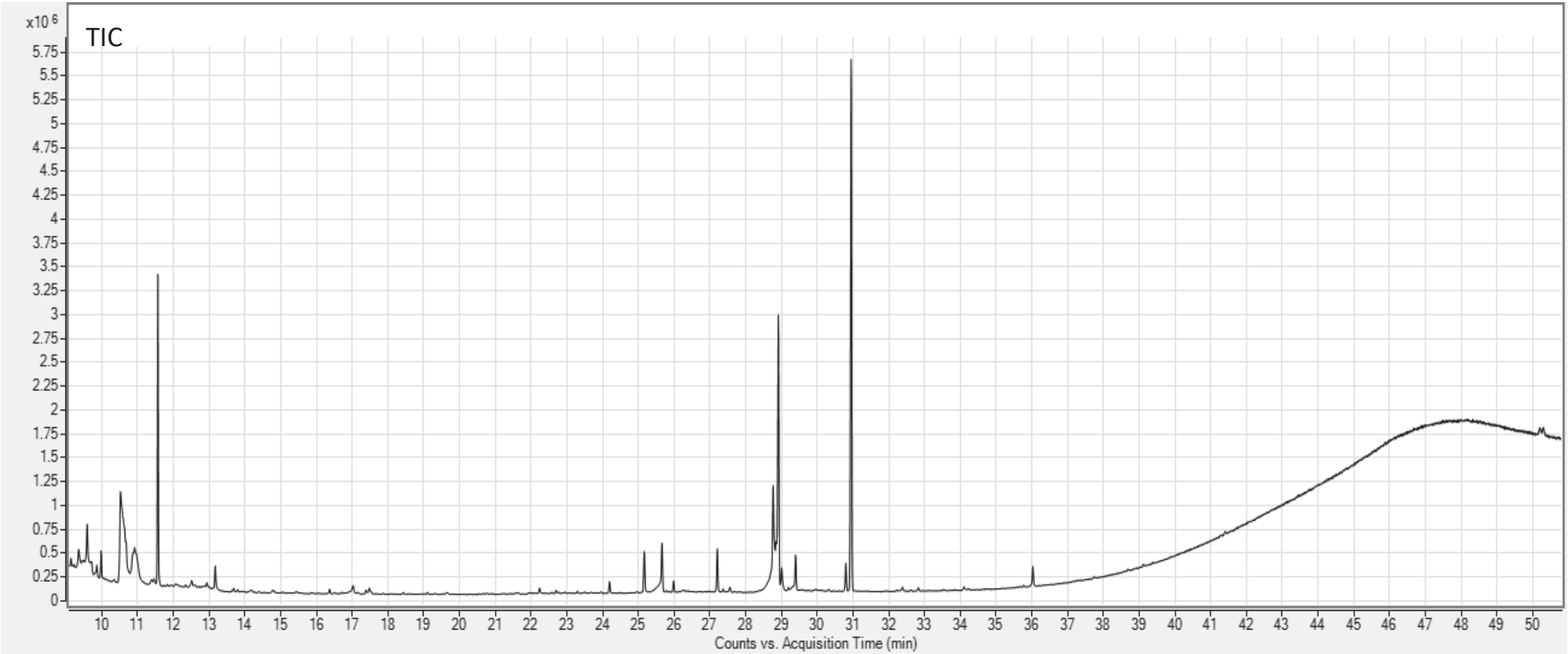


Fig. 132: Partial total ion chromatogram of the outer surface (BECS 2305) of Sample KM150– E150 (BECS 2303)

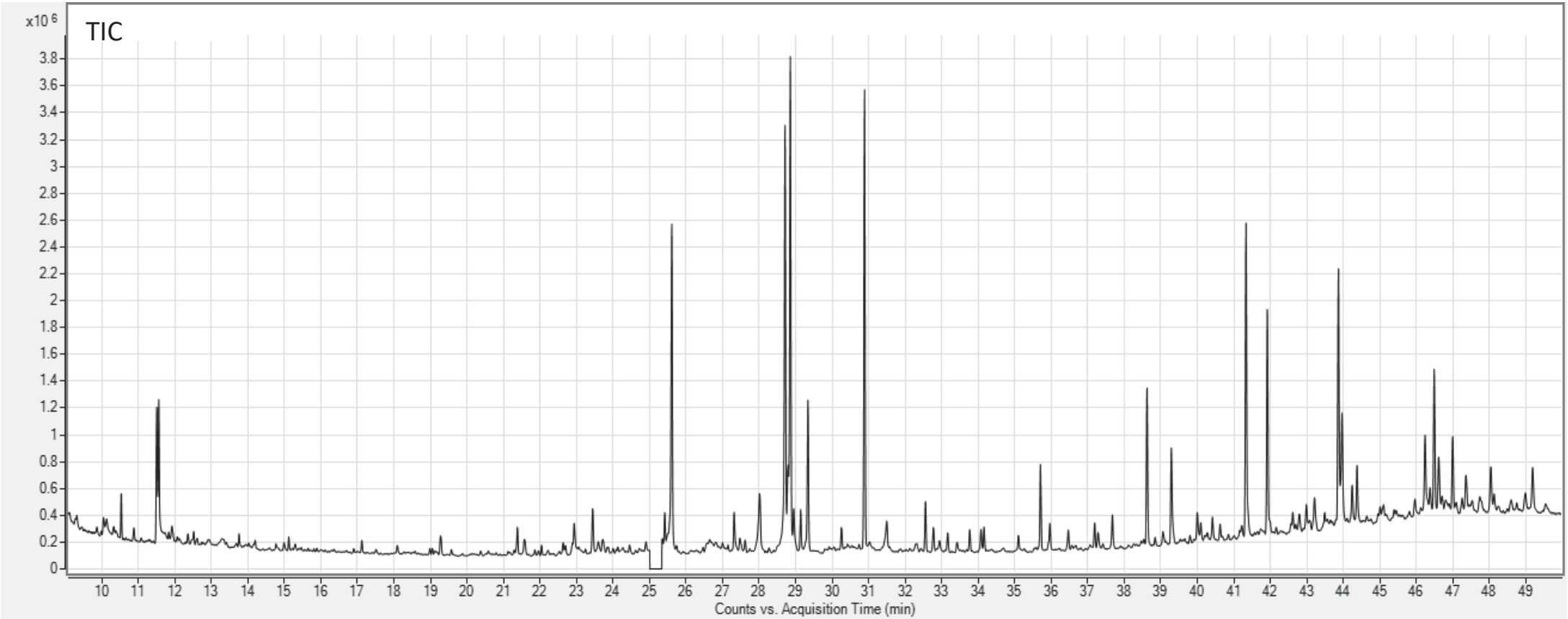


Fig. 121 : Partial total ion chromatogram of the soil sample (BECS 2819) associated with Sample KM150– E150 (BECS 2303)

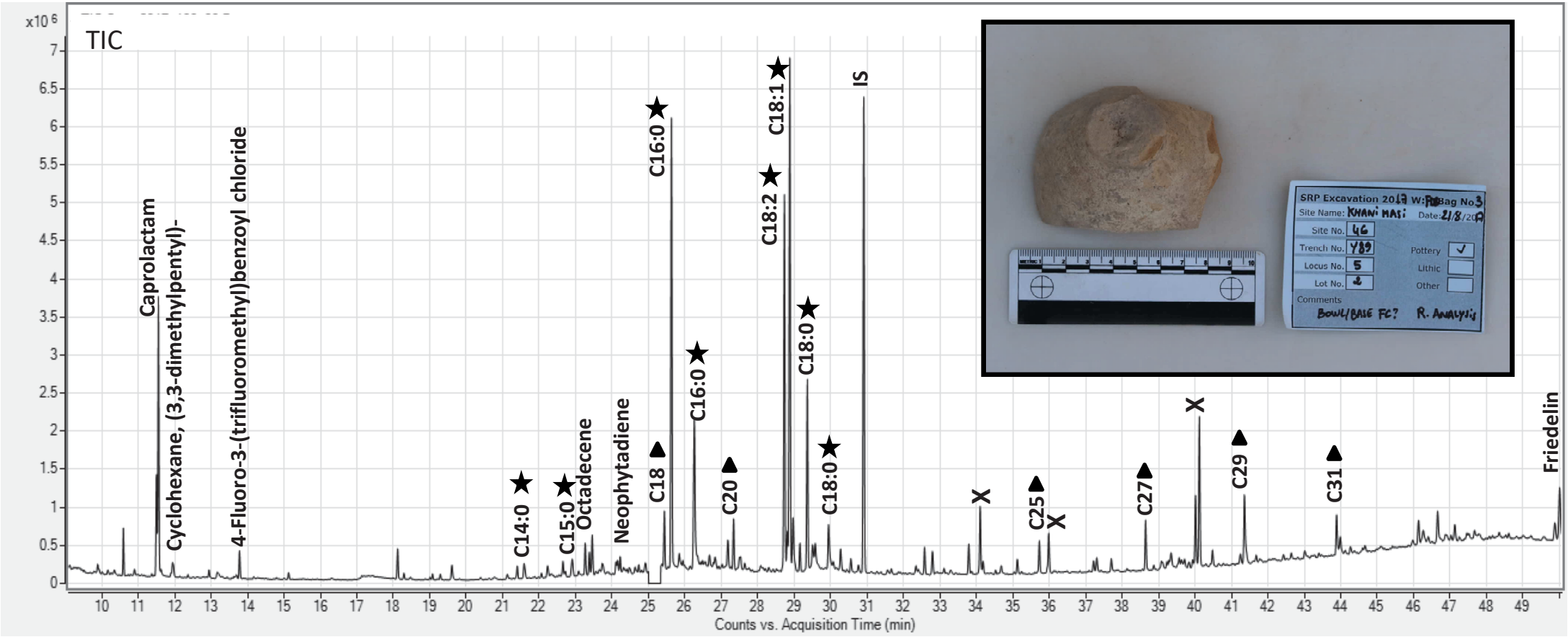


Fig. 134: Partial total ion chromatogram of Sample KM140– E140 (BECS 2317) of a cup in Trench Y89 (Locus 5 Lot 2): Cx:y fatty acids ★, CxOH alcohols ■ , Cx alkanes ▲ , aldehydes and amides ♦ , ketones ● , **MAG** and **DAG** mono- and diacylglycerols, wax esters ● , plasticizers (cross).

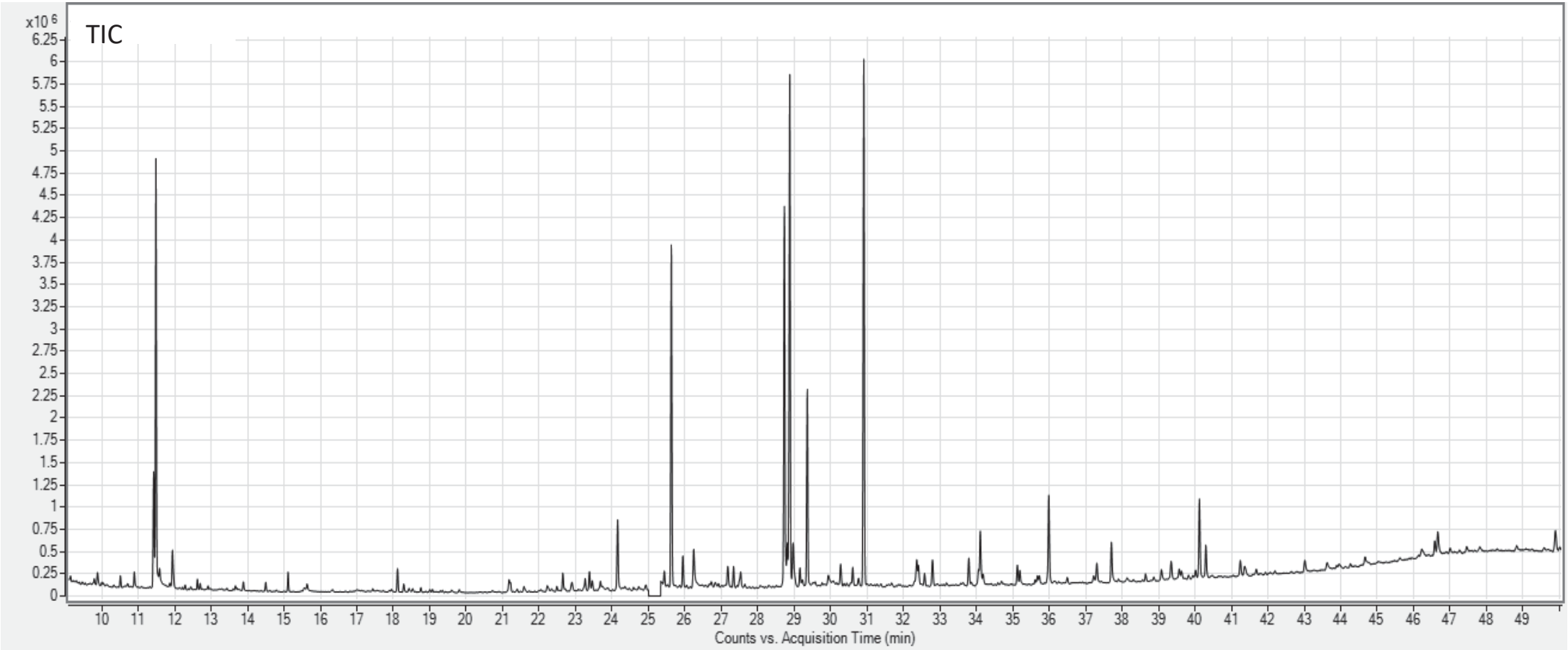


Fig. 135: Partial total ion chromatogram of the inner surface (BECS 2318) of Sample KM140– E140 (BECS 2317)

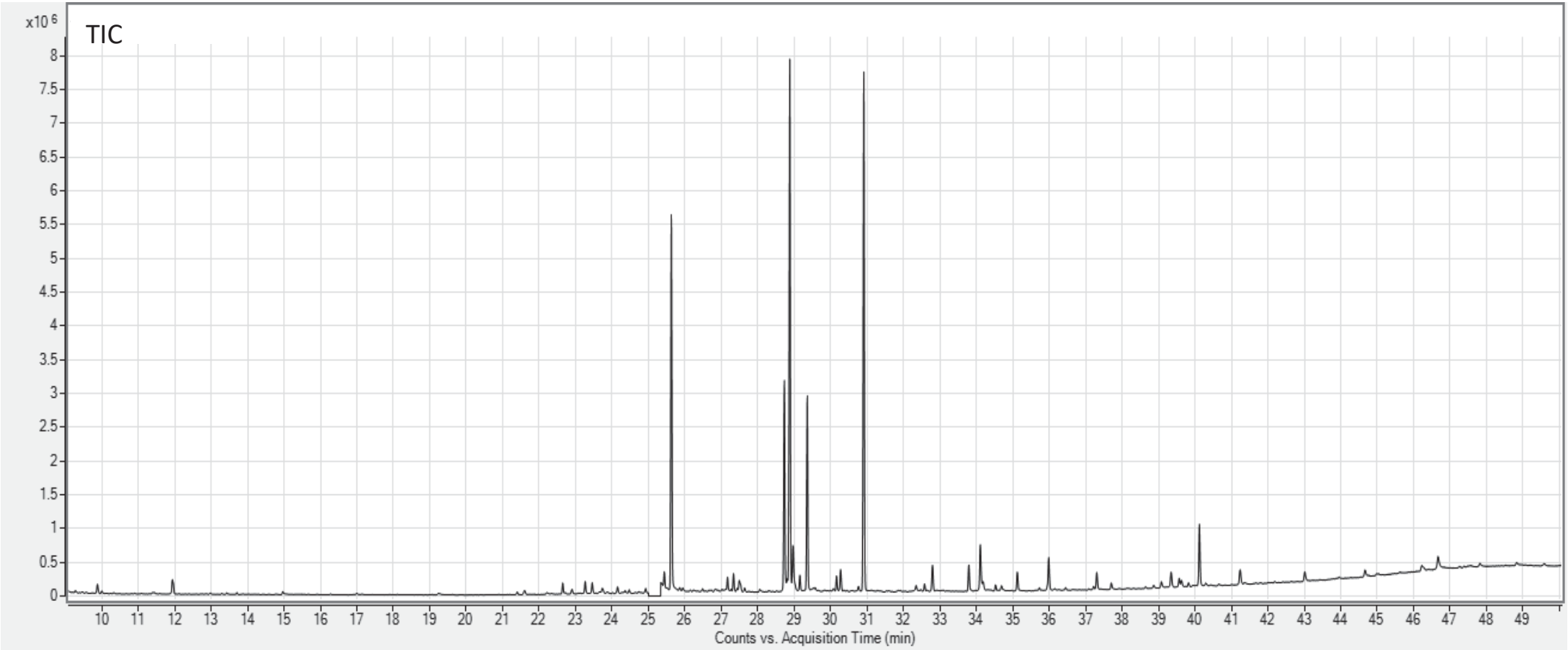


Fig. 136: Partial total ion chromatogram of the outer surface (BECS 2319) of Sample KM140– E140 (BECS 2317)

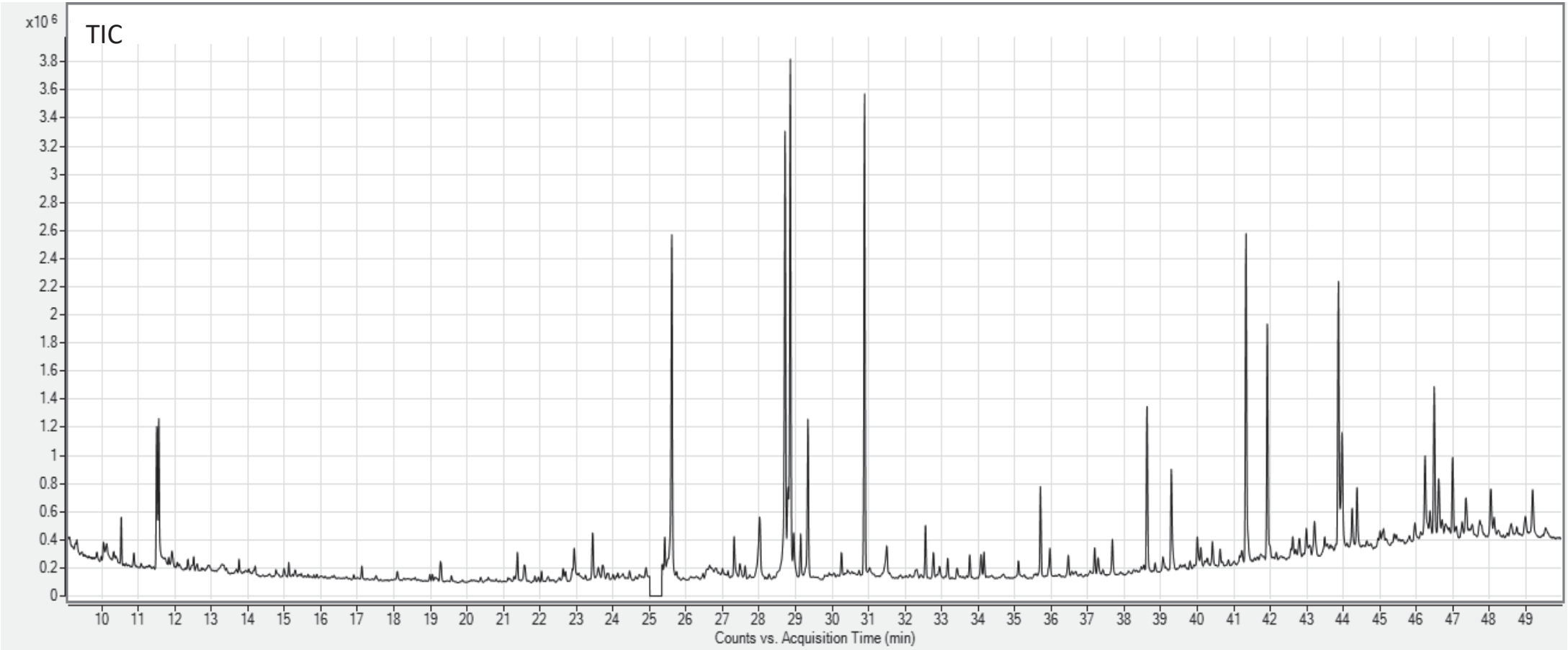


Fig. 137 : Partial total ion chromatogram of the soil sample (BECS 2819) associated with Sample KM140– E140 (BECS 2317)

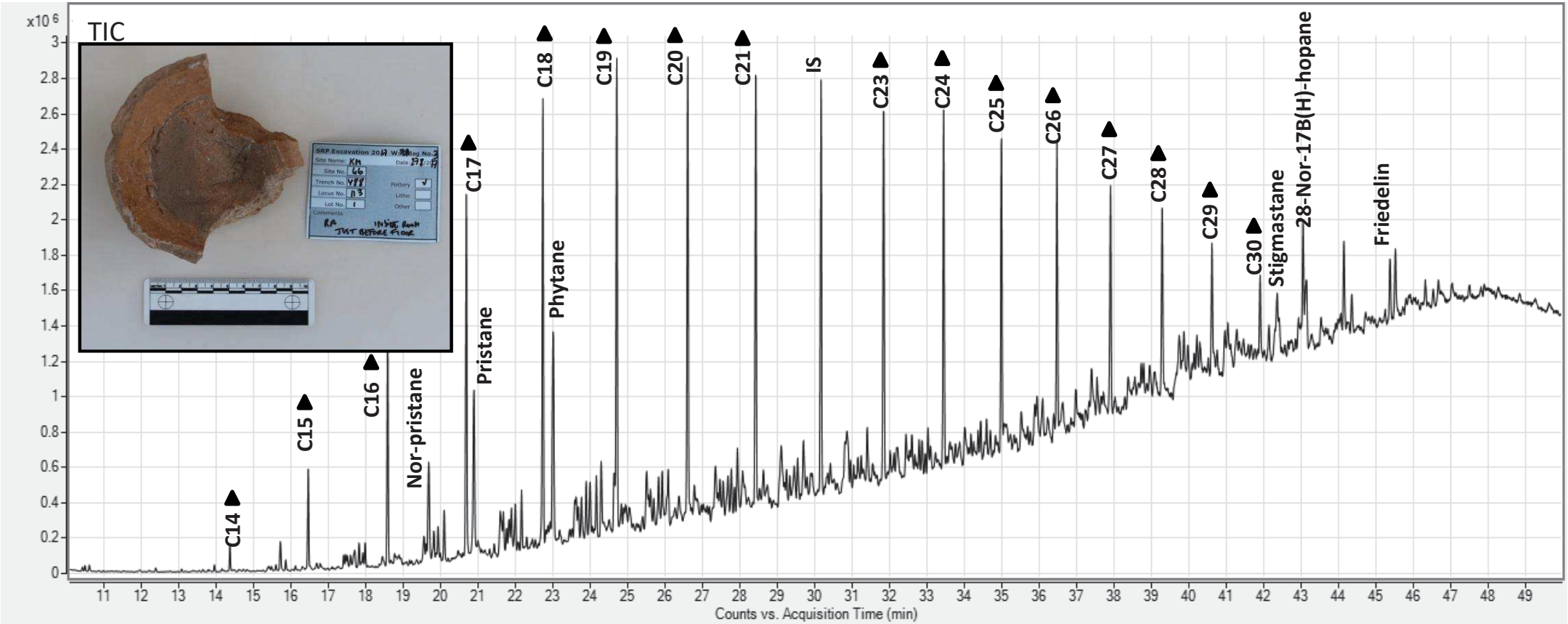


Fig. 138: Partial total ion chromatogram of Sample KM158– E158 (BECS 2540) of a bowl in Trench Y88 (Locus 113 Lot 1): Cx:y fatty acids ★, CxOH alcohols ■ , Cx alkanes ▲ , aldehydes and amides ♦ , ketones ⬟ , **MAG** and **DAG** mono- and diacylglycerols, wax esters ● , plasticizers (cross).

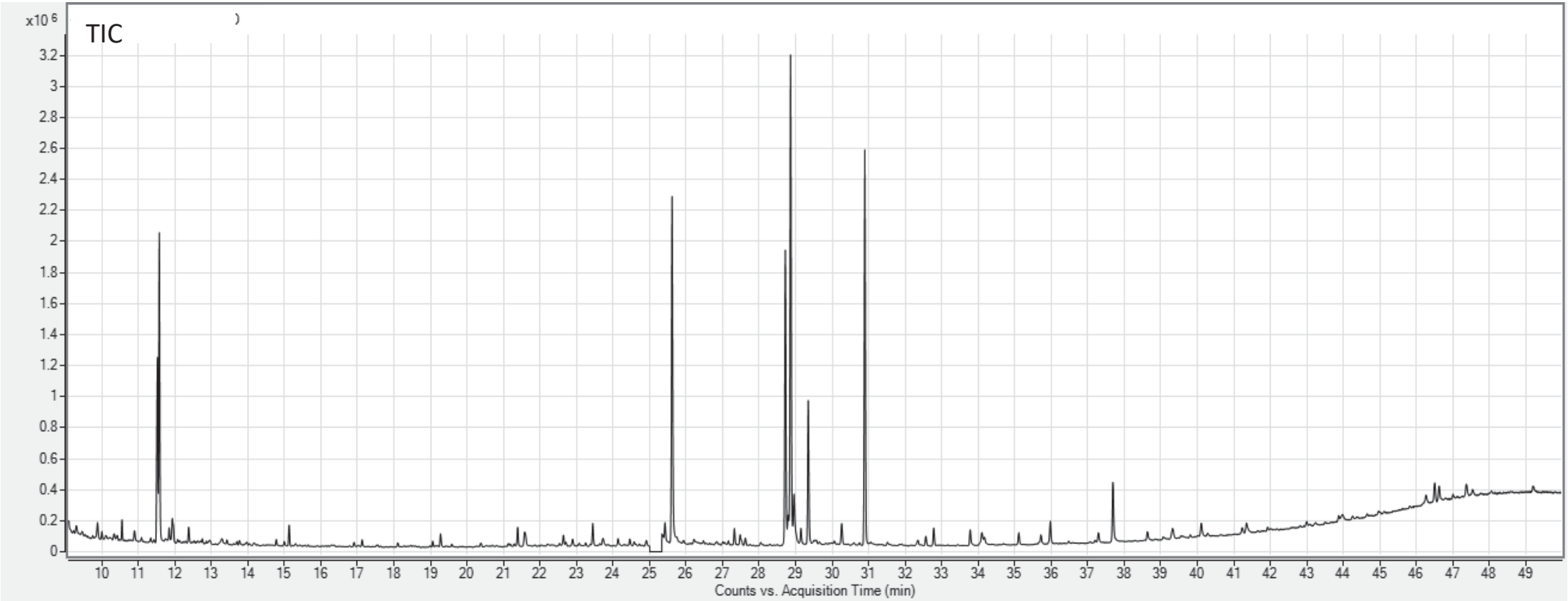


Fig. 139 : Partial total ion chromatogram of the inner surface (BECS 2541) of Sample KM158– E158 (BECS 2540)

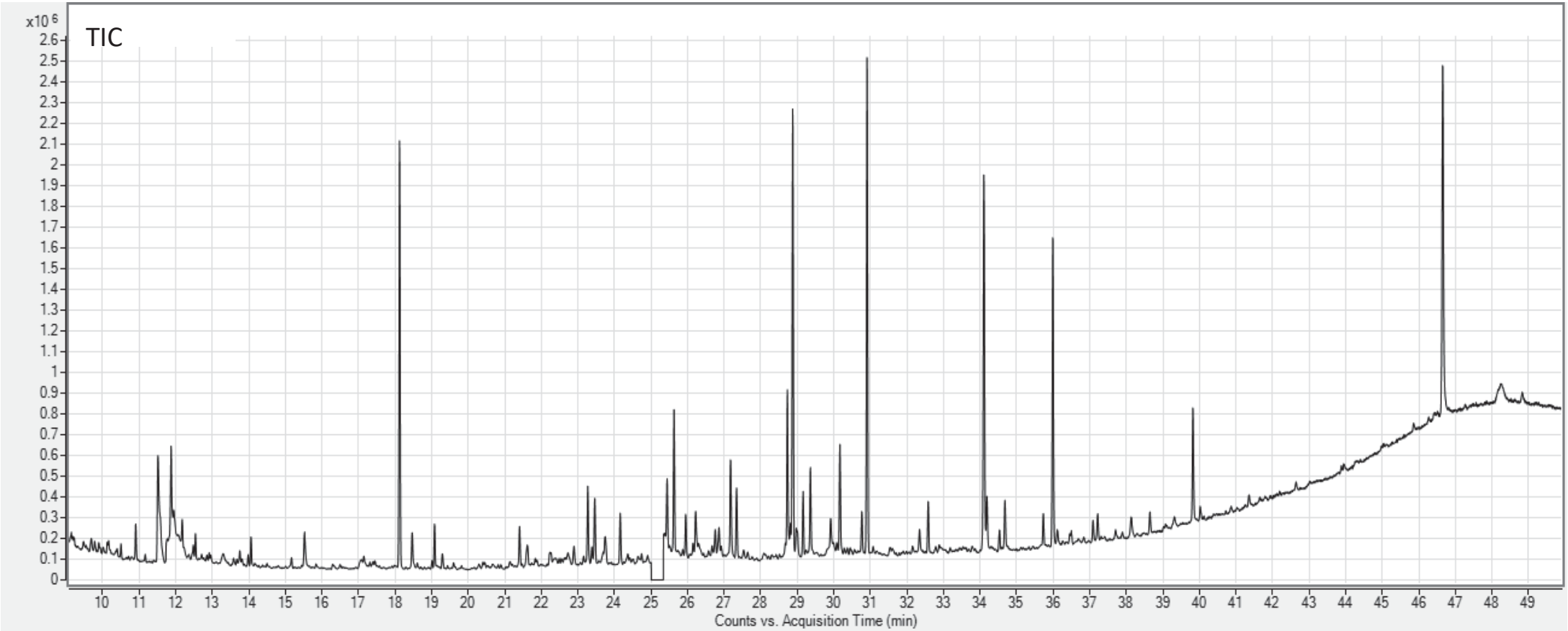


Fig. 140: Partial total ion chromatogram of the outer surface (BECS 2542) of Sample KM158– E158 (BECS 2540)

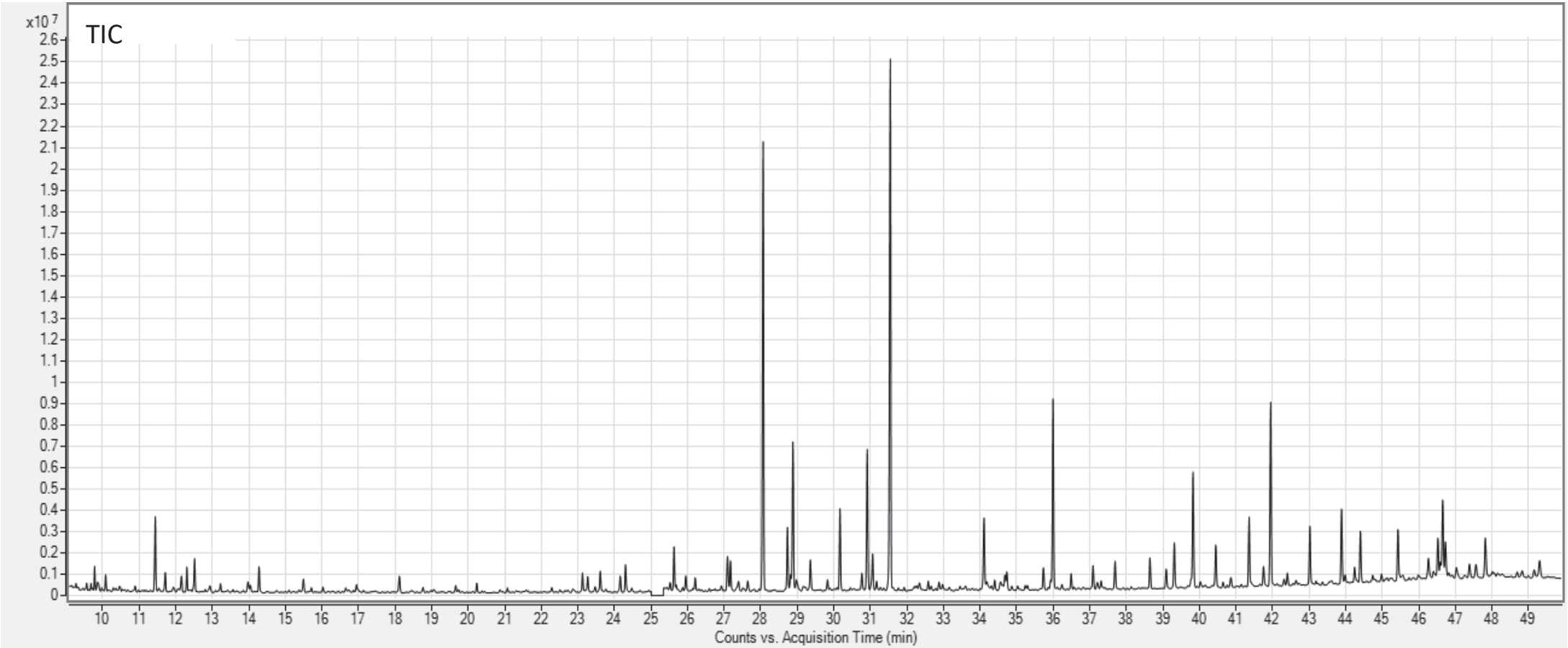


Fig. 141 : Partial total ion chromatogram of the soil sample (BECS 2544) associated with Samples KM150– E150 (BECS 2303) and KM158– E158 (BECS 2540) .

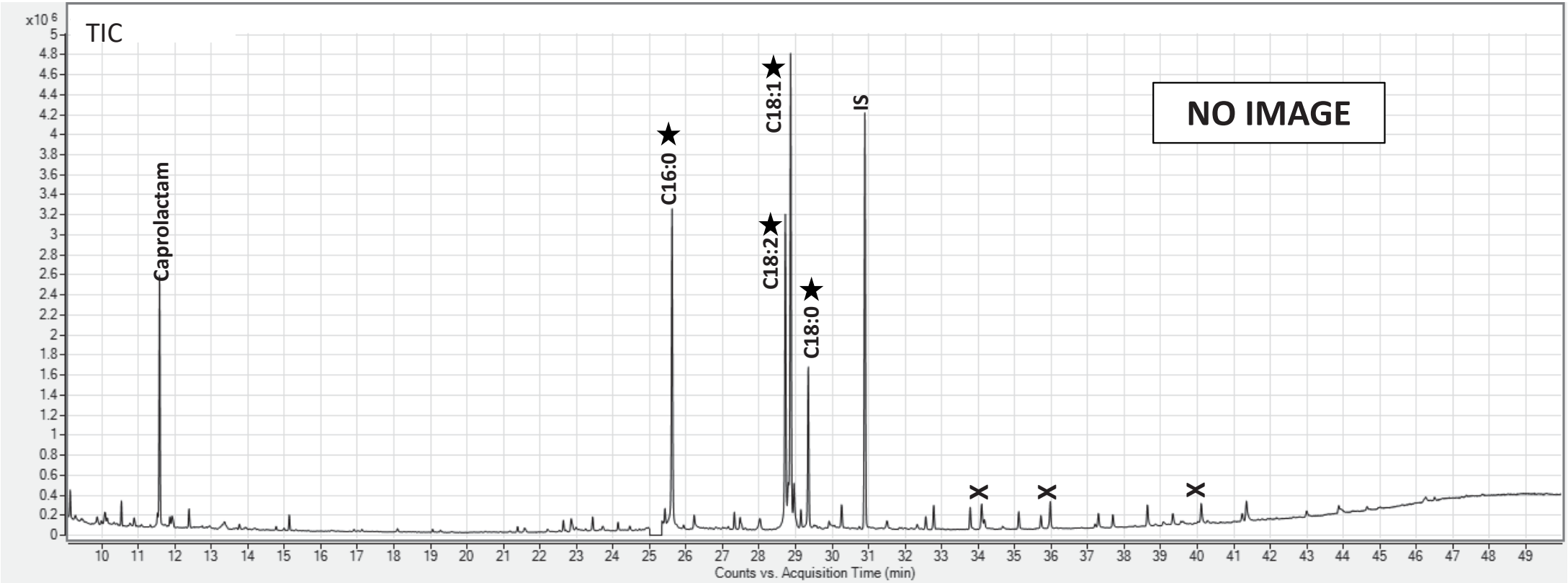


Fig. 142 : Partial total ion chromatogram of Sample KM187– E187 (BECS 2755) of a cup in Trench Y88 (Locus 110 Lot 1): Cx:y fatty acids ★, CxOH alcohols ■ , Cx alkanes ▲ , aldehydes and amides ♦ , ketones ⬣ , **MAG** and **DAG** mono- and diacylglycerols, wax esters ● , plasticizers (cross).

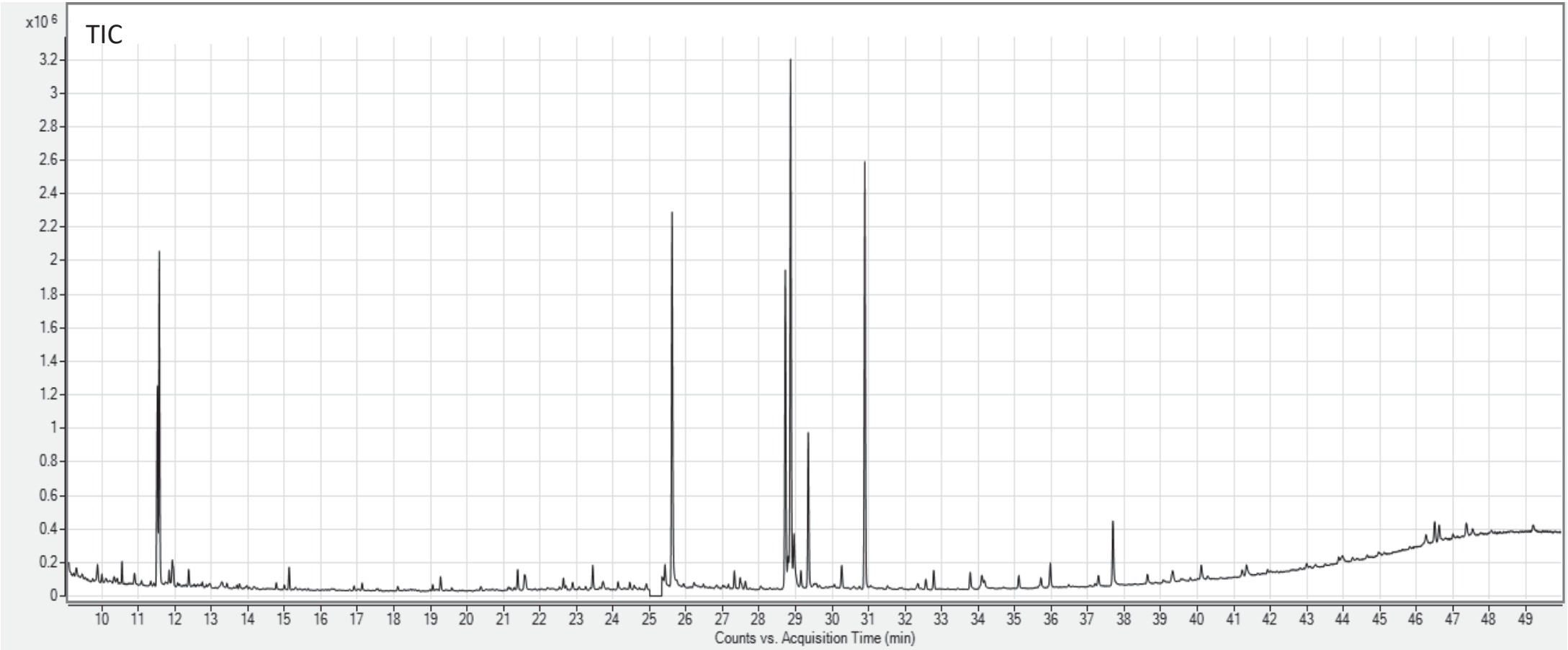


Fig. 143: Partial total ion chromatogram of the inner surface (BECS 2756) of Sample KM187– E187 (BECS 2755)

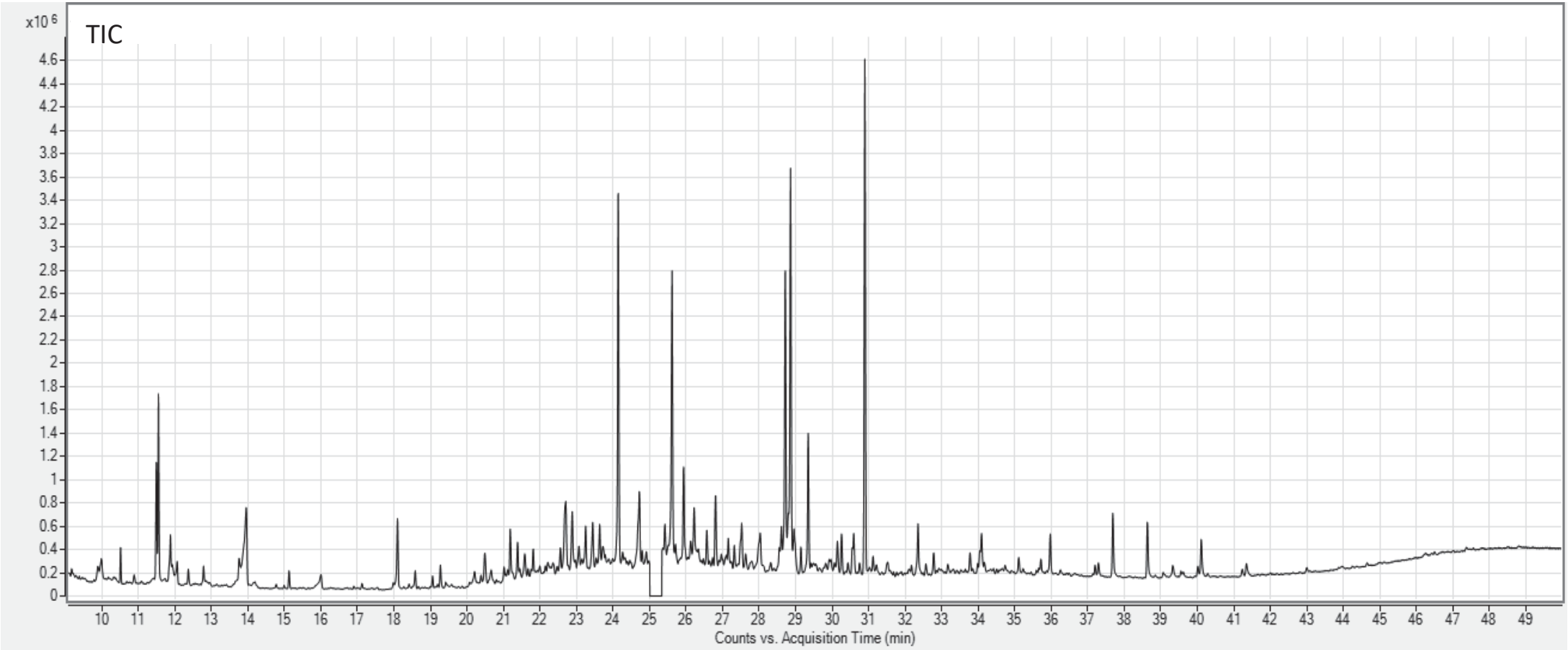


Fig. 144 : Partial total ion chromatogram of the outer surface (BECS 2757) of Sample KM187– E187 (BECS 2755)

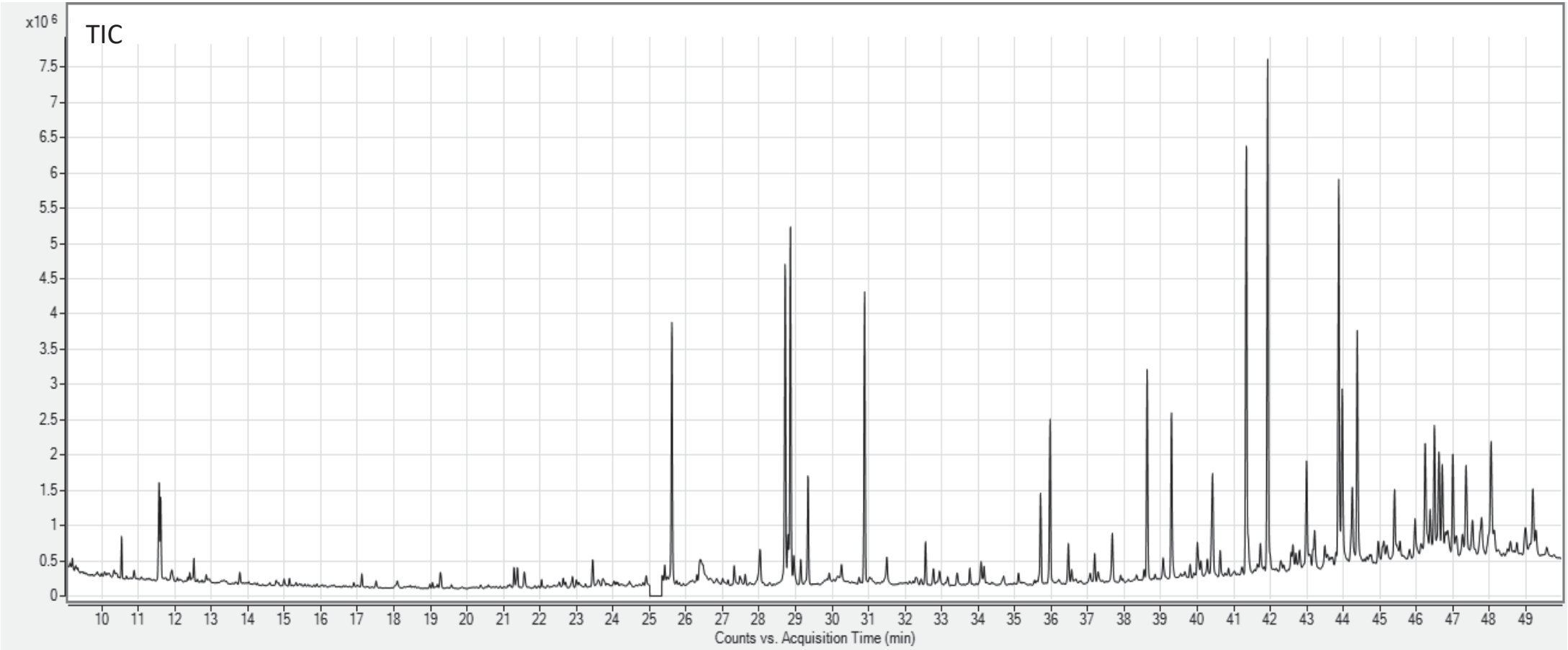


Fig. 145 : Partial total ion chromatogram of the soil sample (BECS 2821) associated with Sample KM187– E187 (BECS 2755)

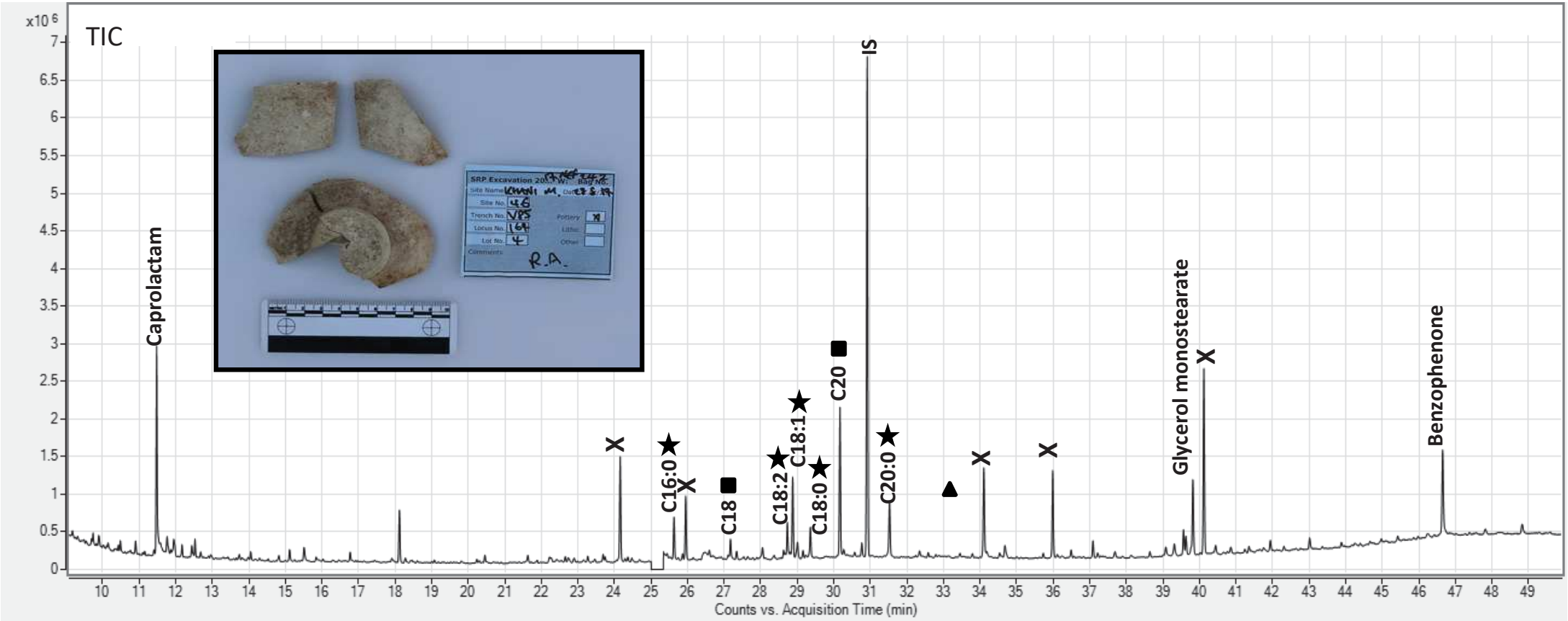


Fig. 146 : Partial total ion chromatogram of Sample KM176– E176 (BECS 2599) of a Bowl in Trench V85 (Locus 164 Lot 4): Cx:y fatty acids ★, CxOH alcohols ■ , Cx alkanes ▲ , aldehydes and amides ♦ , ketones ⬣ , **MAG** and **DAG** mono- and diacylglycerols, wax esters ● , plasticizers (cross).

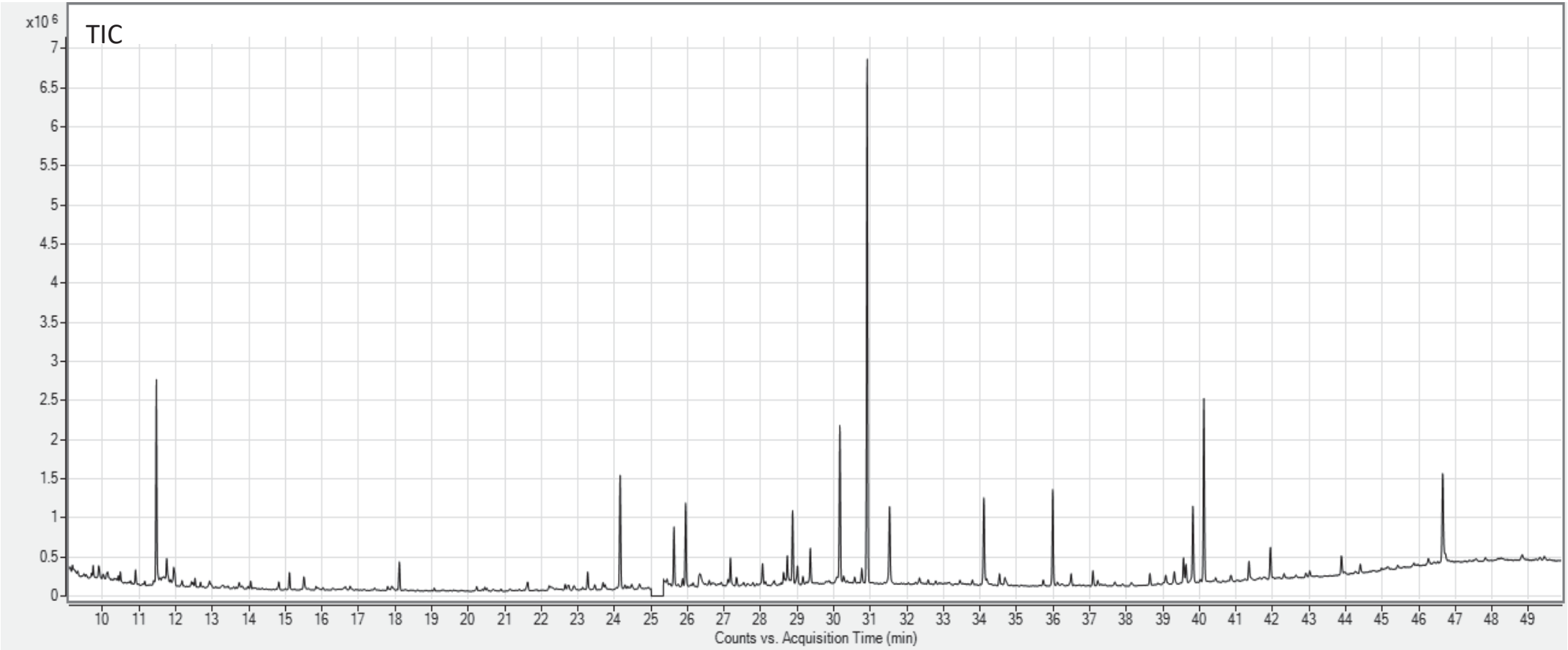


Fig. 147: Partial total ion chromatogram of the inner surface (BECS 2600) of Sample KM176– E176 (BECS 2599)

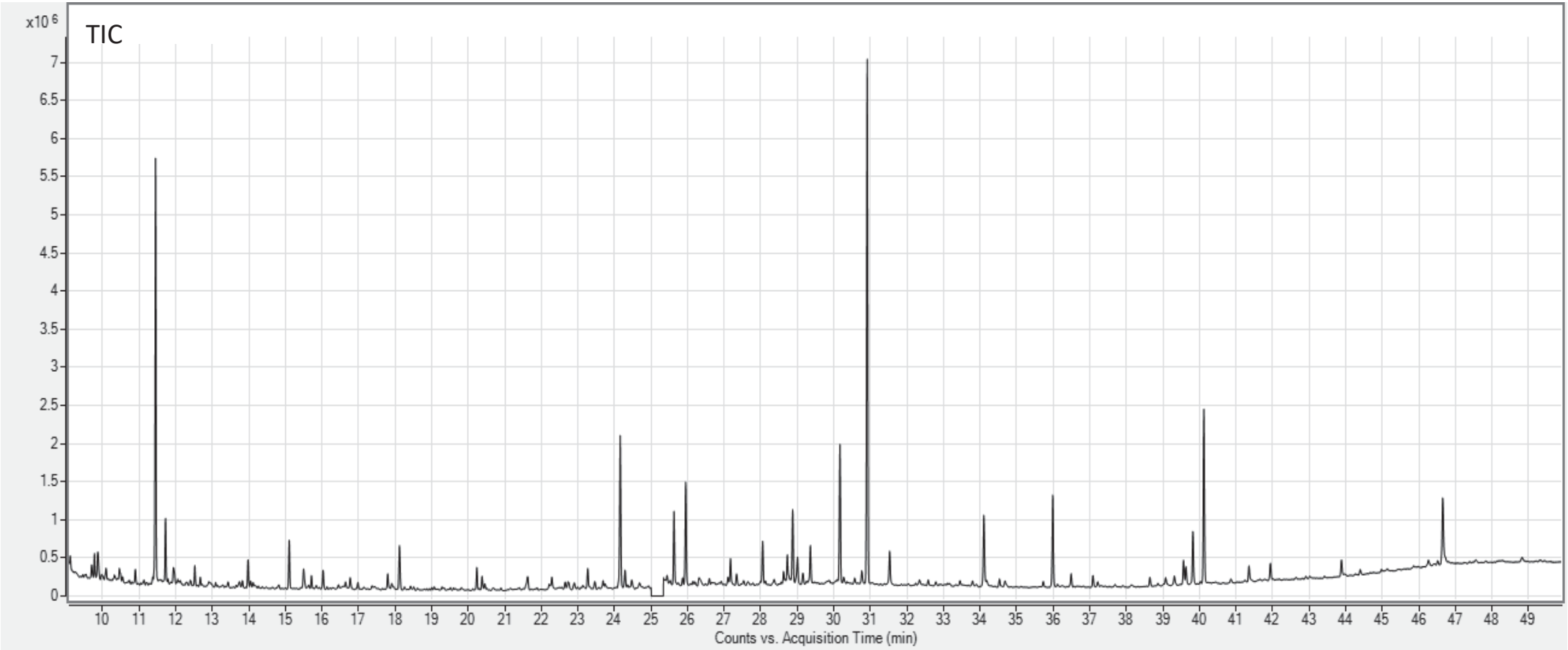


Fig. 148: Partial total ion chromatogram of the outer surface (BECS 2601) of Sample KM176– E176 (BECS 2599)

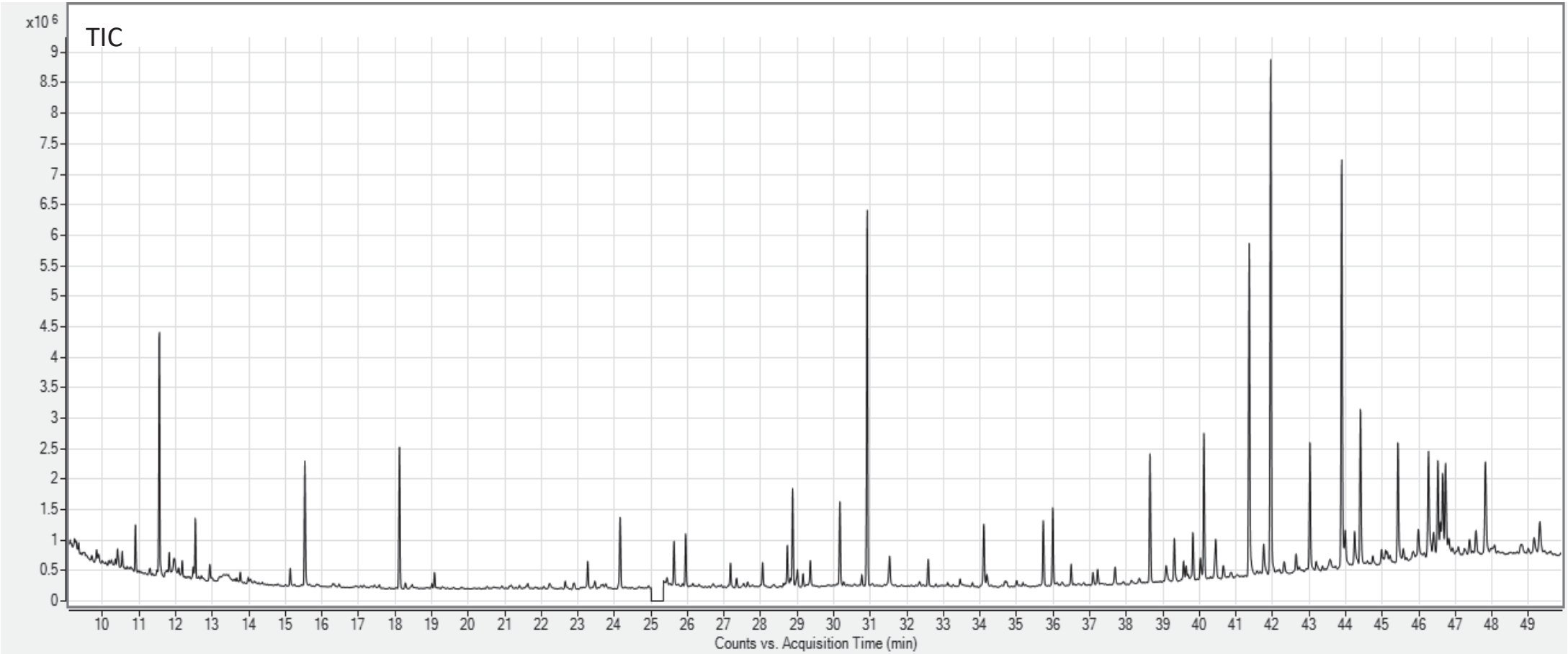


Fig. 149 : Partial total ion chromatogram of the soil sample (BECS 2598) associated with Sample KM176– E176 (BECS 2599)

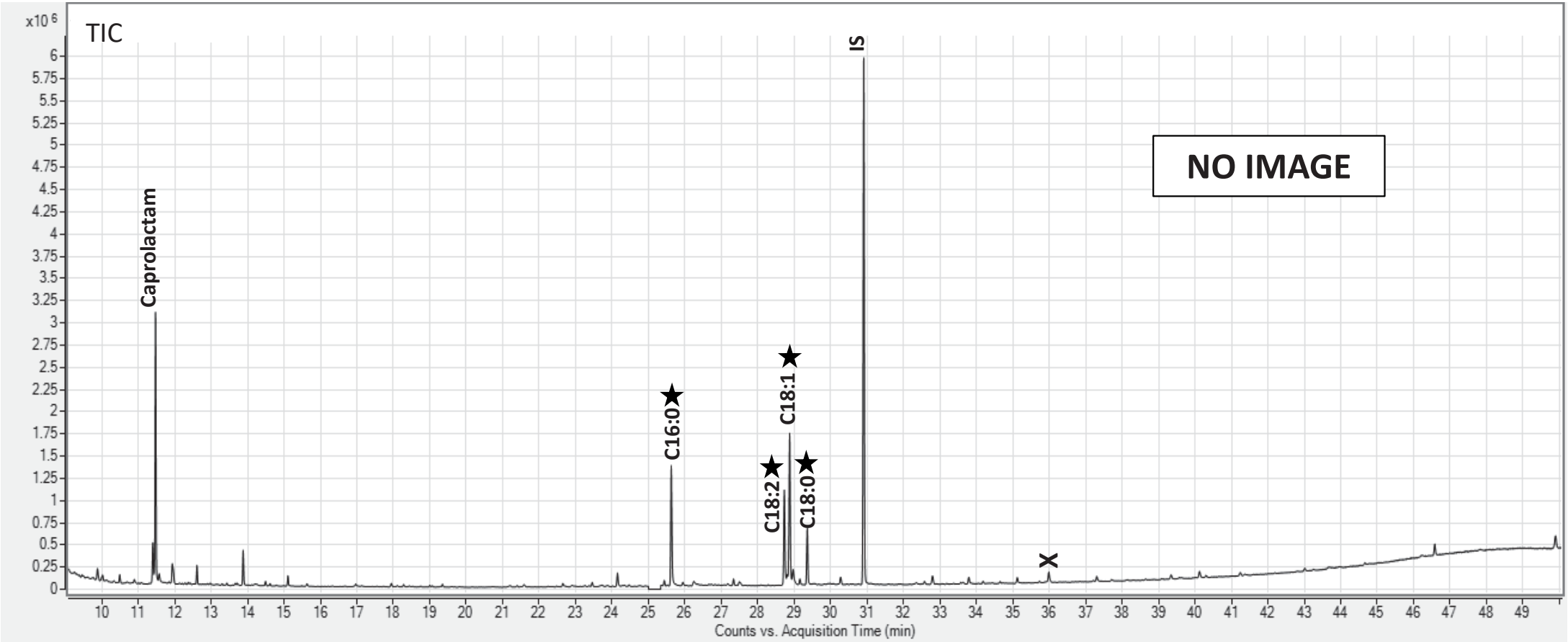


Fig. 150: Partial total ion chromatogram of Sample KM171– E171 (BECS 2720) of a Bowl in Trench V85 (Locus 105 Lot 1): Cx:y fatty acids ★, CxOH alcohols ■ , Cx alkanes ▲ , aldehydes and amides ♦ , ketones ⬣ , **MAG** and **DAG** mono- and diacylglycerols, wax esters ● , plasticizers (cross).

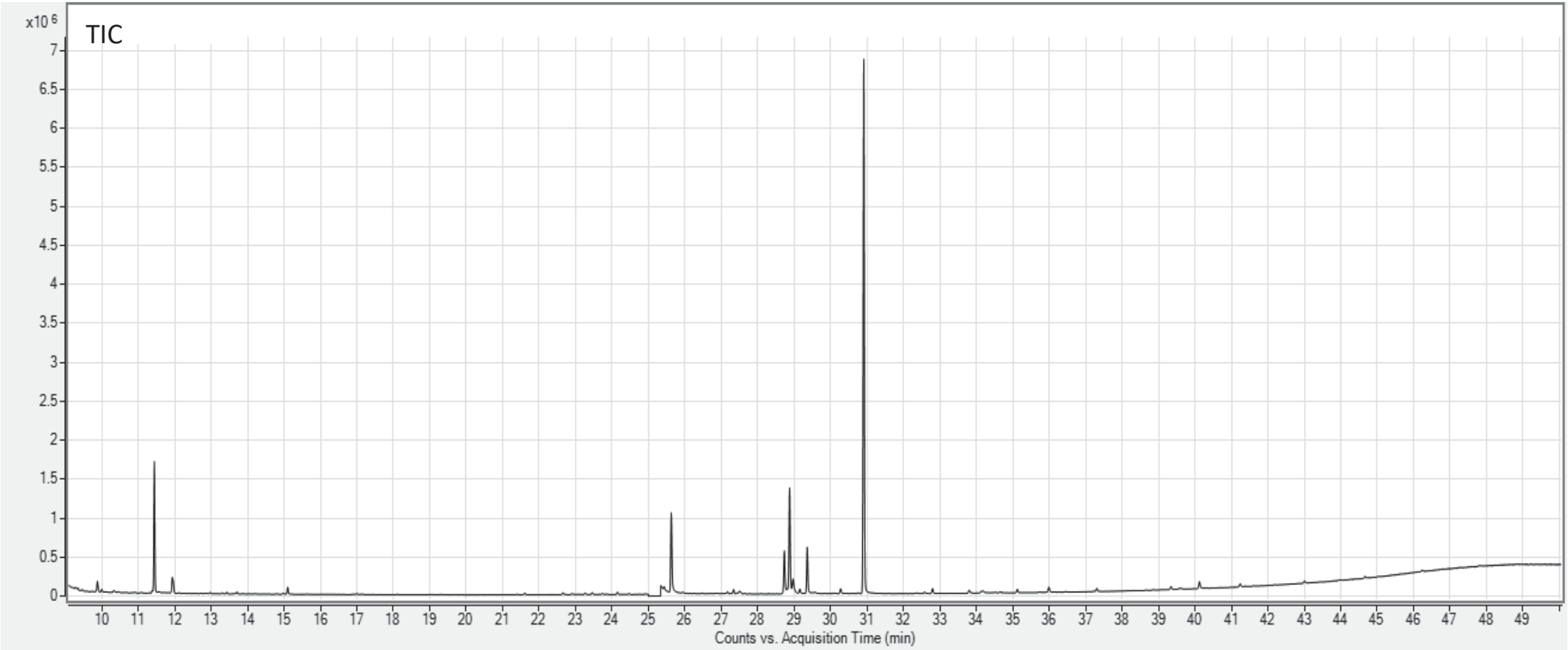


Fig. 151: Partial total ion chromatogram of the inner surface (BECS 2721) of Sample KM171– E171 (BECS 2720)

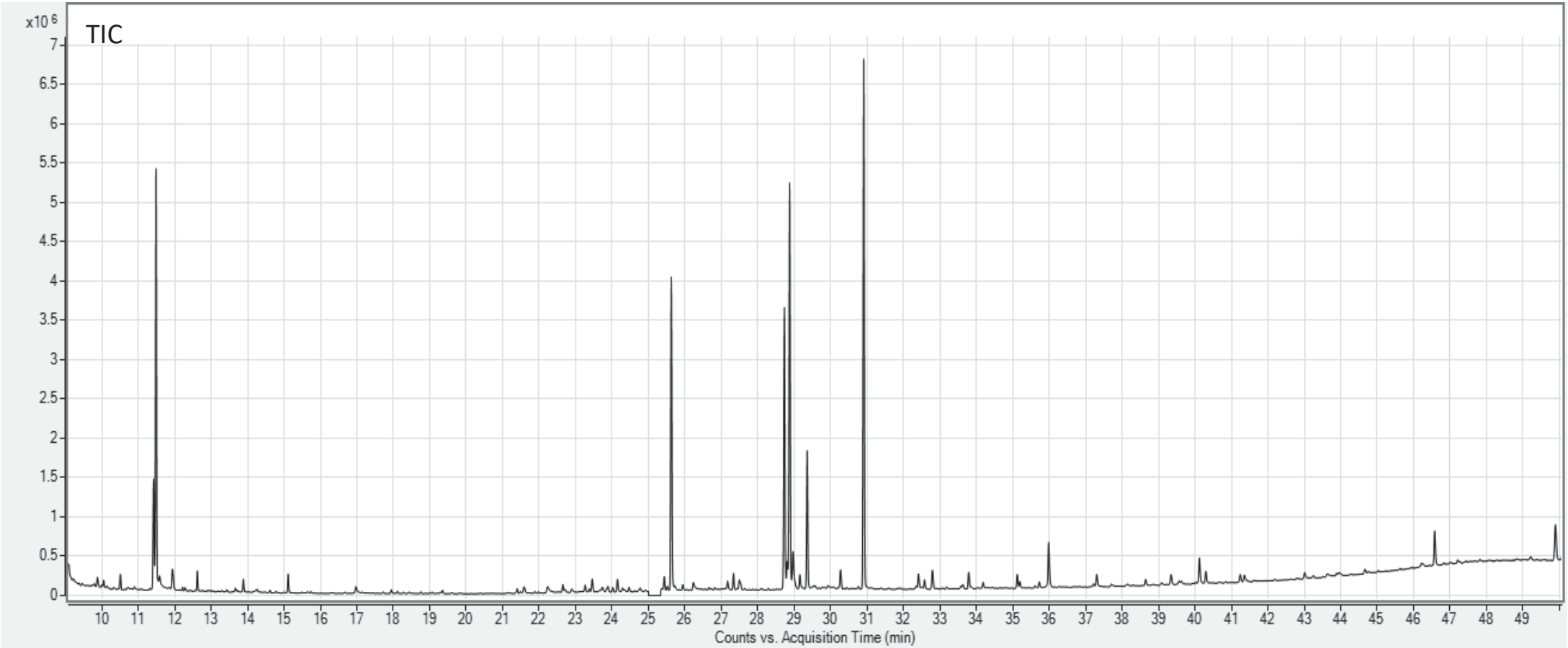


Fig. 152: Partial total ion chromatogram of the outer surface (BECS 2722) of Sample KM171– E171 (BECS 2720)

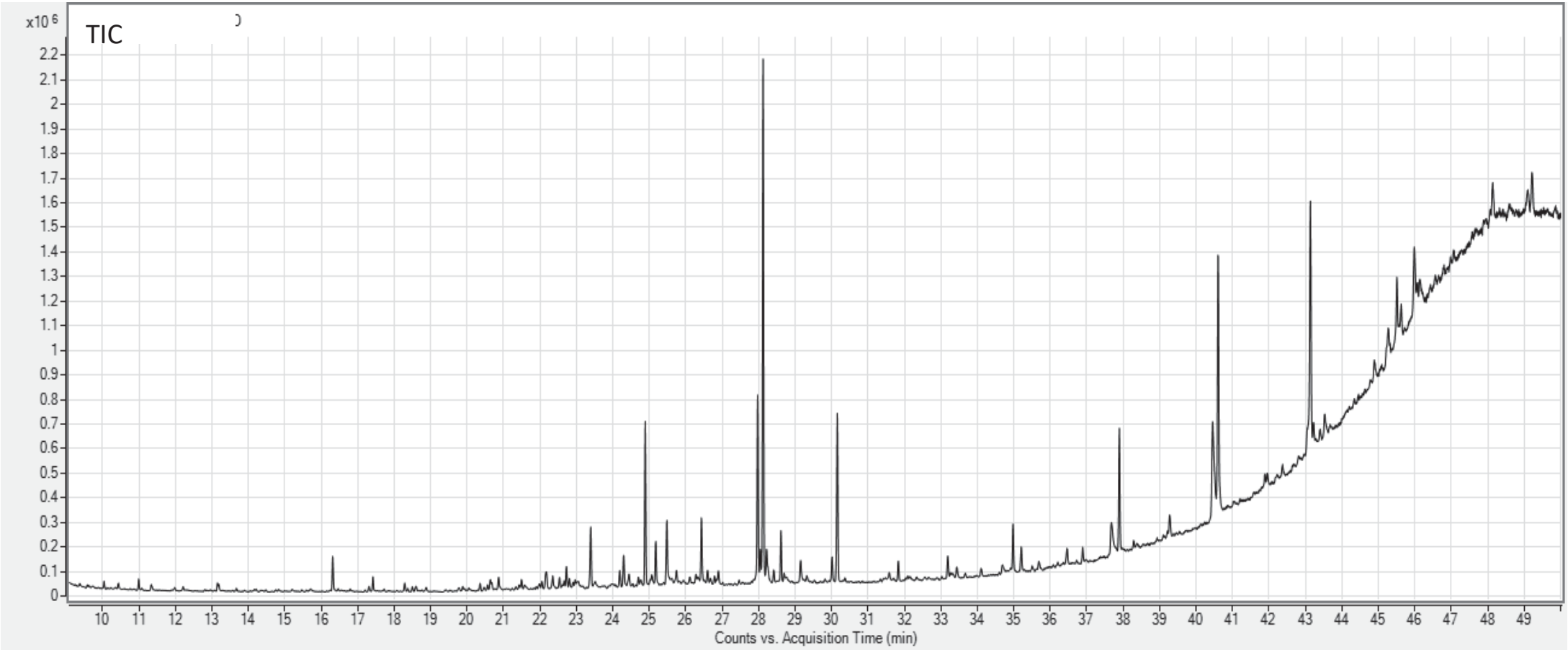


Fig. 153: Partial total ion chromatogram of the soil sample (BECS 2335) associated with Sample KM171– E171 (BECS 2720)

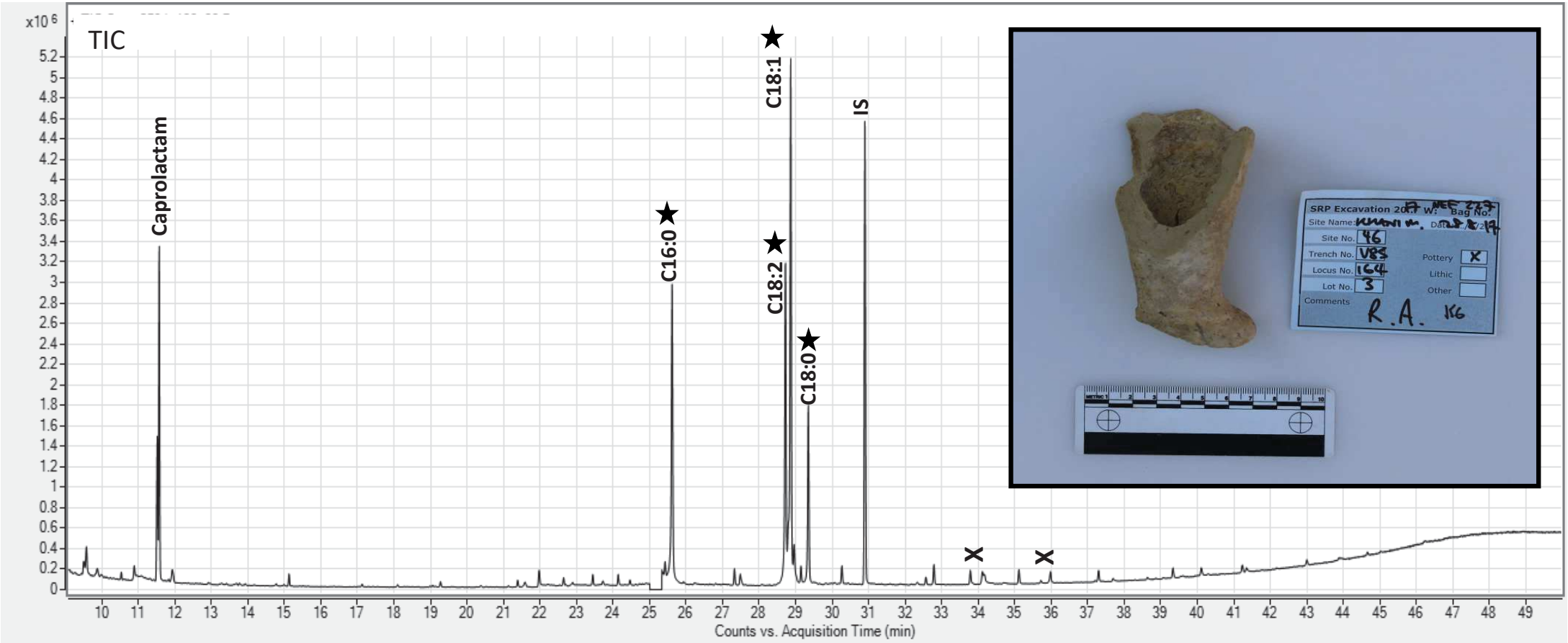


Fig. 154 : Partial total ion chromatogram of Sample KM121– E121 (BECS 2594) of a Kassite goblet in Trench V85 (Locus 164 Lot 3): Cx:y fatty acids ★, CxOH alcohols ■ , Cx alkanes ▲ , aldehydes and amides ♦ , ketones ⬣ , **MAG** and **DAG** mono- and diacylglycerols, wax esters ● , plasticizers (cross).

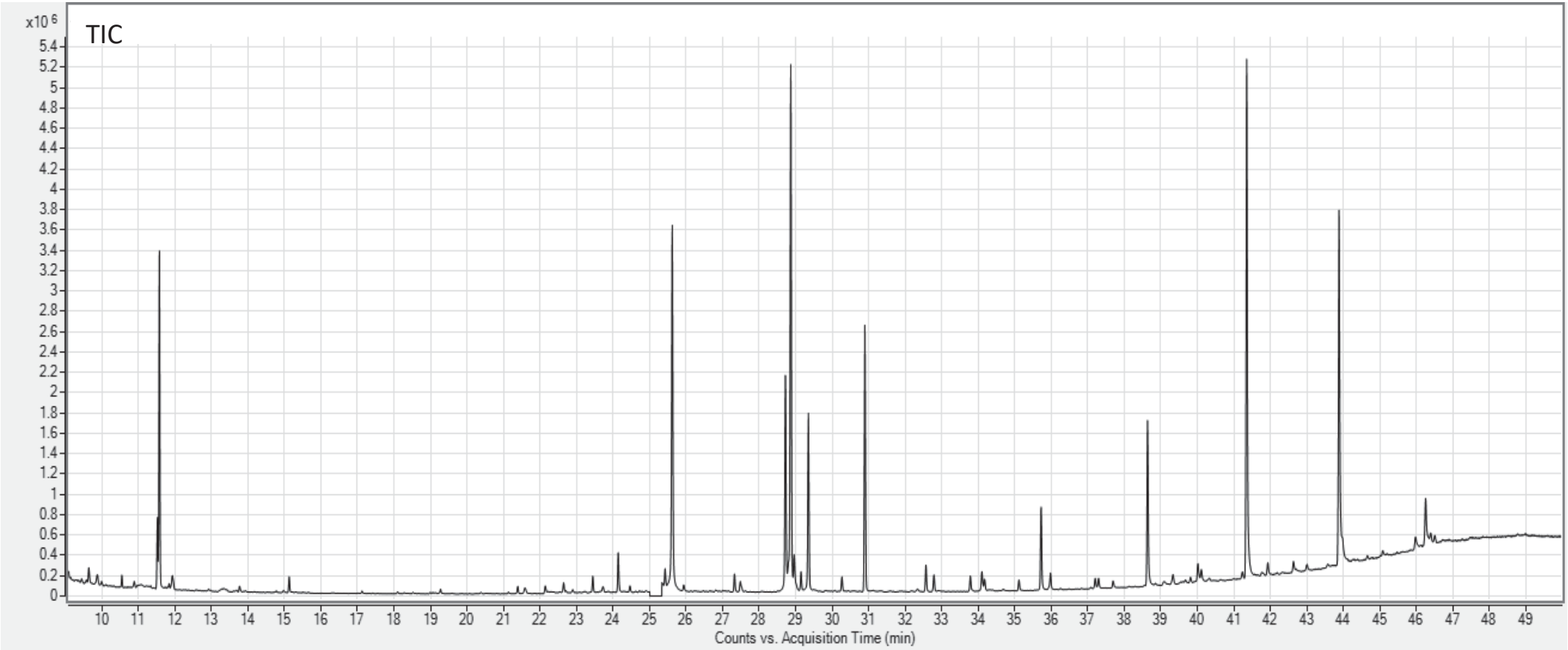


Fig. 155 : Partial total ion chromatogram of the inner surface (BECS 2595) of Sample KM121– E121 (BECS 2594)

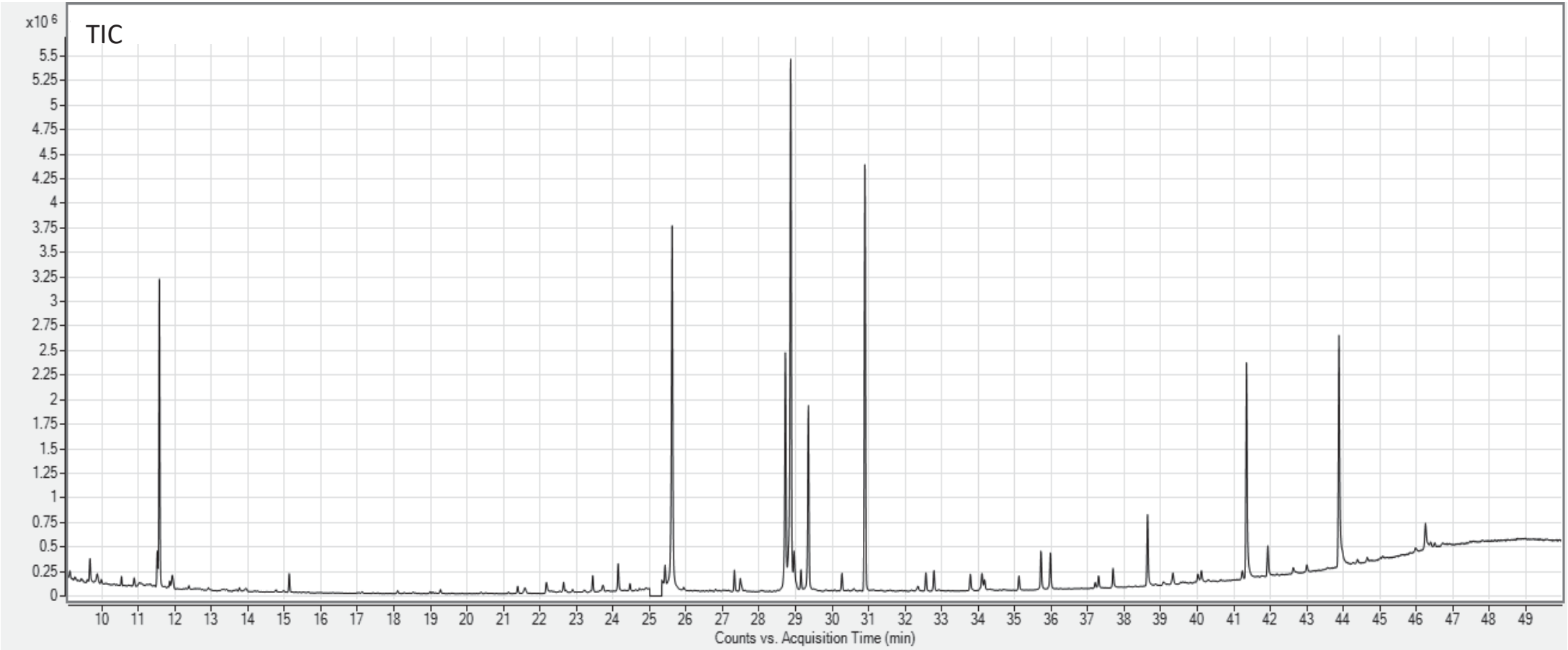


Fig. 156 : Partial total ion chromatogram of the outer surface (BECS 2596) of Sample KM121– E121 (BECS 2594)

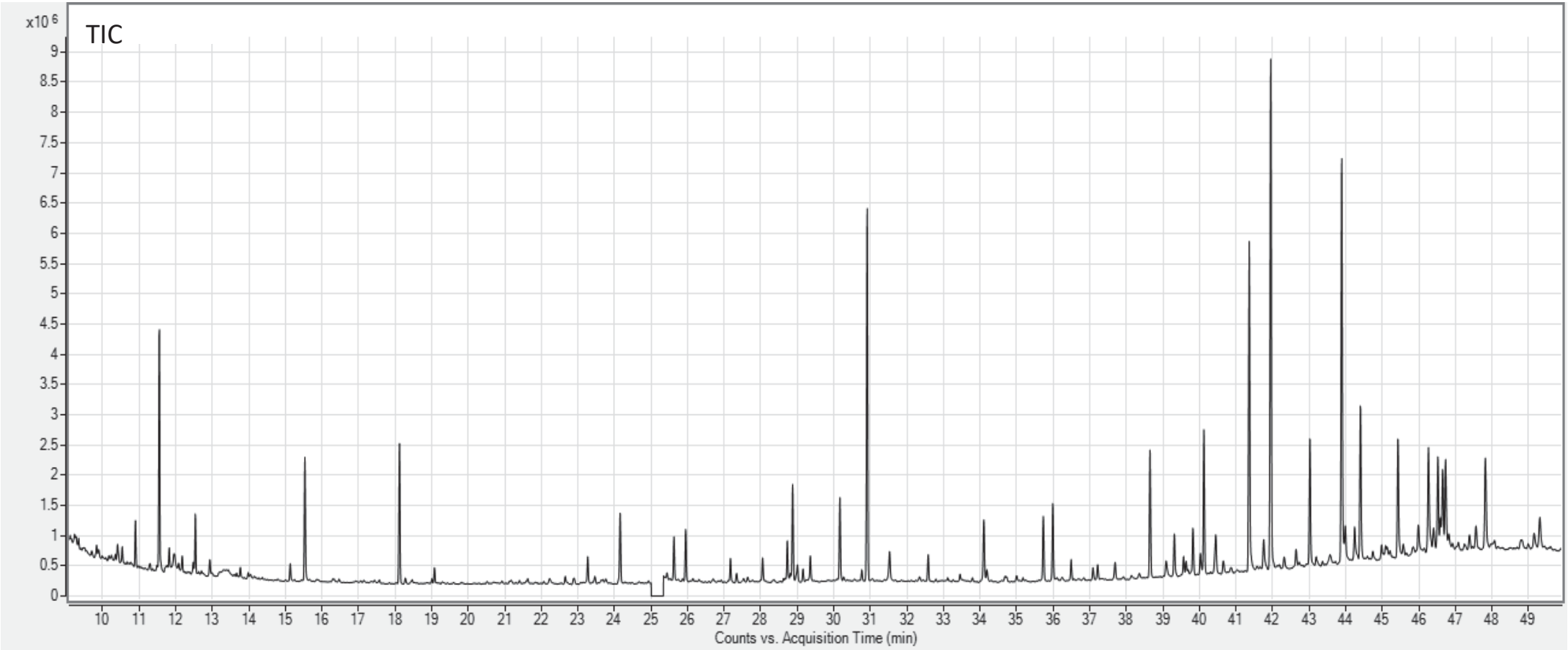


Fig. 157: Partial total ion chromatogram of the soil sample (BECS 2598) associated with Sample KM121– E121 (BECS 2594)

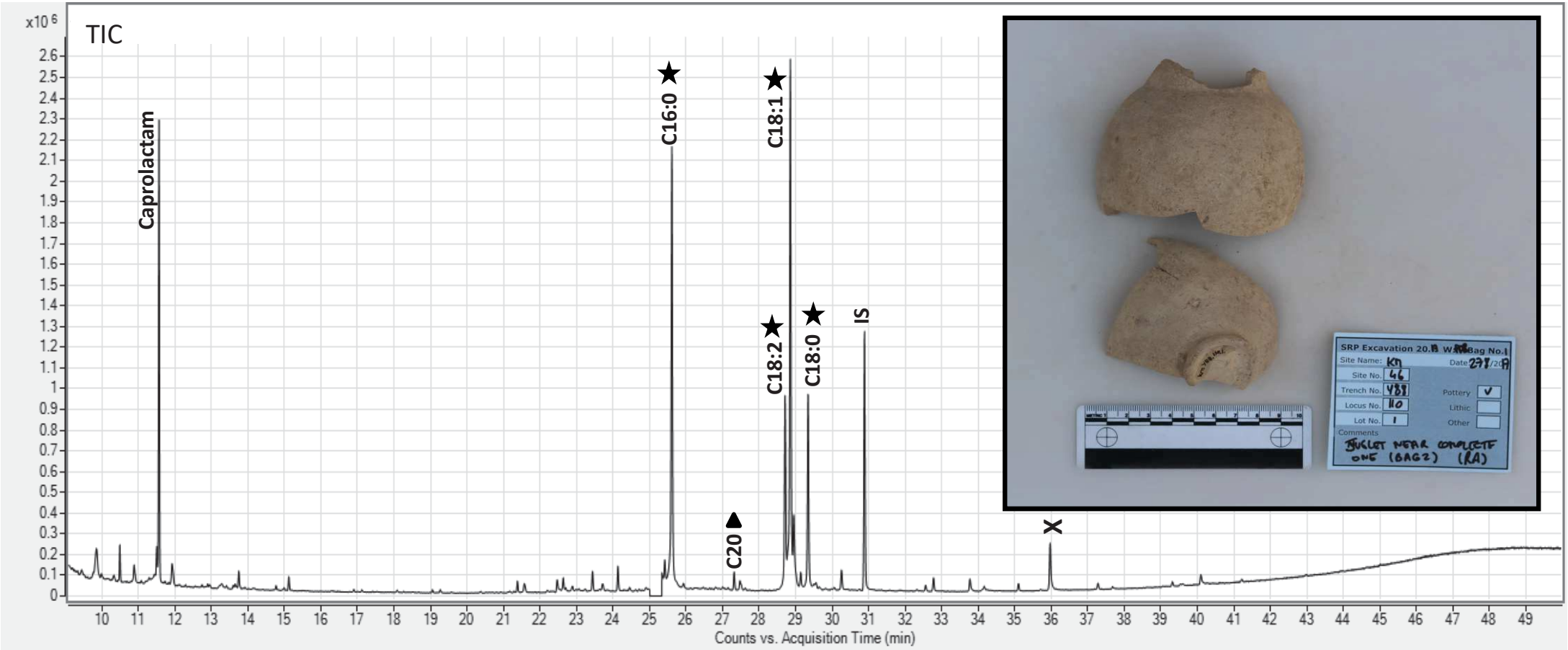


Fig. 158: Partial total ion chromatogram of Sample KM200– E200 (BECS 2813) of a Juglet in Trench Y88 (Locus 110 Lot 1): Cx:y fatty acids ★, CxOH alcohols ■ , Cx alkanes ▲ , aldehydes and amides ♦ , ketones ⬣ , **MAG** and **DAG** mono- and diacylglycerols, wax esters ● , plasticizers (cross).

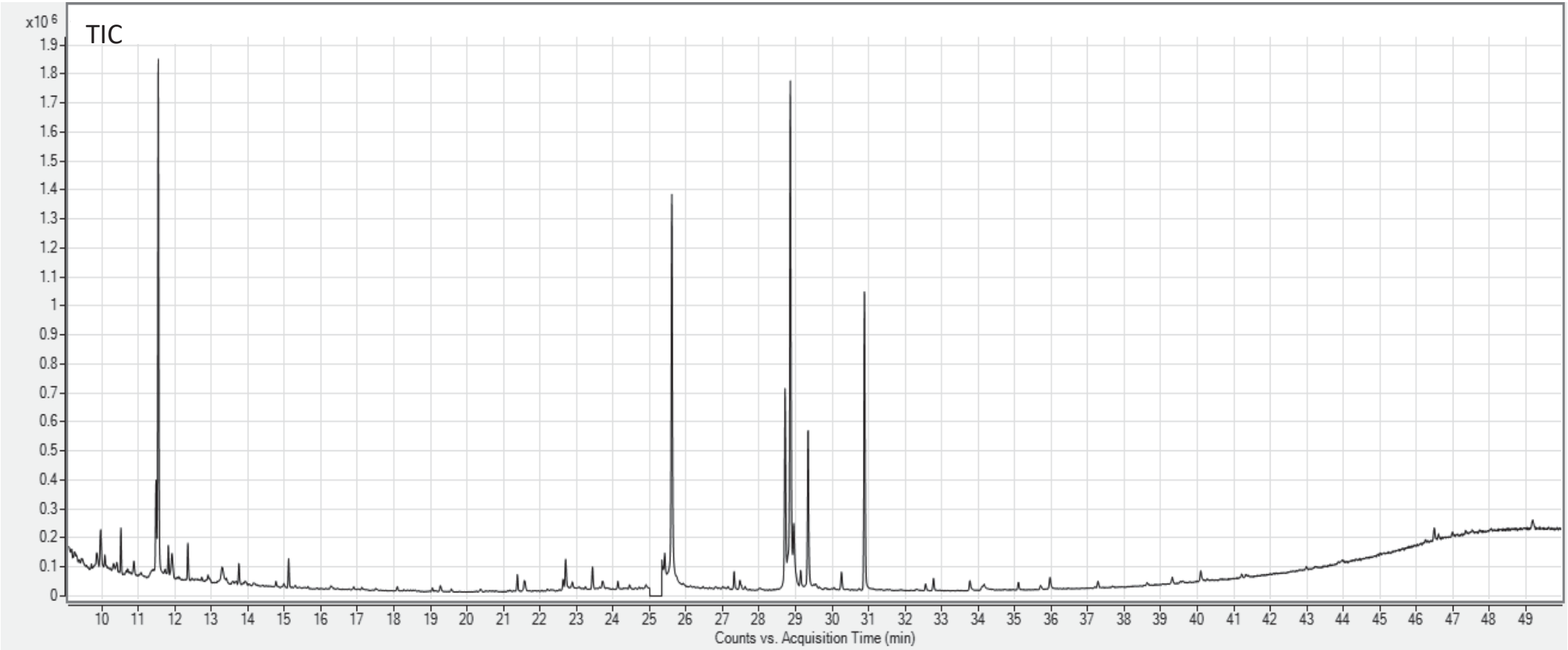


Fig. 159 : Partial total ion chromatogram of the inner surface (BECS 2814) of Sample KM200– E200 (BECS 2813)

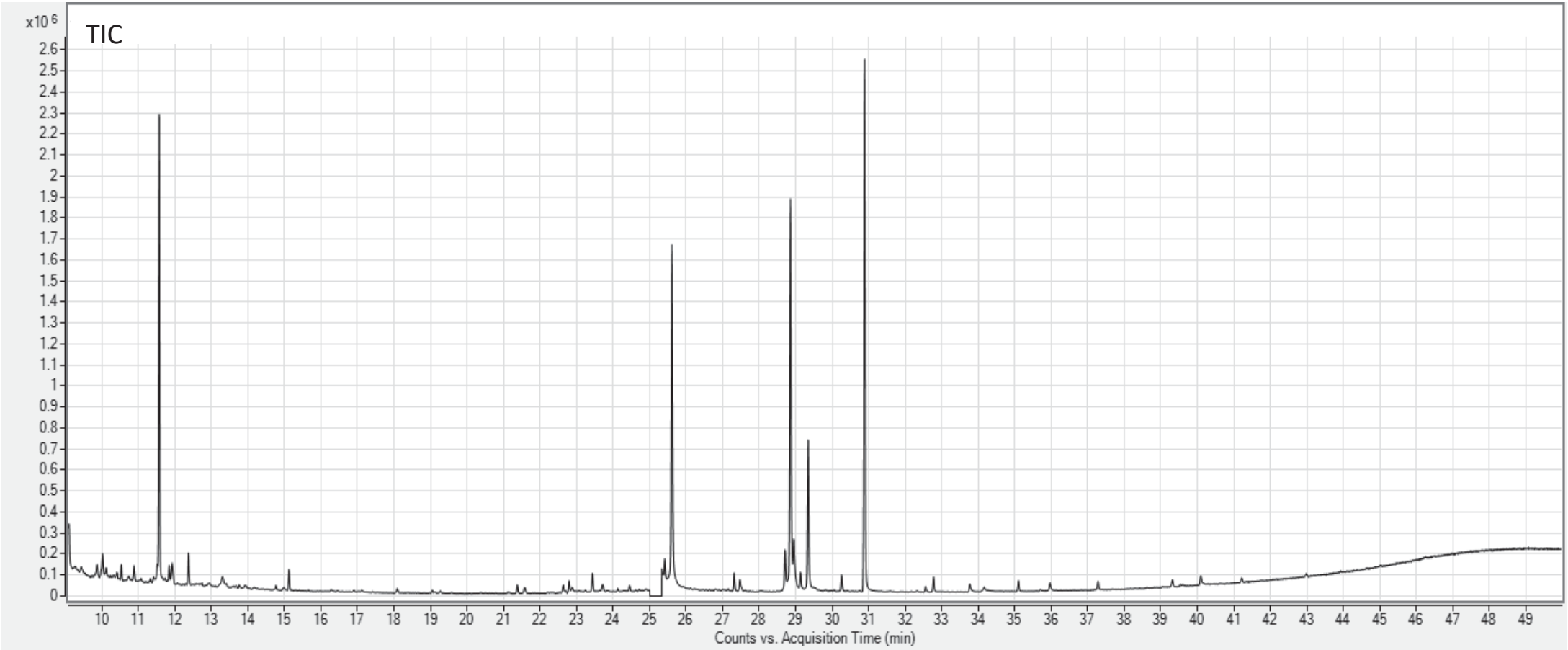


Fig. 160: Partial total ion chromatogram of the outer surface (BECS 2815) of Sample KM200– E200 (BECS 2813)

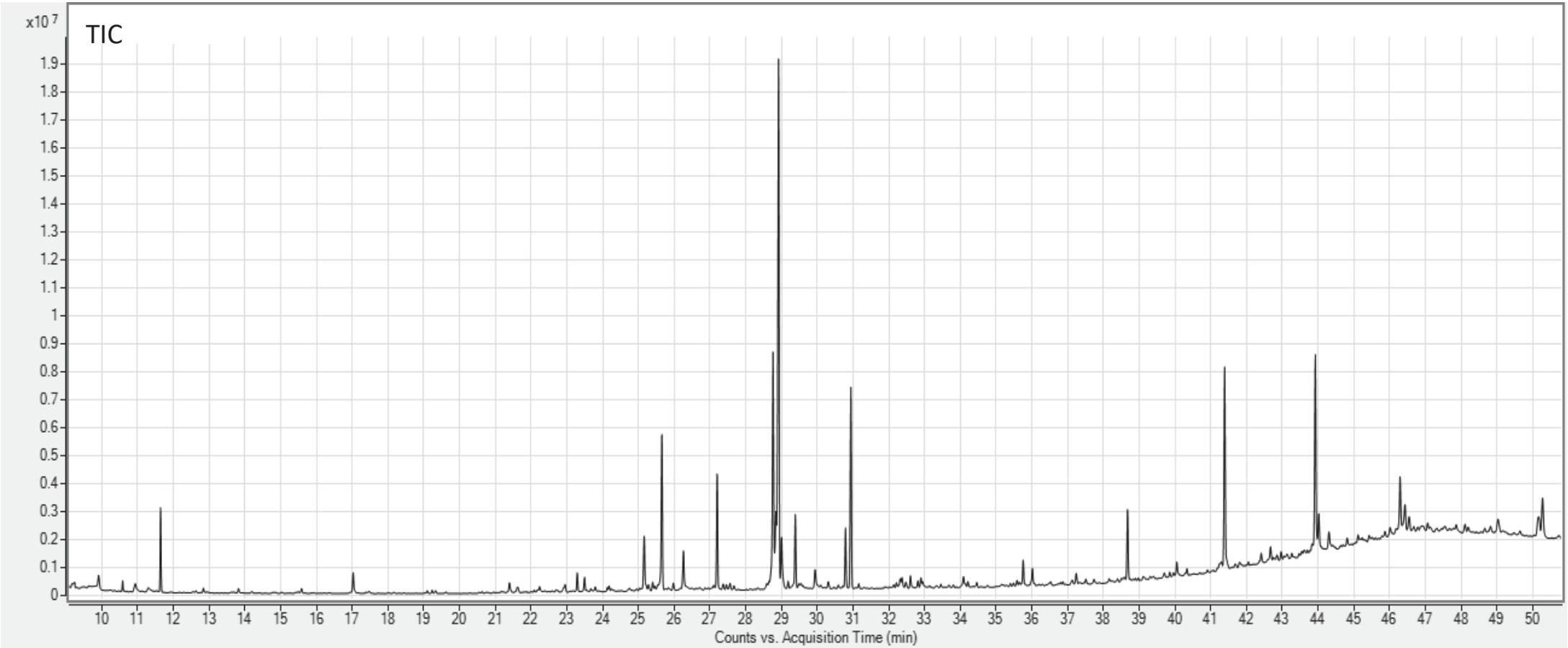


Fig. 161: Partial total ion chromatogram of the soil sample (BECS 2323) associated with Sample KM200– E200 (BECS 2813)

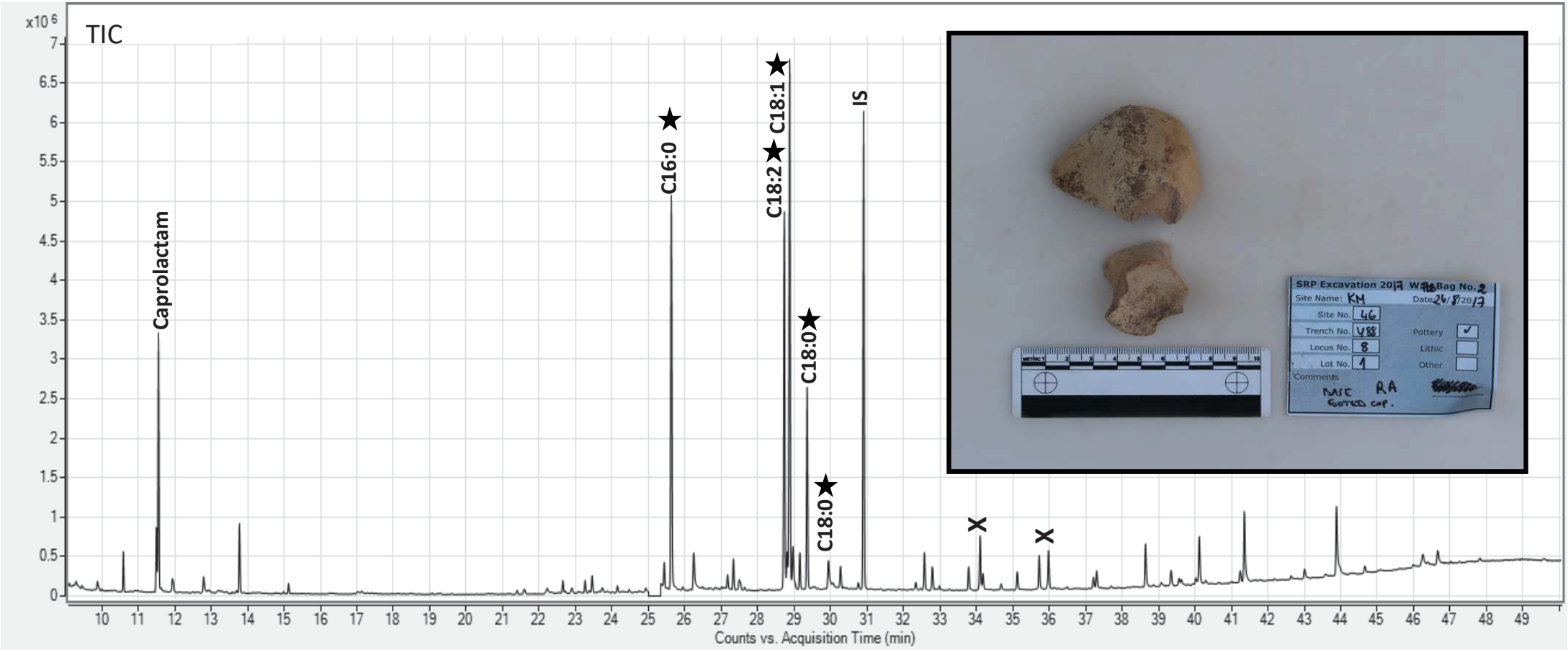


Fig. 162: Partial total ion chromatogram of Sample KM175– E175 (BECS 2728) of a cup in Trench Y88 (Locus 108 Lot 1): Cx:y fatty acids ★, CxOH alcohols ■ , Cx alkanes ▲ , aldehydes and amides ♦ , ketones ⬣ , **MAG** and **DAG** mono- and diacylglycerols, wax esters ● , plasticizers (cross).

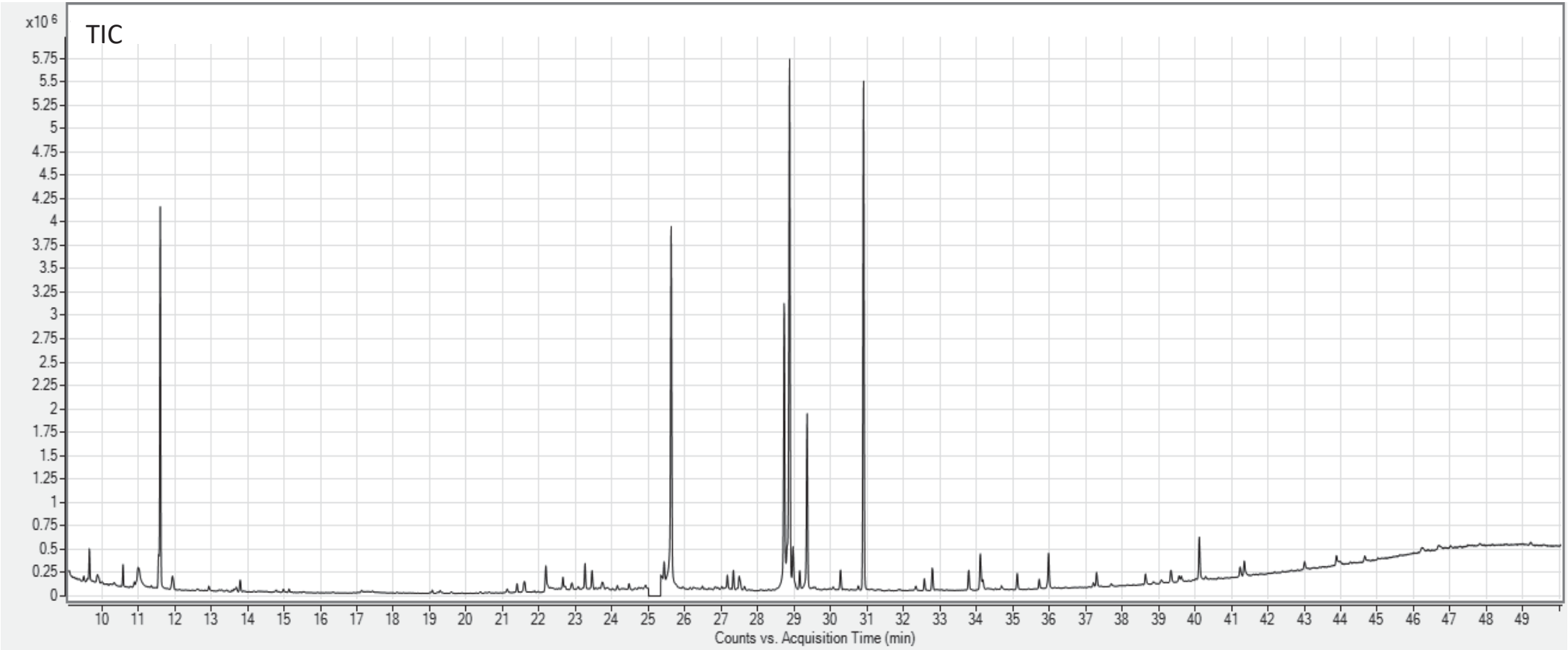


Fig. 163 : Partial total ion chromatogram of the inner surface (BECS 2729) of Sample KM175– E175 (BECS 2728)

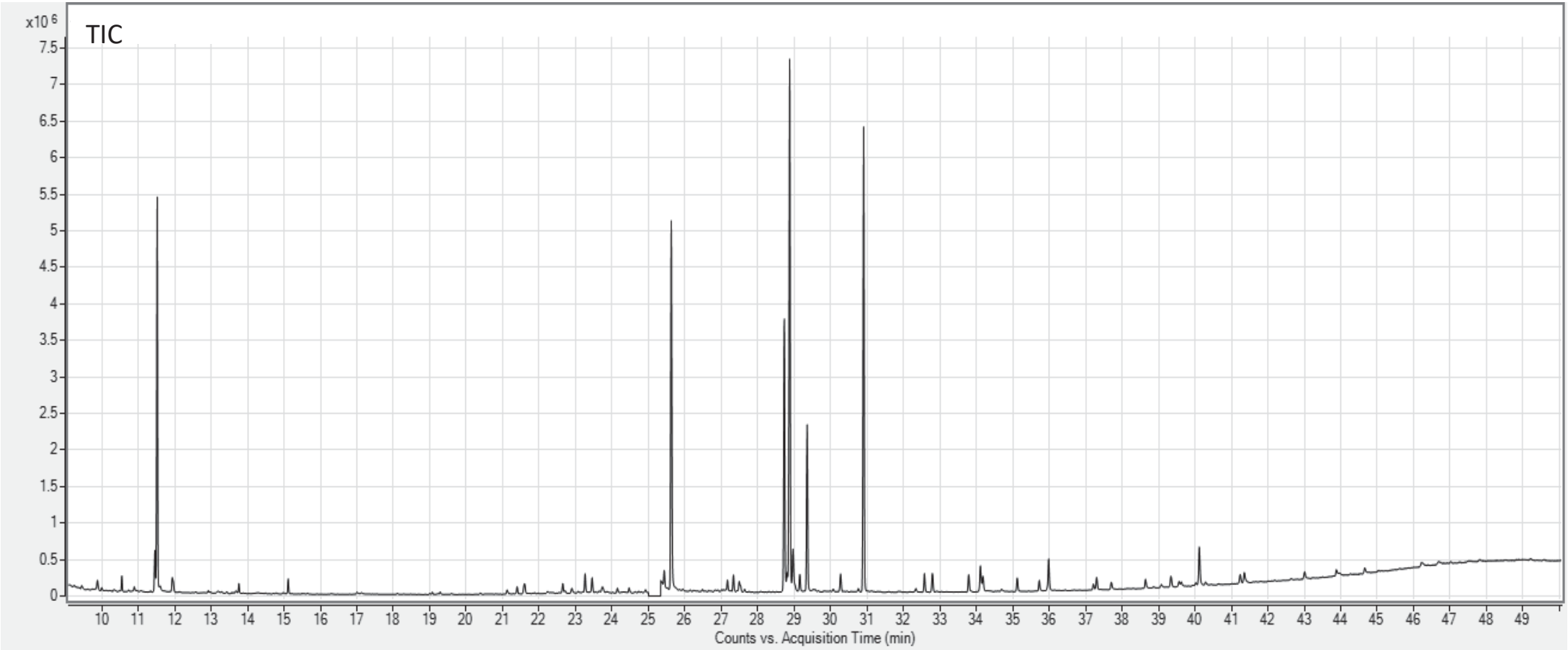


Fig. 164 : Partial total ion chromatogram of the outer surface (BECS 2730) of Sample KM175– E175 (BECS 2728)

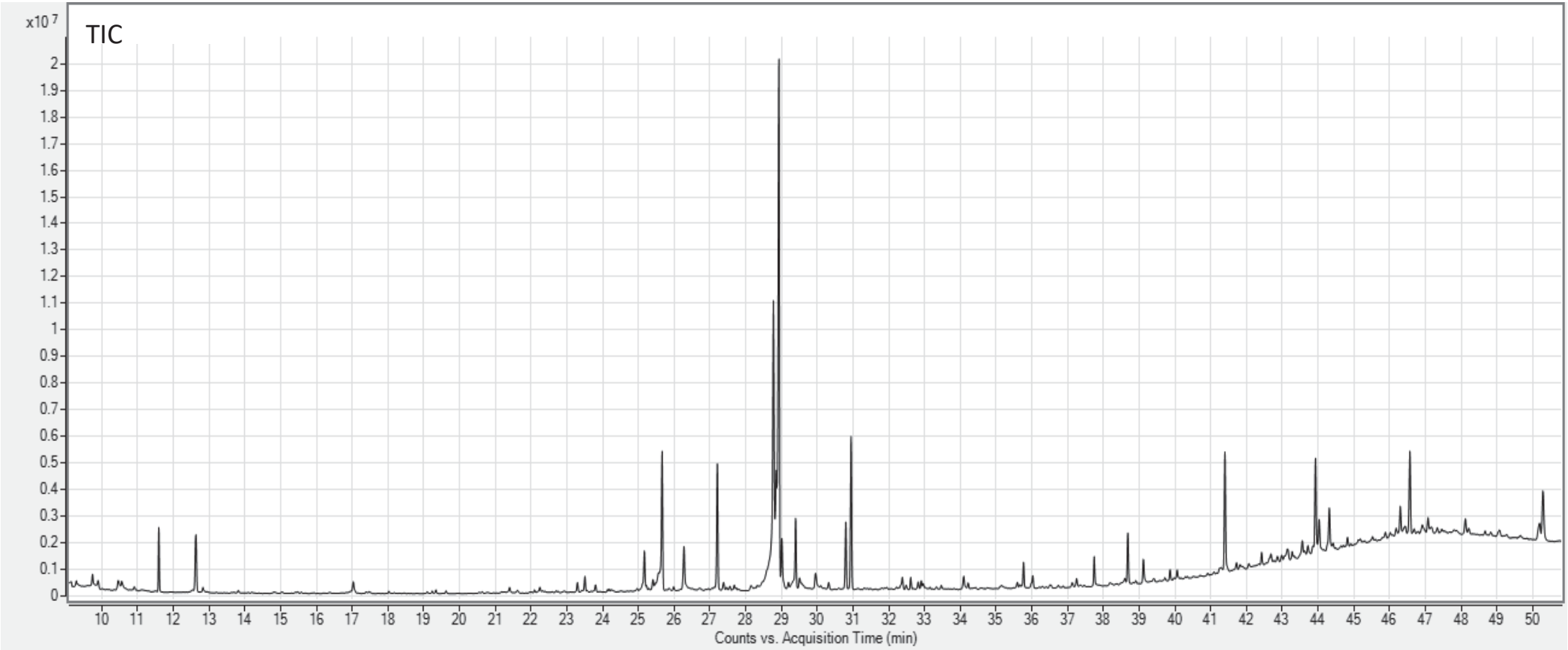


Fig. 165 : Partial total ion chromatogram of the soil sample (BECS 2312) associated with Sample KM175– E175 (BECS 2728)

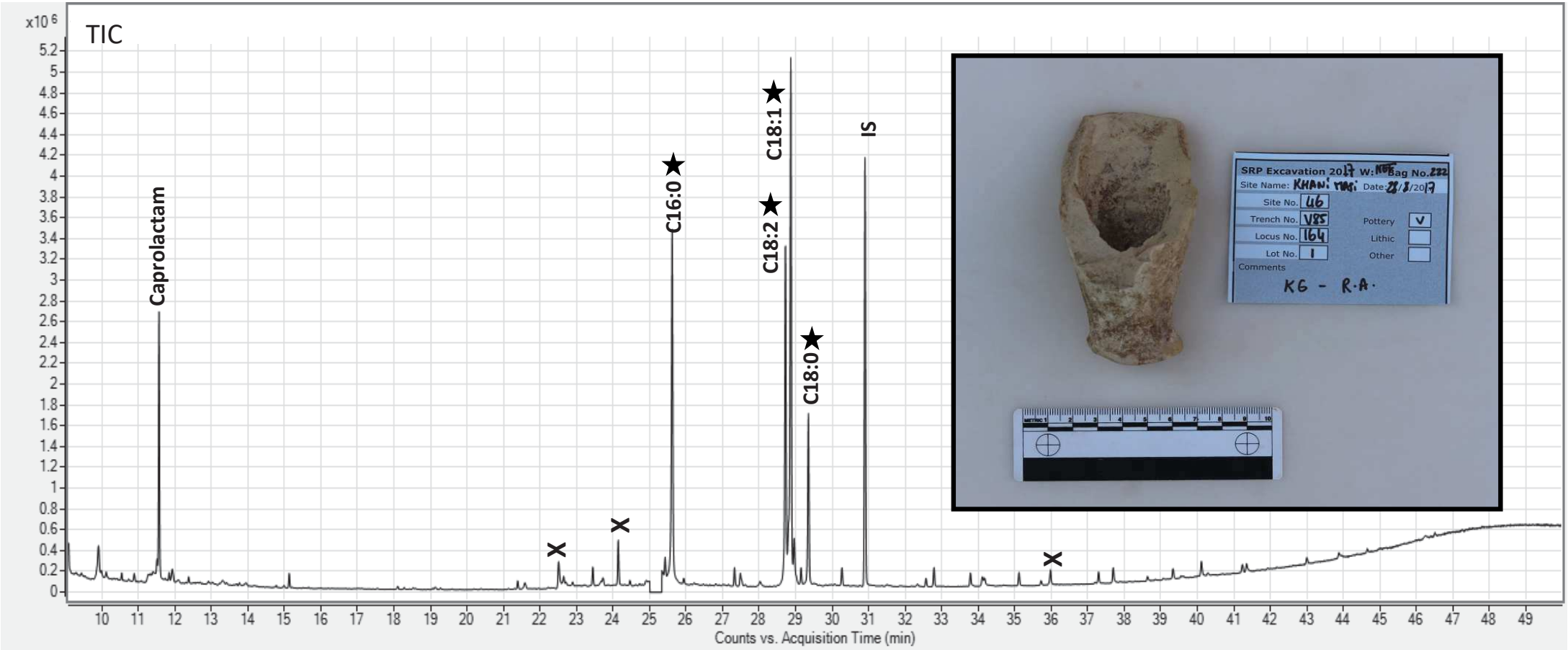


Fig. 166: Partial total ion chromatogram of Sample KM182– E182 (BECS 2591) of a Kassite goblet in Trench V85 (Locus 164 Lot 1): Cx:y fatty acids ★, CxOH alcohols ■ , Cx alkanes ▲ , aldehydes and amides ♦ , ketones ⬣ , **MAG** and **DAG** mono- and diacylglycerols, wax esters ● , plasticizers (cross).

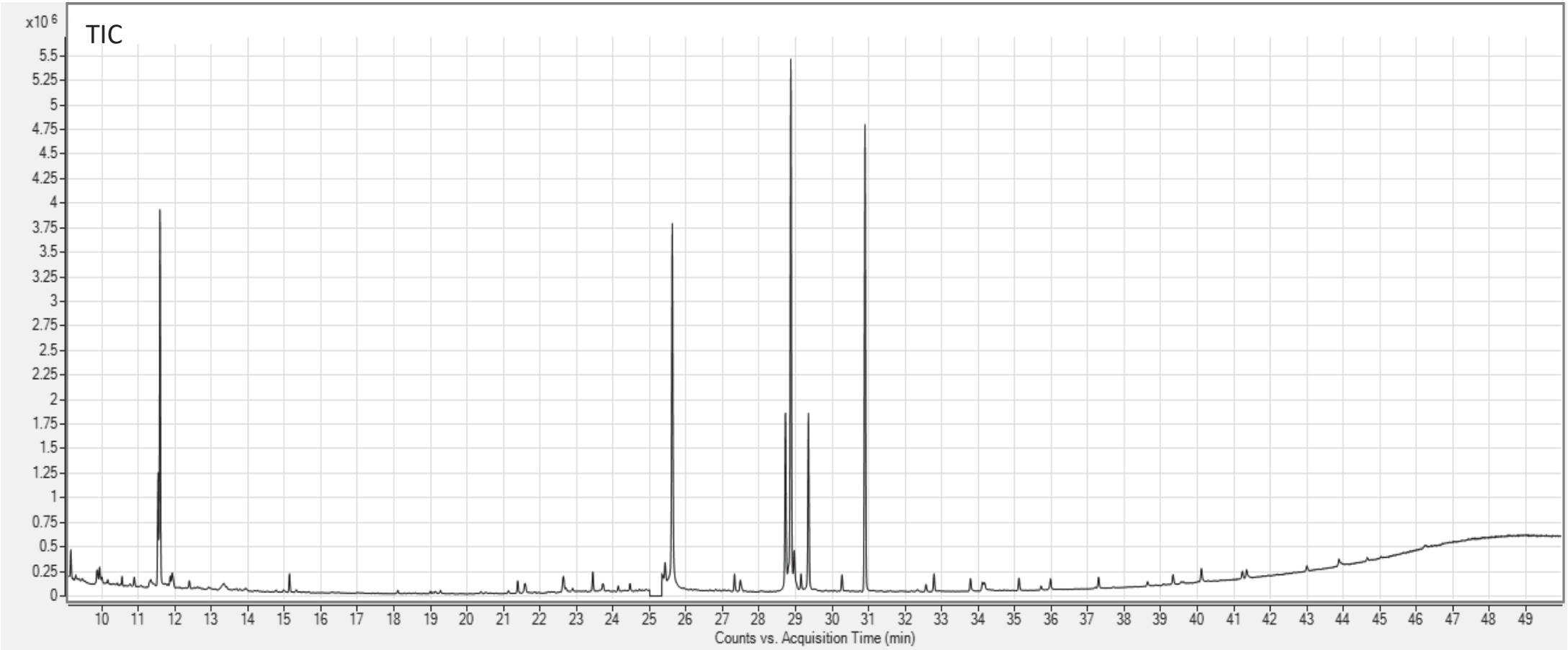


Fig. 167: Partial total ion chromatogram of the inner surface (BECS 2592) of Sample KM182– E182 (BECS 2591)

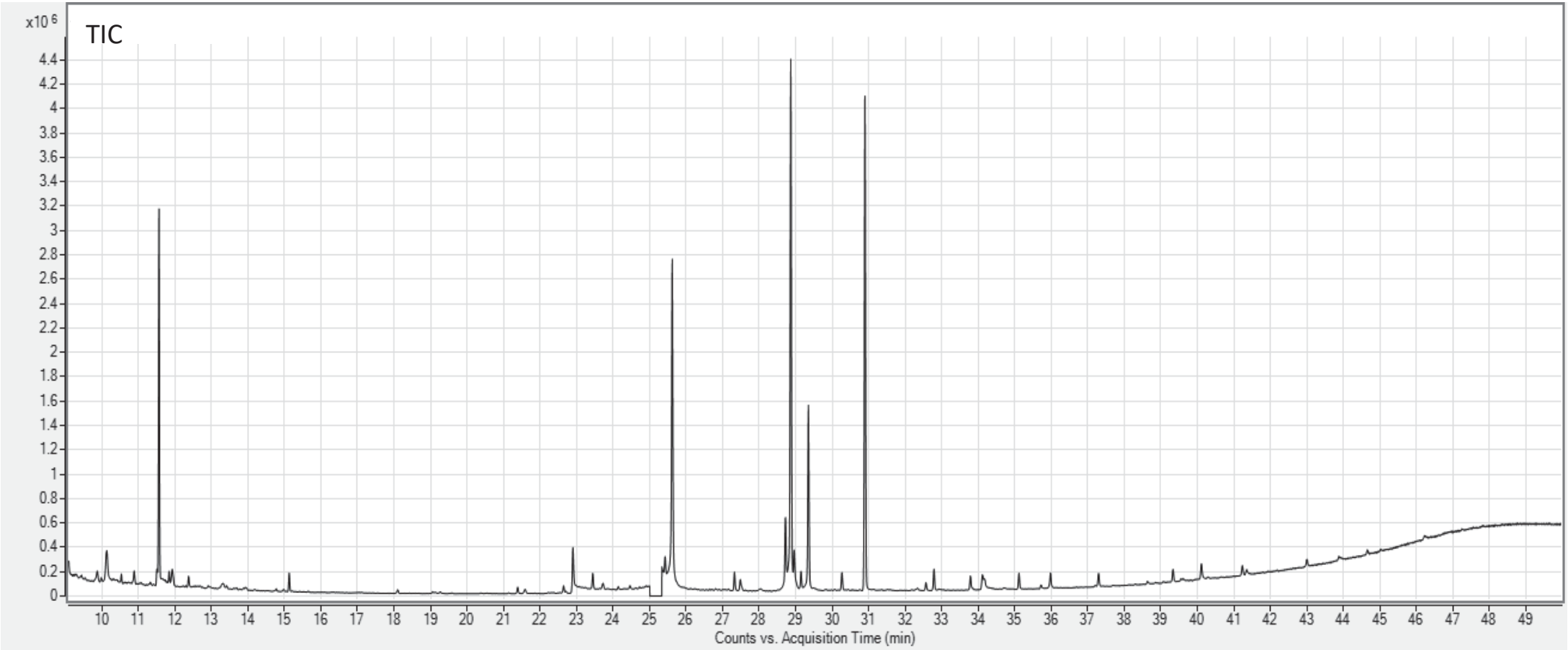


Fig. 168: Partial total ion chromatogram of the outer surface (BECS 2593) of Sample KM182– E182 (BECS 2591)

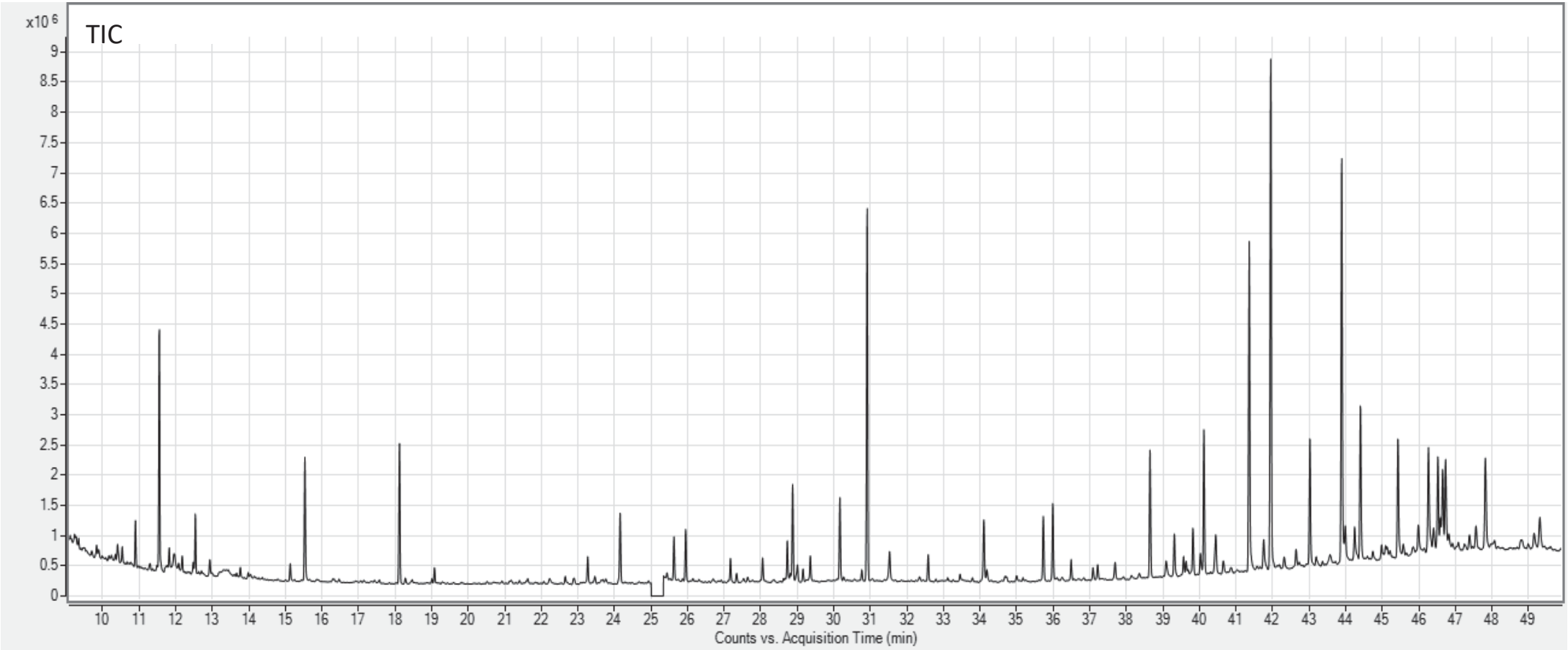


Fig. 169 : Partial total ion chromatogram of the soil sample (BECS 2598) associated with Sample KM182– E182 (BECS 2591)

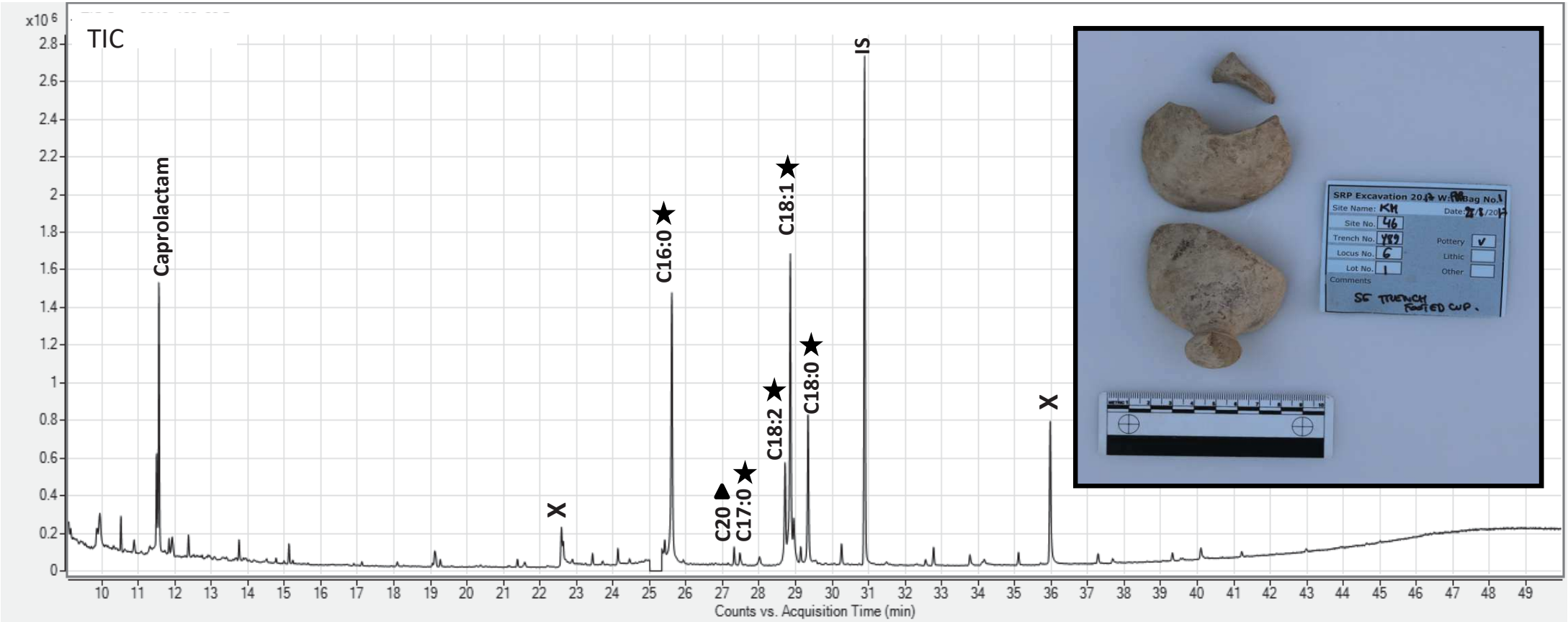


Fig. 170: Partial total ion chromatogram of Sample KM170– E170 (BECS 2810) of a cup in Trench Y89 (Locus 6 Lot 1): Cx:y fatty acids ★, CxOH alcohols ■ , Cx alkanes ▲ , aldehydes and amides ♦ , ketones ● , **MAG** and **DAG** mono- and diacylglycerols, wax esters ● , plasticizers (cross).

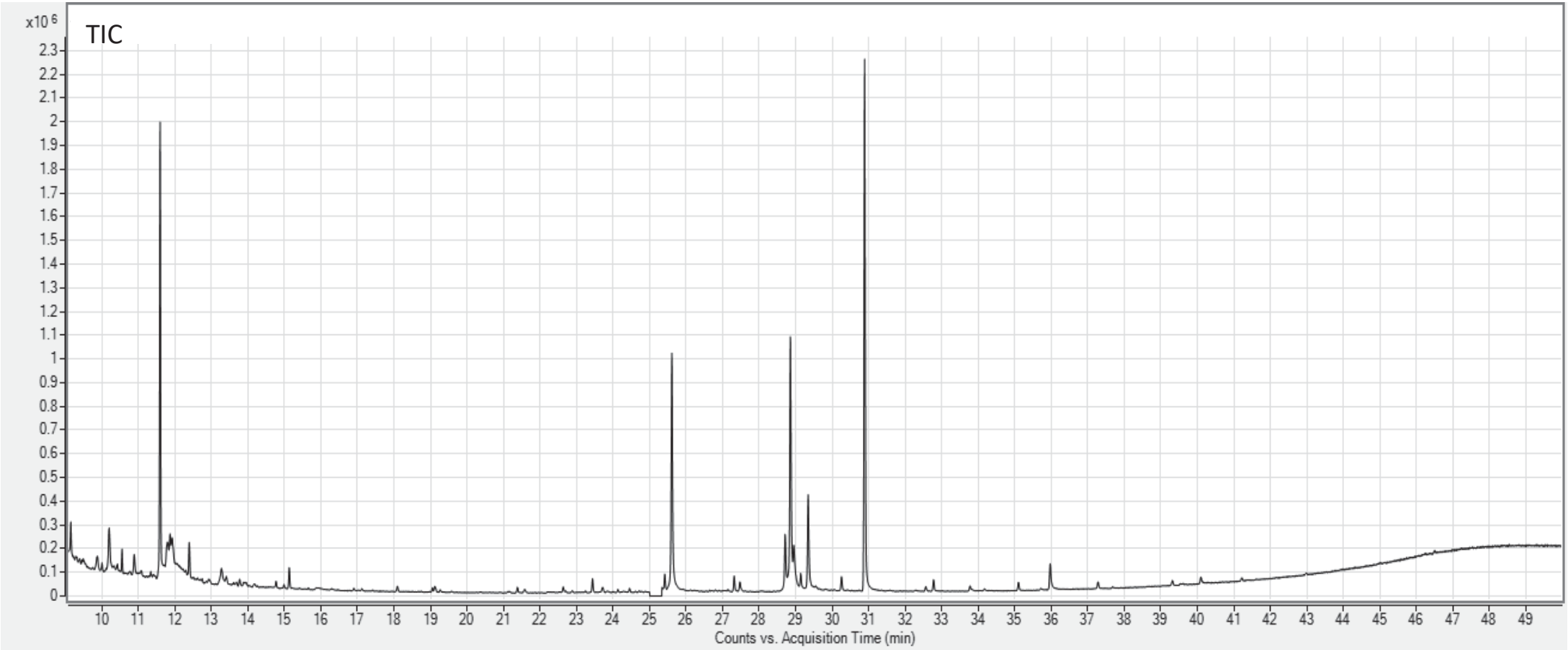


Fig. 171: Partial total ion chromatogram of the inner surface (BECS 2811) of Sample KM170– E170 (BECS 2810)

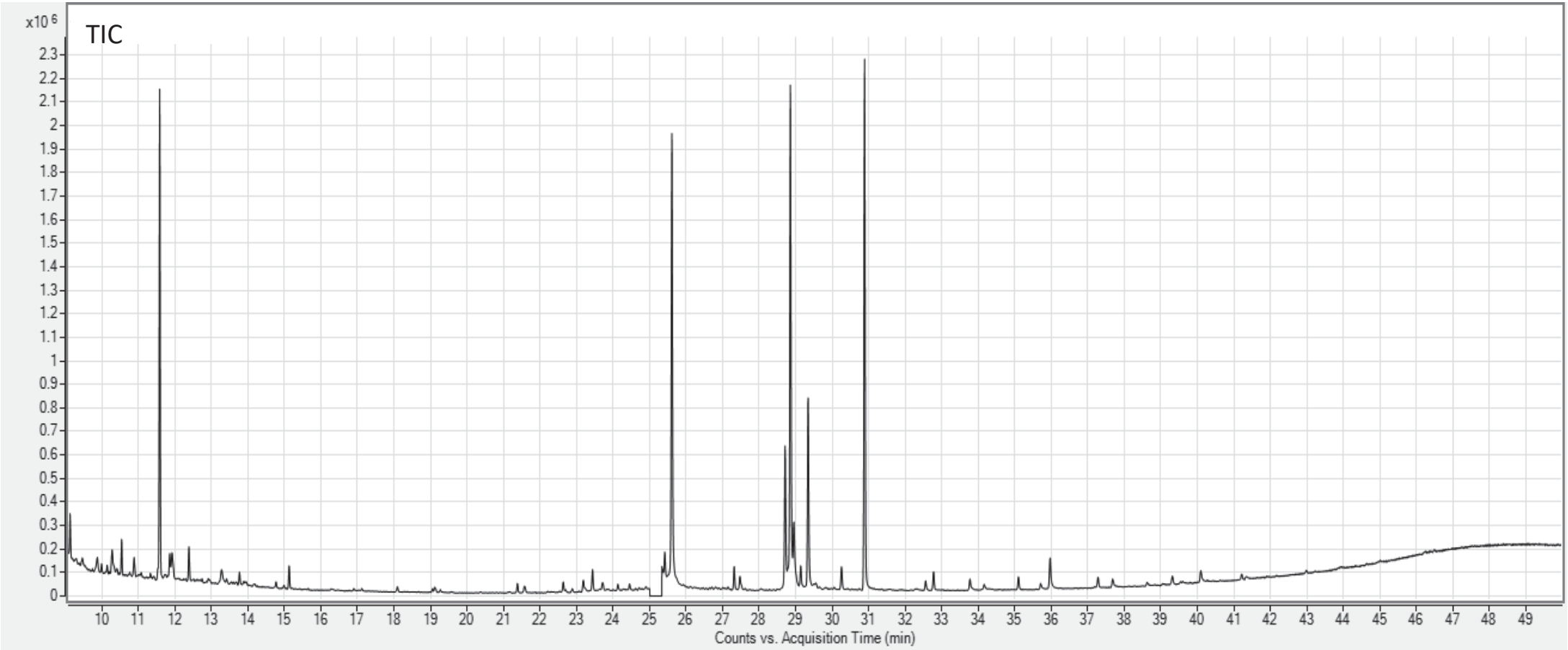


Fig. 172 : Partial total ion chromatogram of the outer surface (BECS 2812) of Sample KM170– E170 (BECS 2810)

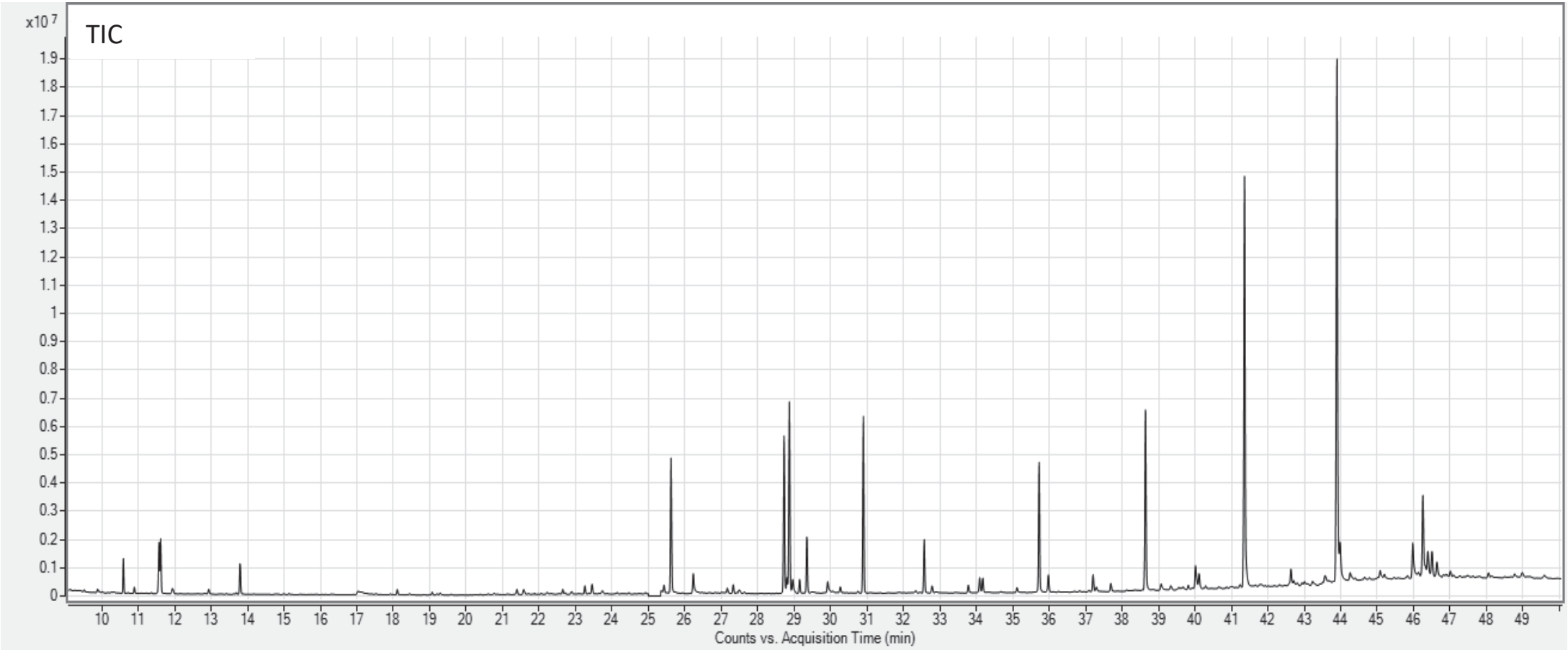


Fig. 173 : Partial total ion chromatogram of the soil sample (BECS 2745) associated with Sample KM170– E170 (BECS 2810)

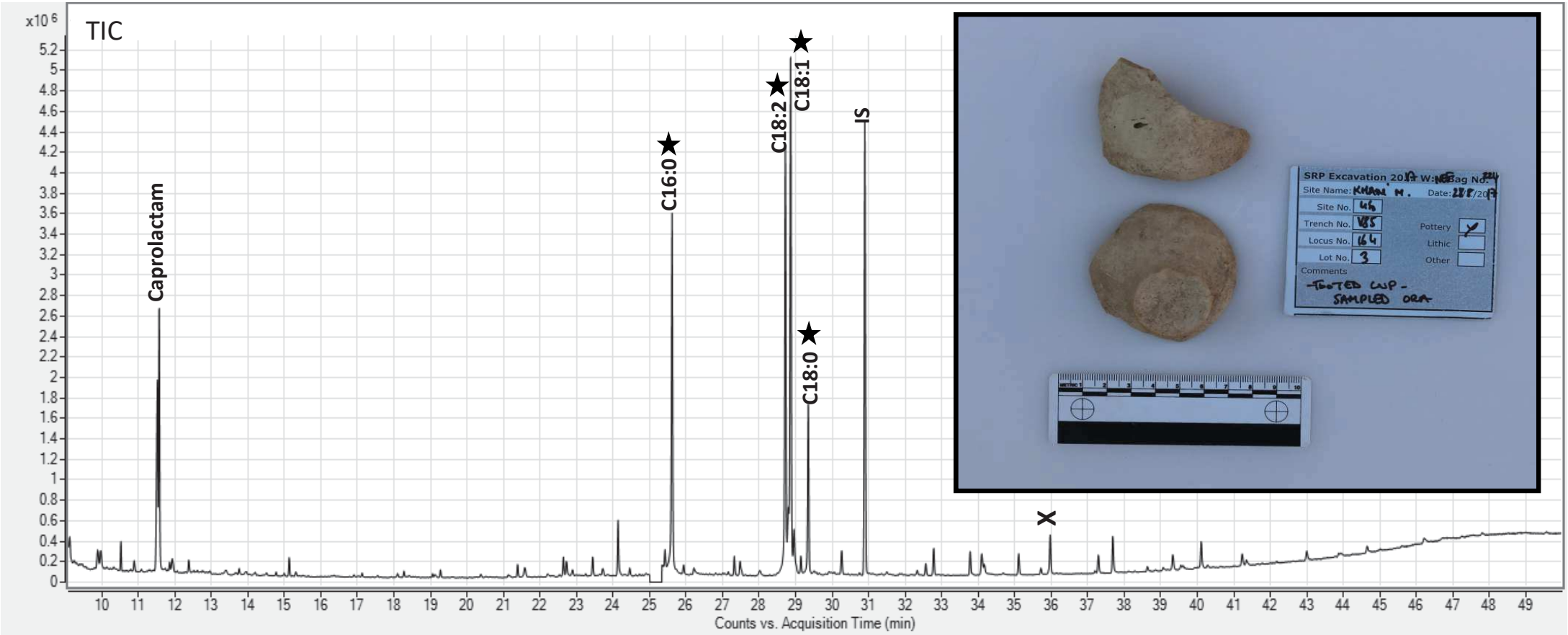


Fig. 174 : Partial total ion chromatogram of Sample KM155– E155 (BECS 2605) of a high-neck footed cup in Trench V85 (Locus 164 Lot 3): Cx:y fatty acids ★, CxOH alcohols ■ , Cx alkanes ▲ , aldehydes and amides ♦ , ketones ● , **MAG** and **DAG** mono- and diacylglycerols, wax esters ● , plasticizers (cross).

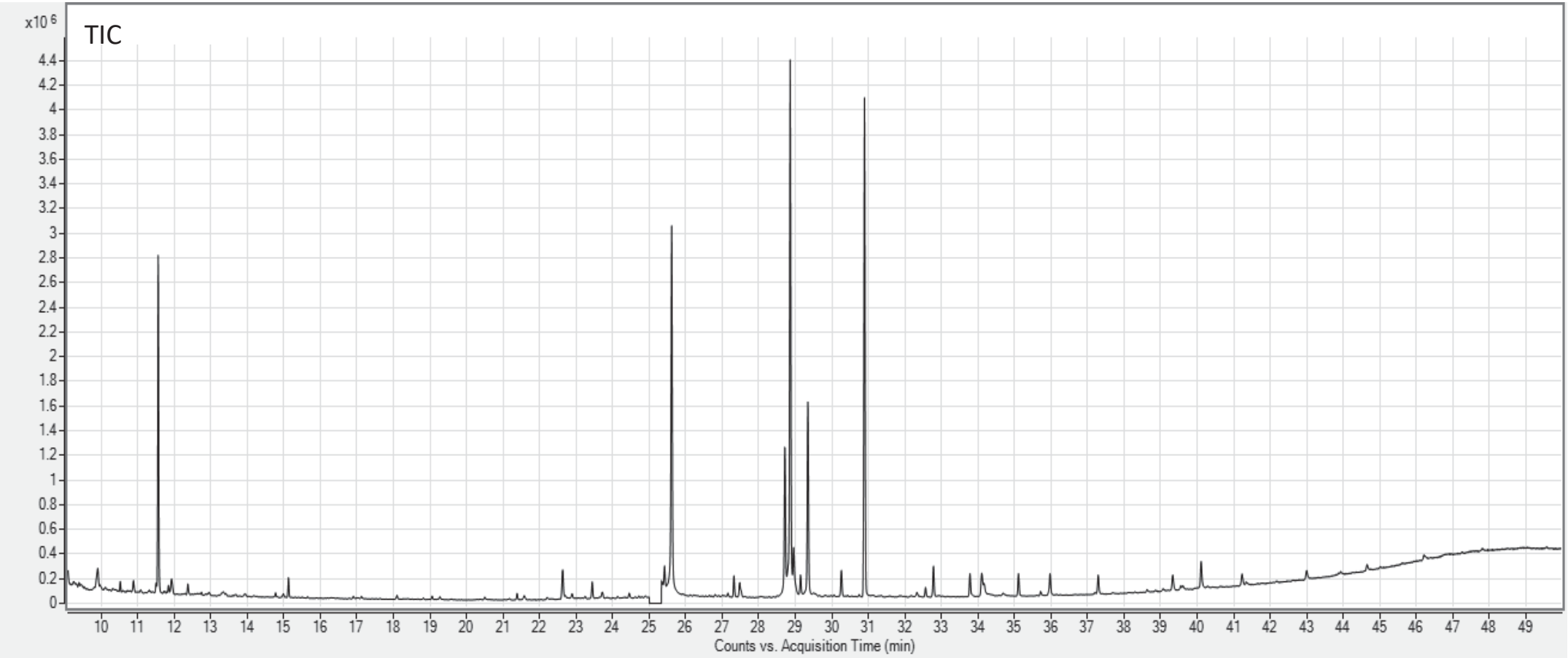


Fig. 175: Partial total ion chromatogram of the inner surface (BECS 2606) of Sample KM155– E155 (BECS 2605)

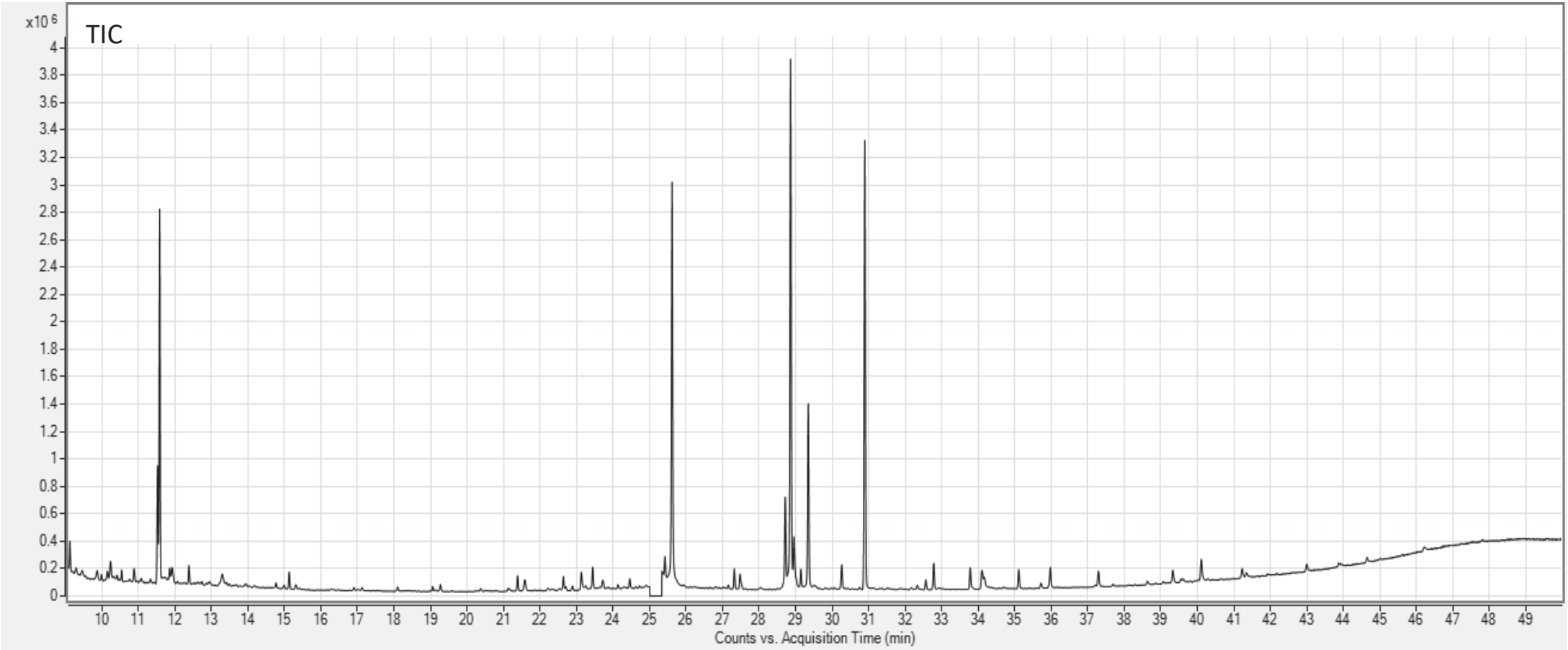


Fig. 176: Partial total ion chromatogram of the outer surface (BECS 2607) of Sample KM155– E155 (BECS 2605)

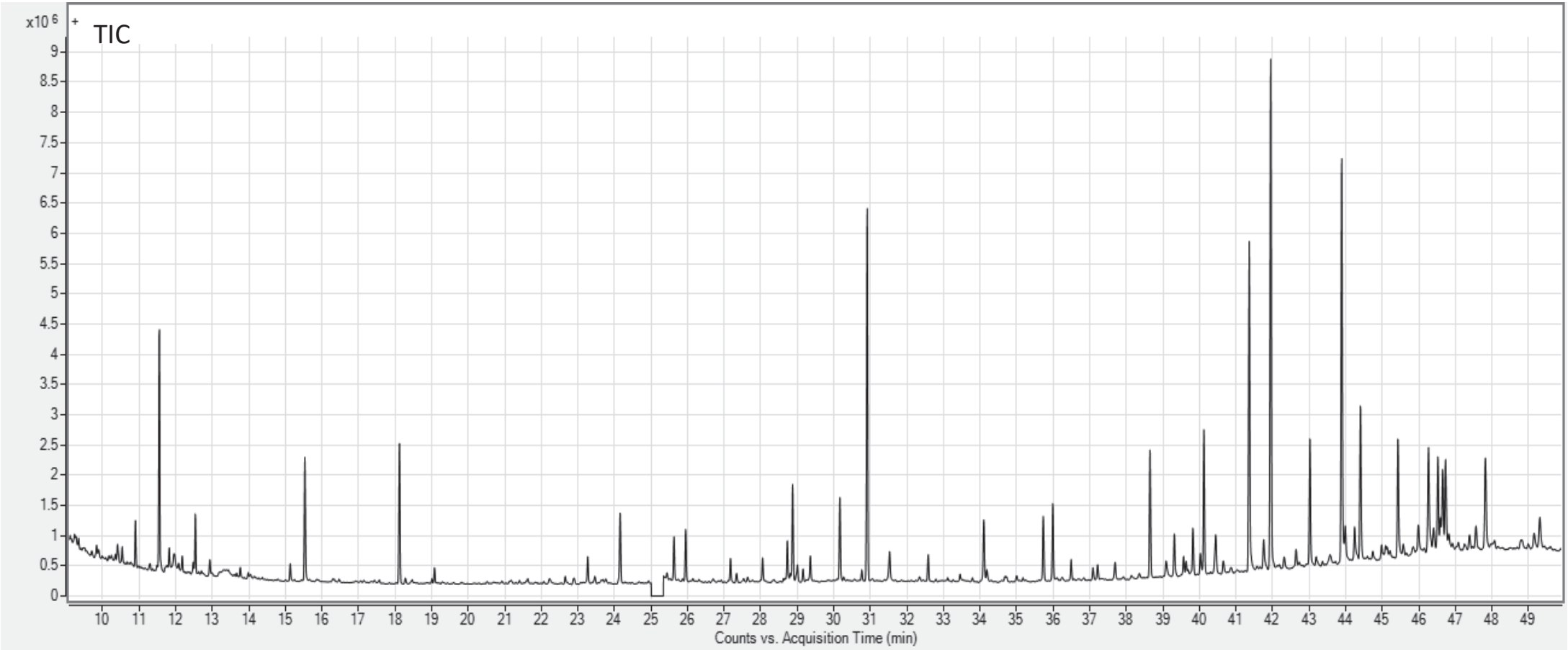


Fig. 177: Partial total ion chromatogram of the soil sample (BECS 2598) associated with Sample KM155– E155 (BECS 2605)

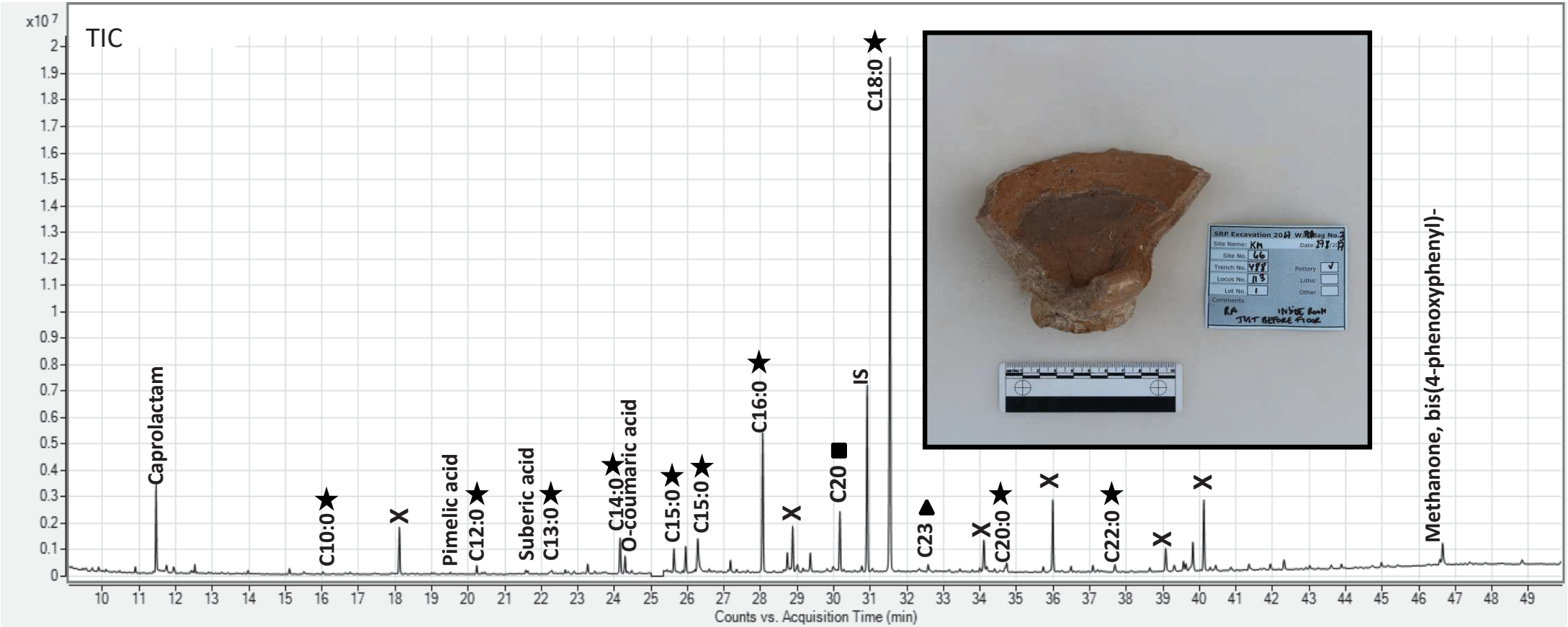


Fig. 178 : Partial total ion chromatogram of Sample KM201– E201 (BECS 2652) of a cup in Trench Y88 (Locus 113 Lot 1): Cx:y fatty acids ★, CxOH alcohols ■ , Cx alkanes ▲ , aldehydes and amides ♦ , ketones ● , **MAG** and **DAG** mono- and diacylglycerols, wax esters ● , plasticizers (cross).

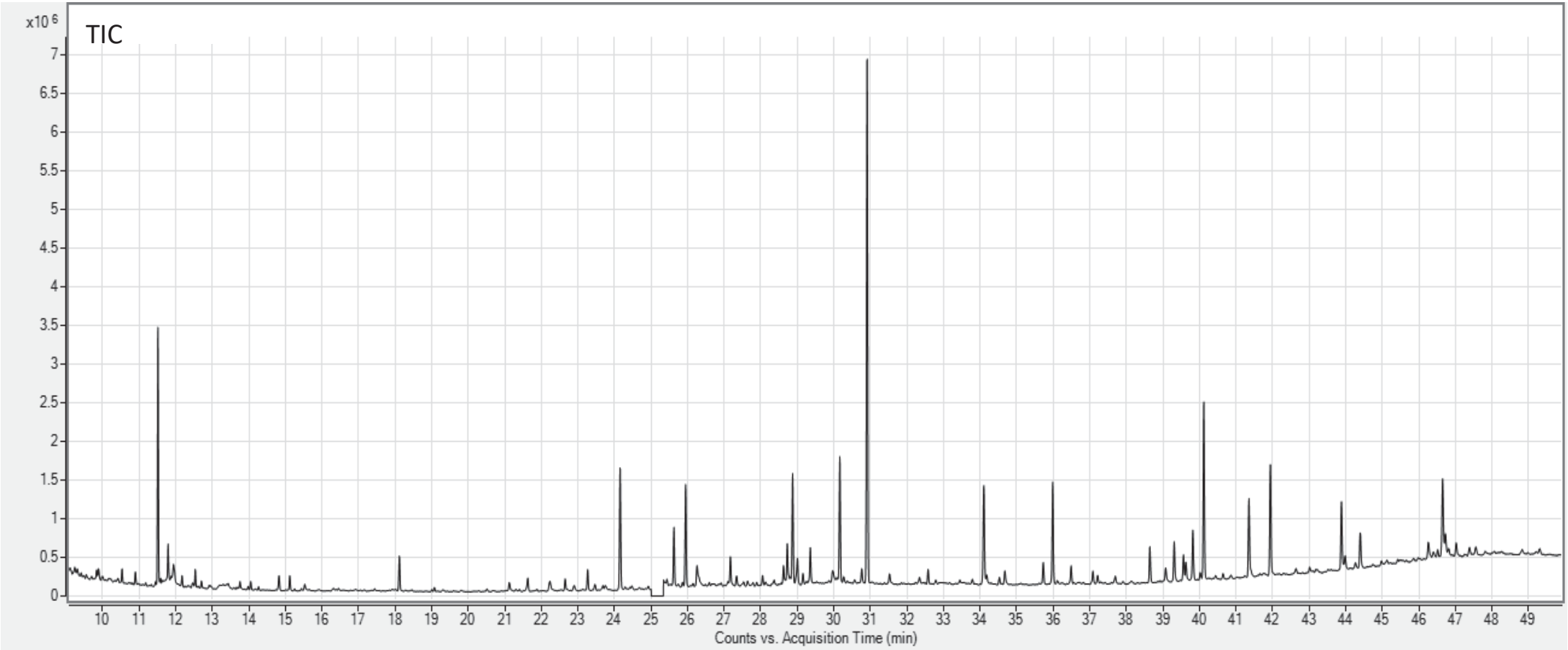


Fig. 179: Partial total ion chromatogram of the inner surface (BECS 2653) of Sample KM201– E201 (BECS 2652)

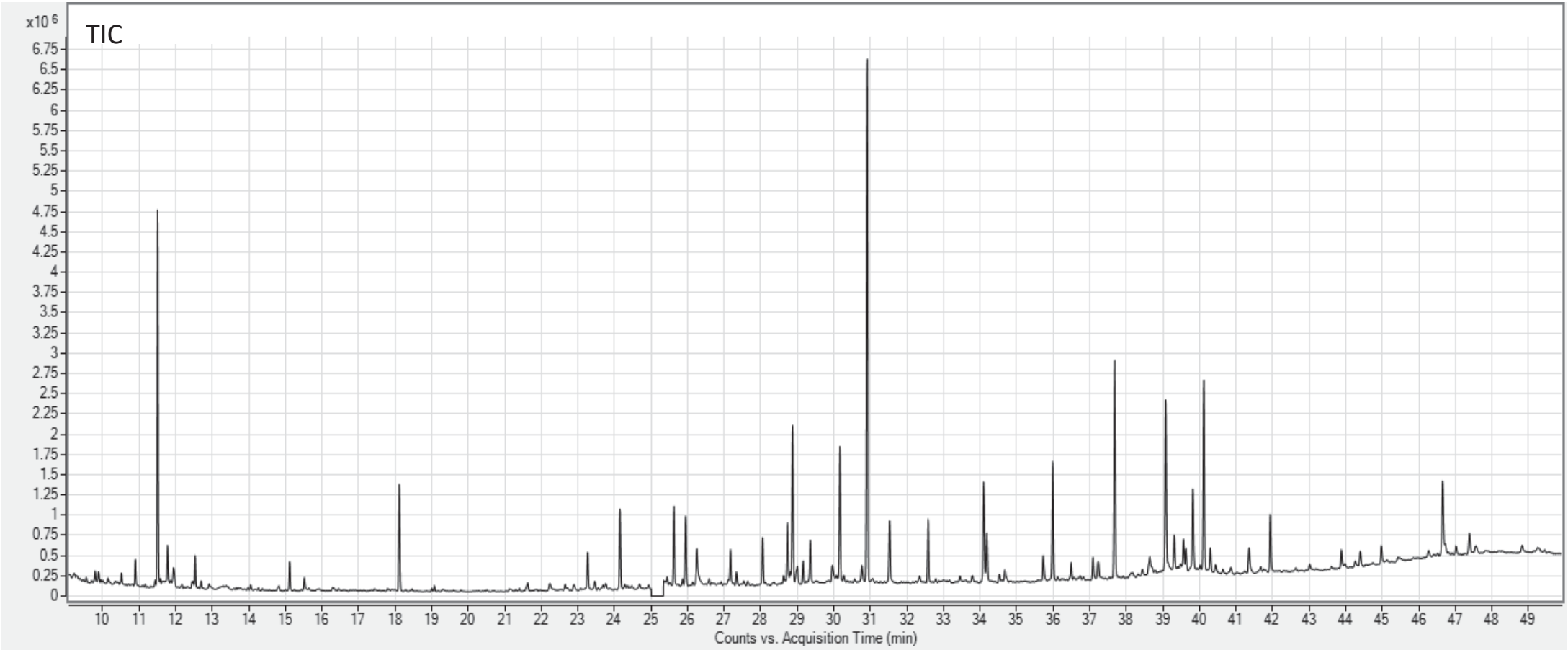


Fig. 180: Partial total ion chromatogram of the inner surface (BECS 2654) of Sample KM201– E201 (BECS 2652)

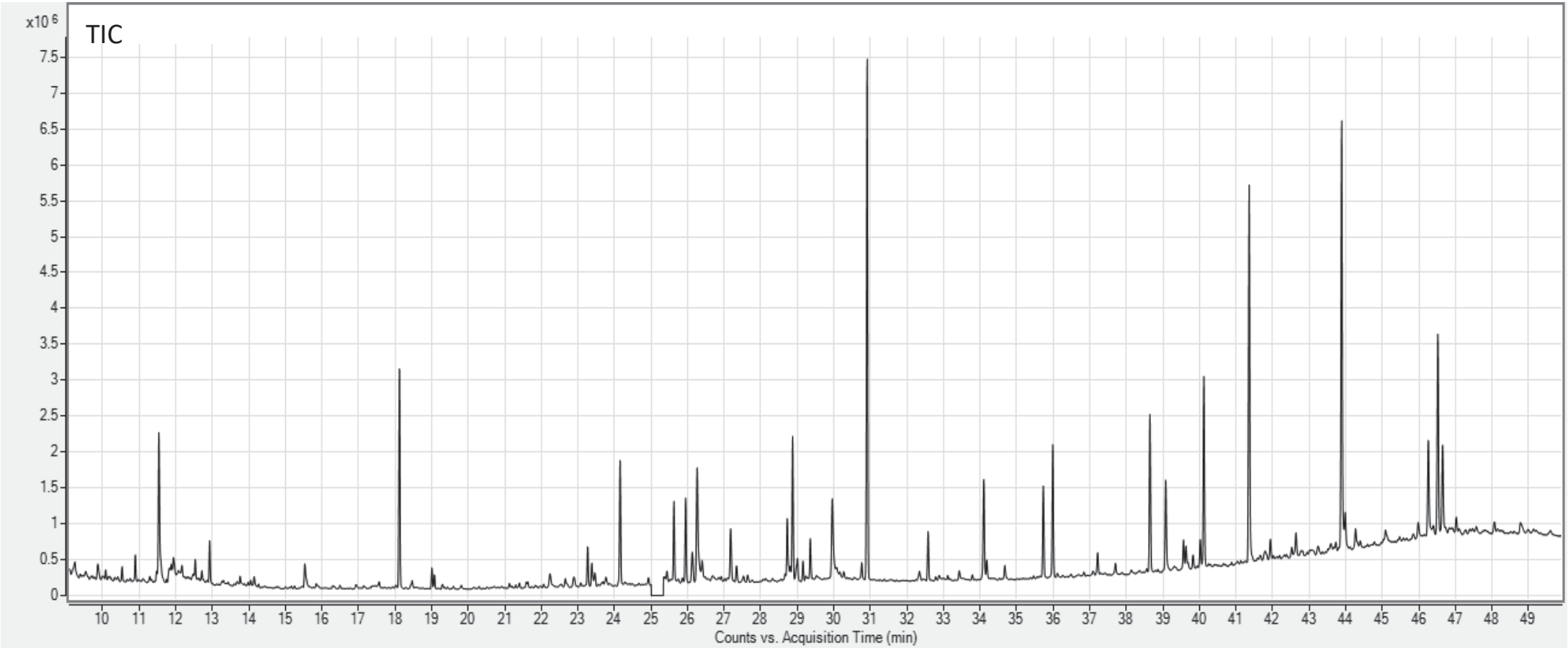


Fig. 181: Partial total ion chromatogram of the soil sample (BECS 2655) associated with Sample KM201– E201 (BECS 2652)

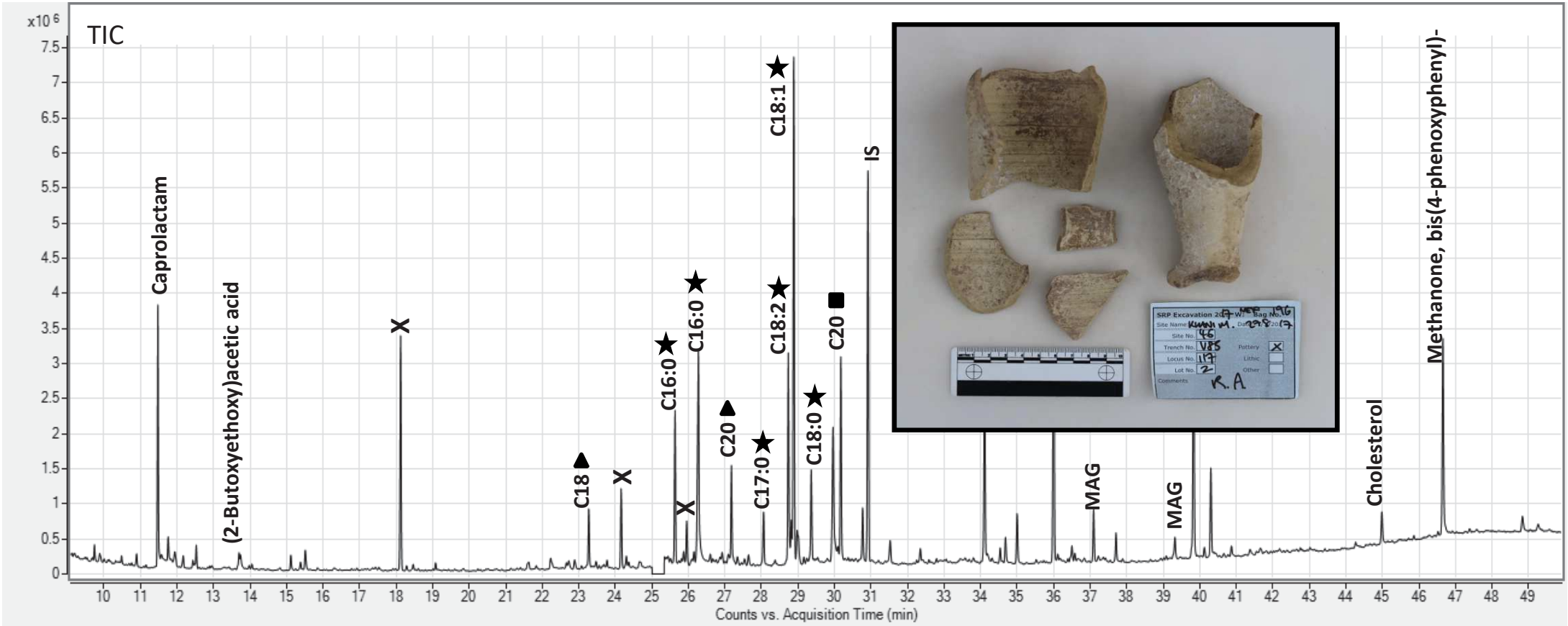


Fig. 182 : Partial total ion chromatogram of Sample KM196– E196 (BECS 2531) of a footed goblet in Trench V85 (Locus 117 Lot 2): Cx:y fatty acids ★, CxOH alcohols ■ , Cx alkanes ▲ , aldehydes and amides ♦ , ketones ● , **MAG** and **DAG** mono- and diacylglycerols, wax esters ● , plasticizers (cross).

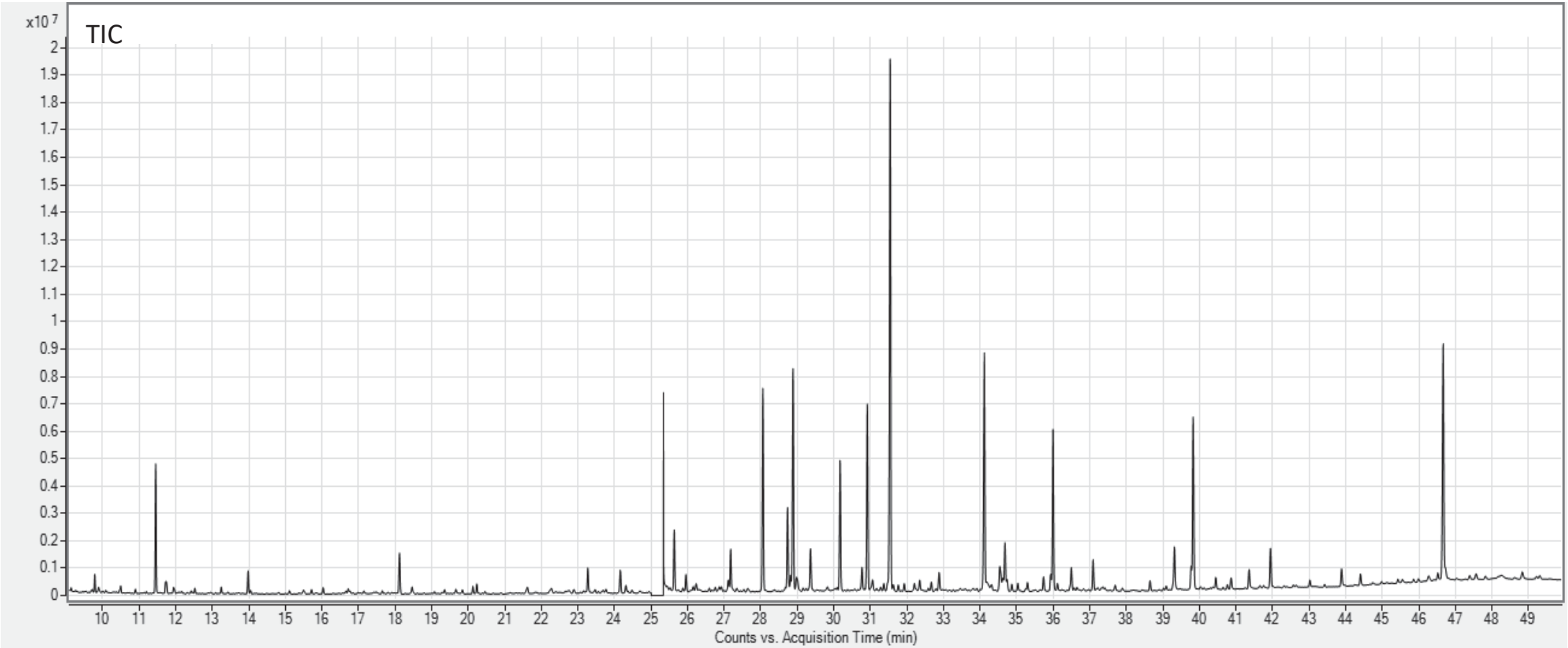


Fig. 183 : Partial total ion chromatogram of the inner surface (BECS 2532) of Sample KM196– E196 (BECS 2531)

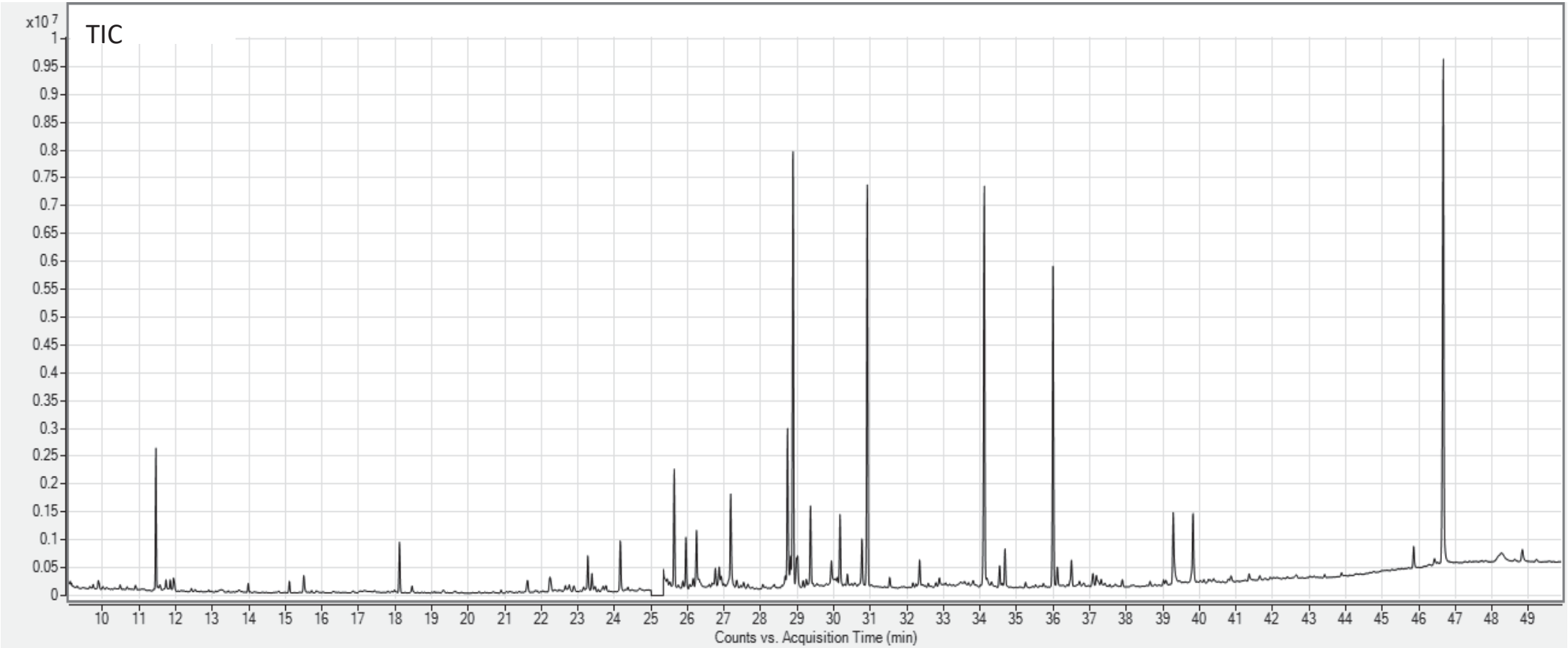


Fig. 184: Partial total ion chromatogram of the outer surface (BECS 2533) of Sample KM196– E196 (BECS 2531)

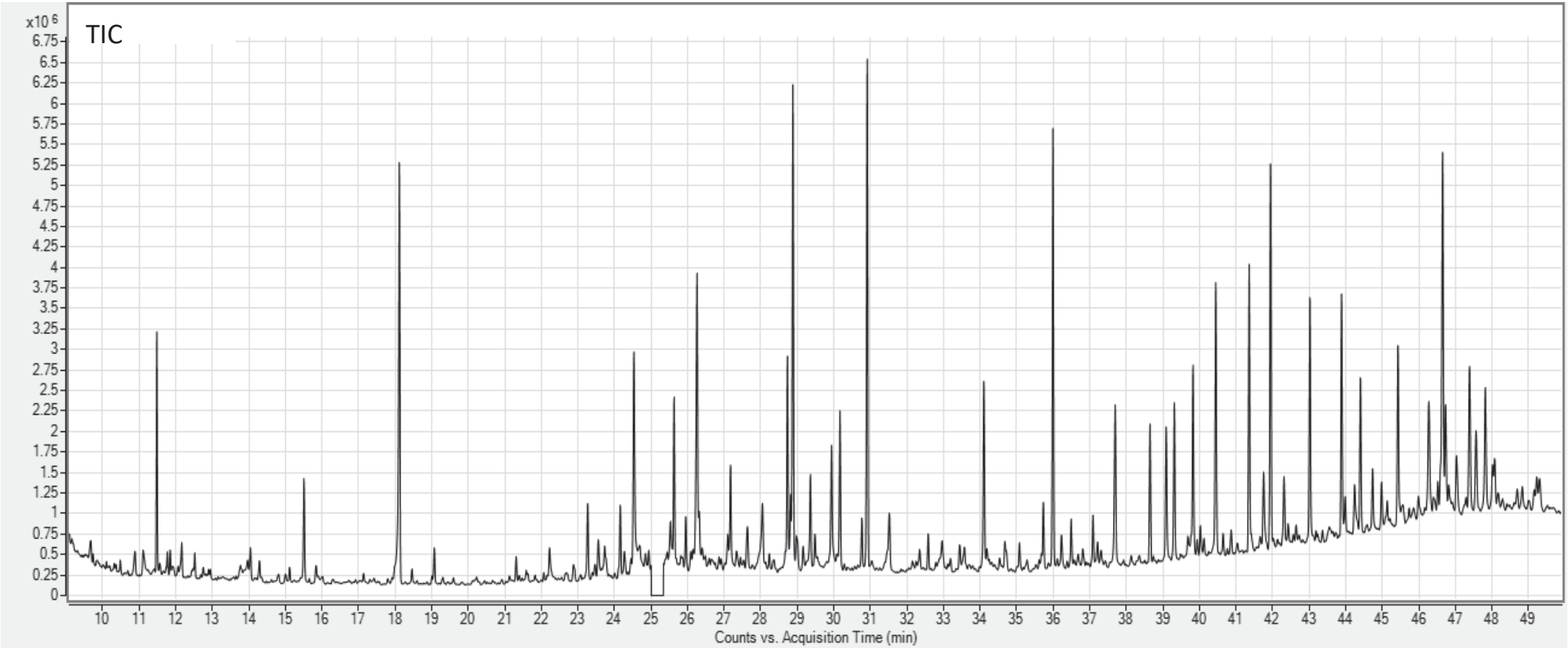


Fig. 185 : Partial total ion chromatogram of the soil sample (BECS 2543) associated with Sample KM196– E196 (BECS 2531)

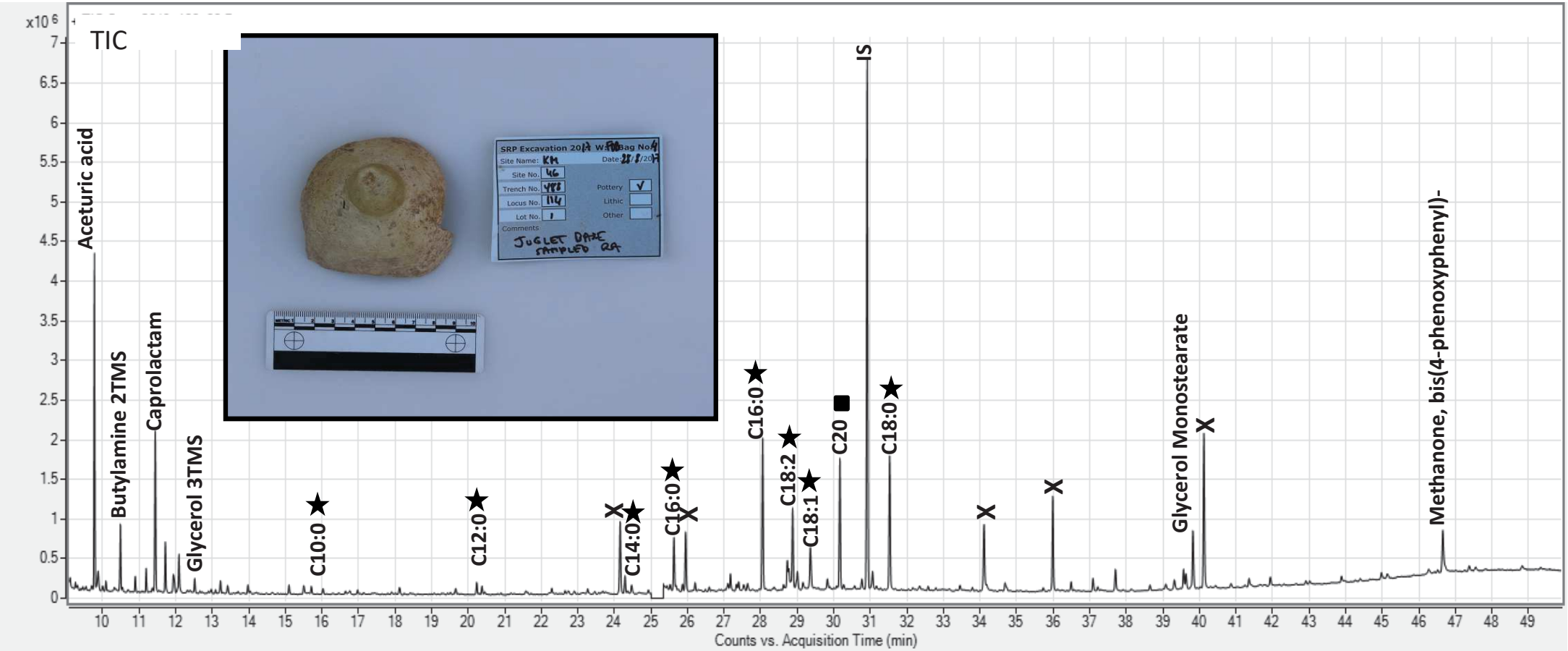


Fig. 186 : Partial total ion chromatogram of Sample KM179– E179 (BECS 2649) of a juglet in Trench Y88 (Locus 114 Lot 1): Cx:y fatty acids ★, CxOH alcohols ■ , Cx alkanes ▲ , aldehydes and amides ♦ , ketones ⬣ , **MAG** and **DAG** mono- and diacylglycerols, wax esters ● , plasticizers (cross).

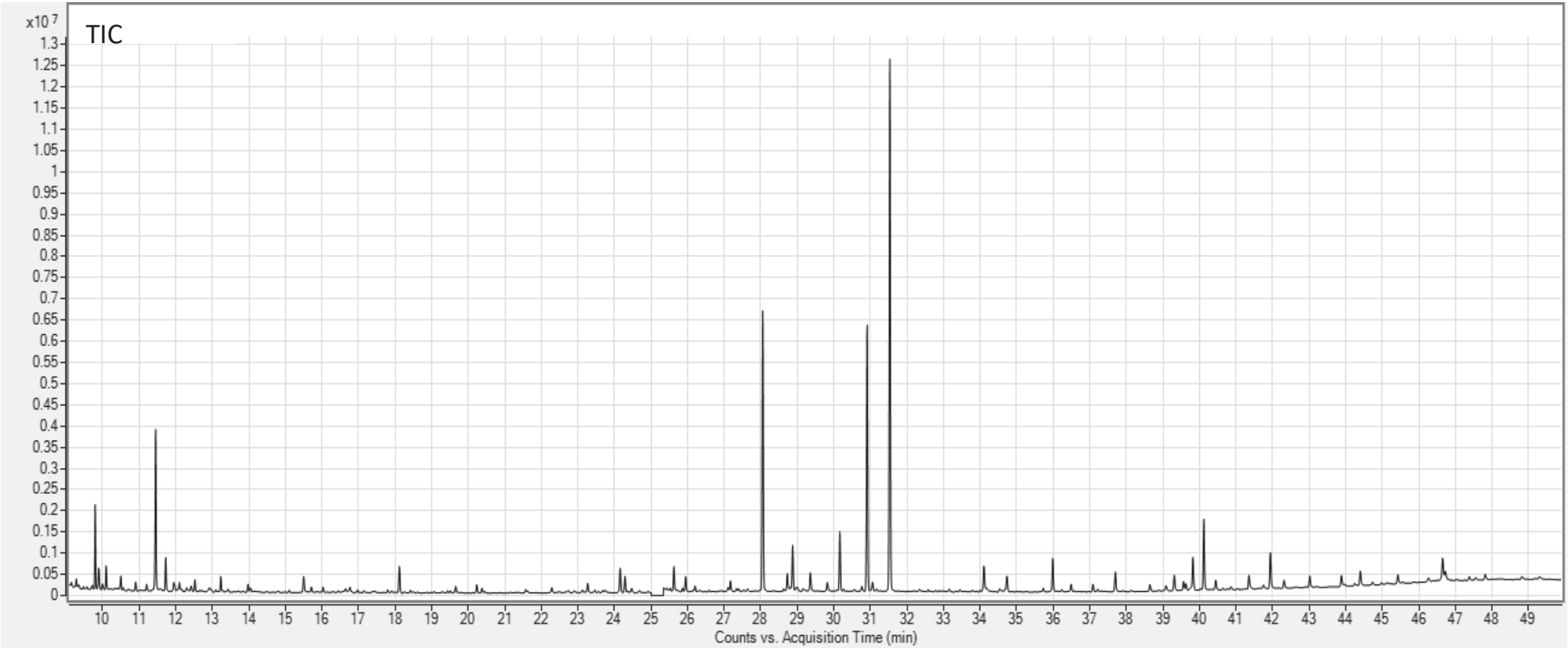


Fig. 187: Partial total ion chromatogram of the inner surface (BECS 2650) of Sample KM179– E179 (BECS 2649)

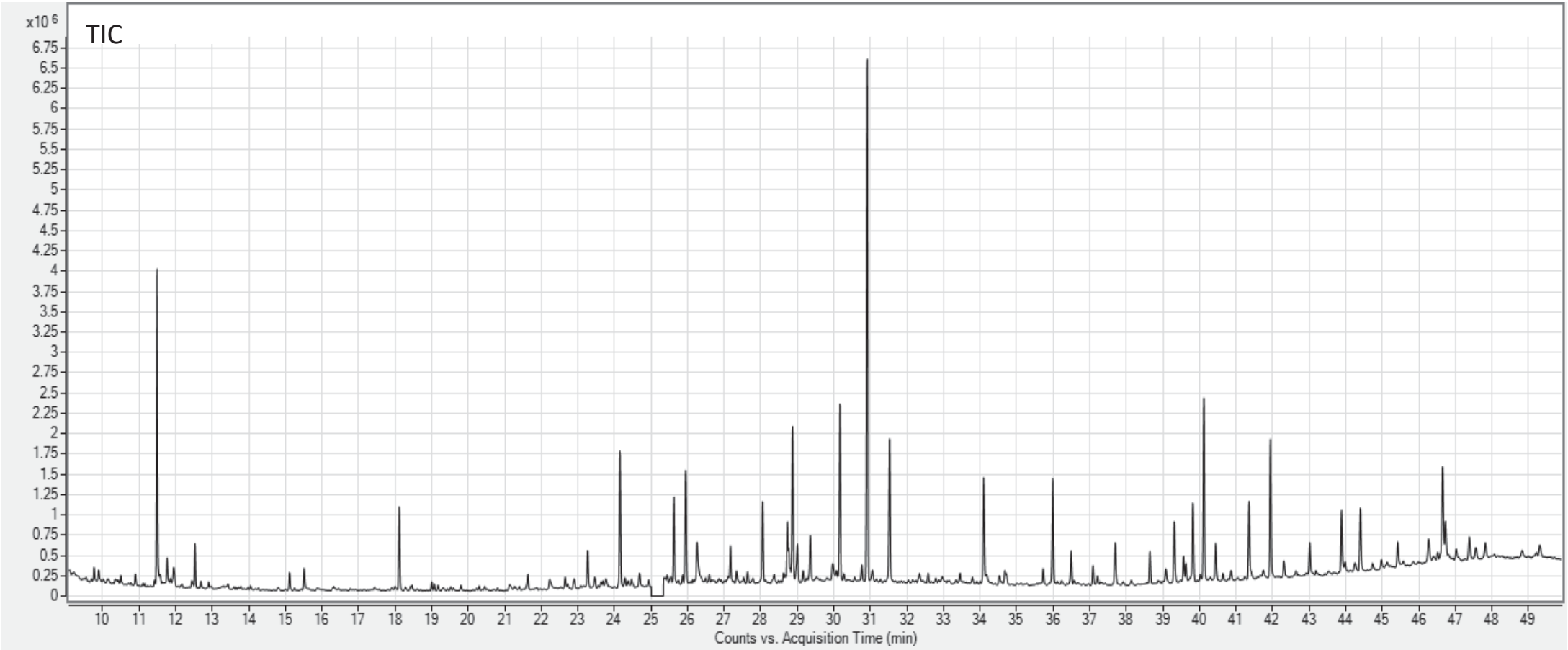


Fig. 188: Partial total ion chromatogram of the outer surface (BECS 2651) of Sample KM179– E179 (BECS 2649)

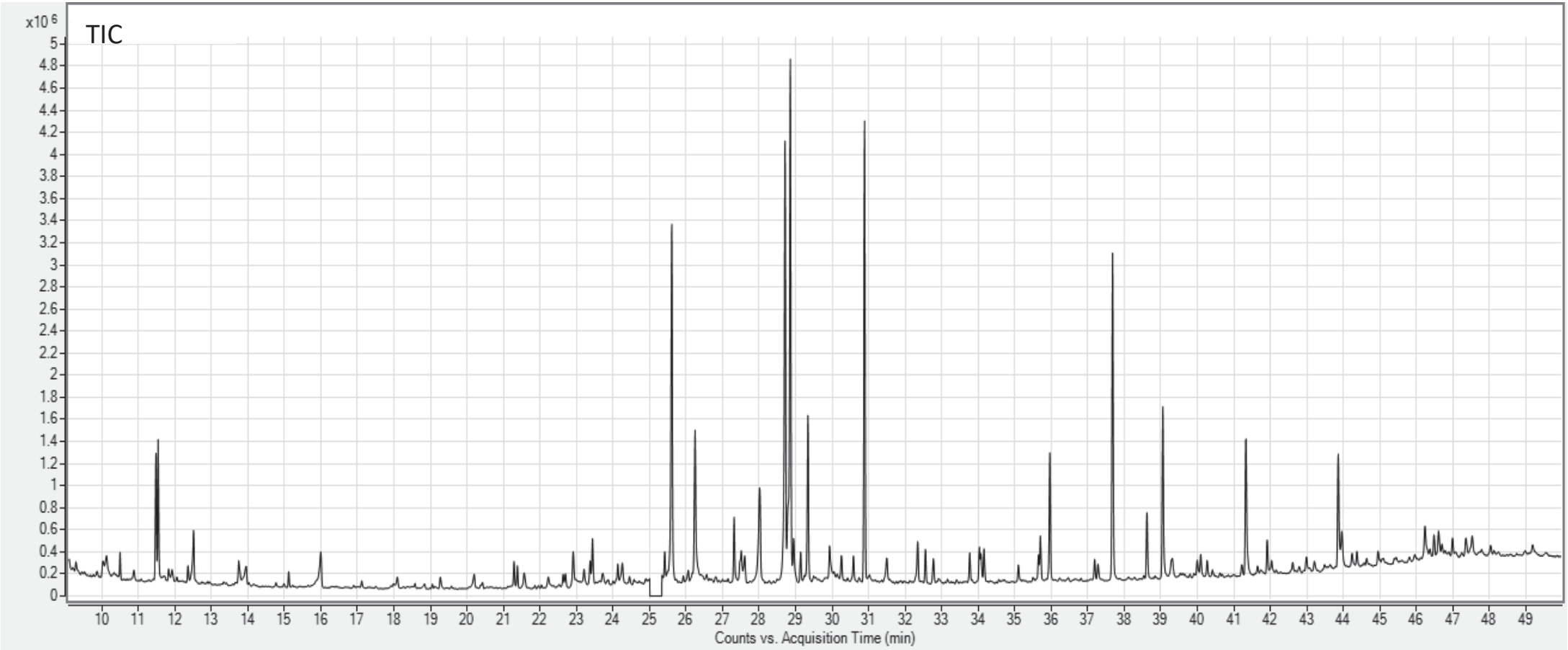


Fig. 189: Partial total ion chromatogram of the soil sample (BECS 2817) associated with Sample KM179– E179 (BECS 2649)

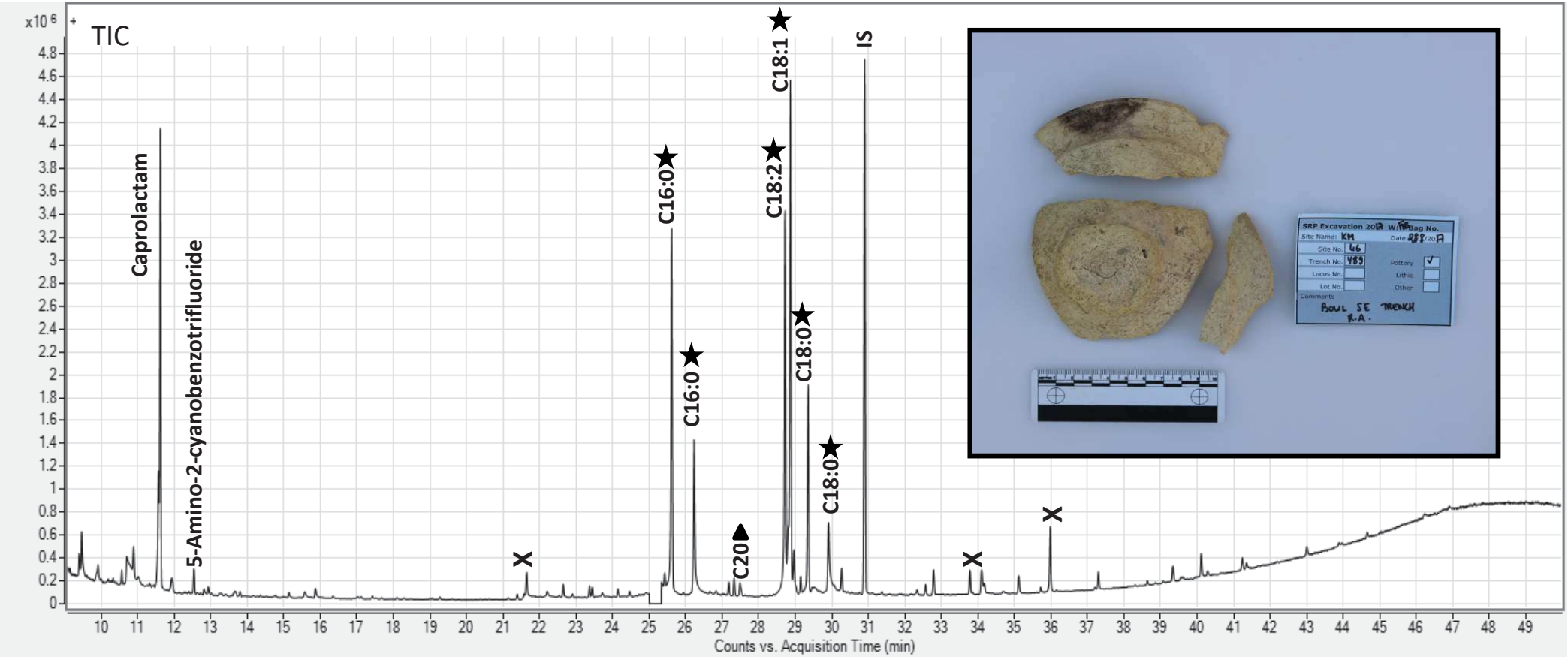


Fig. 190: Partial total ion chromatogram of Sample KM172– E172 (BECS 2807) of a bowl in Trench Y89 (Locus 6 Lot 1): Cx:y fatty acids ★, CxOH alcohols ■ , Cx alkanes ▲ , aldehydes and amides ♦ , ketones ⬣ , **MAG** and **DAG** mono- and diacylglycerols, wax esters ● , plasticizers (cross).

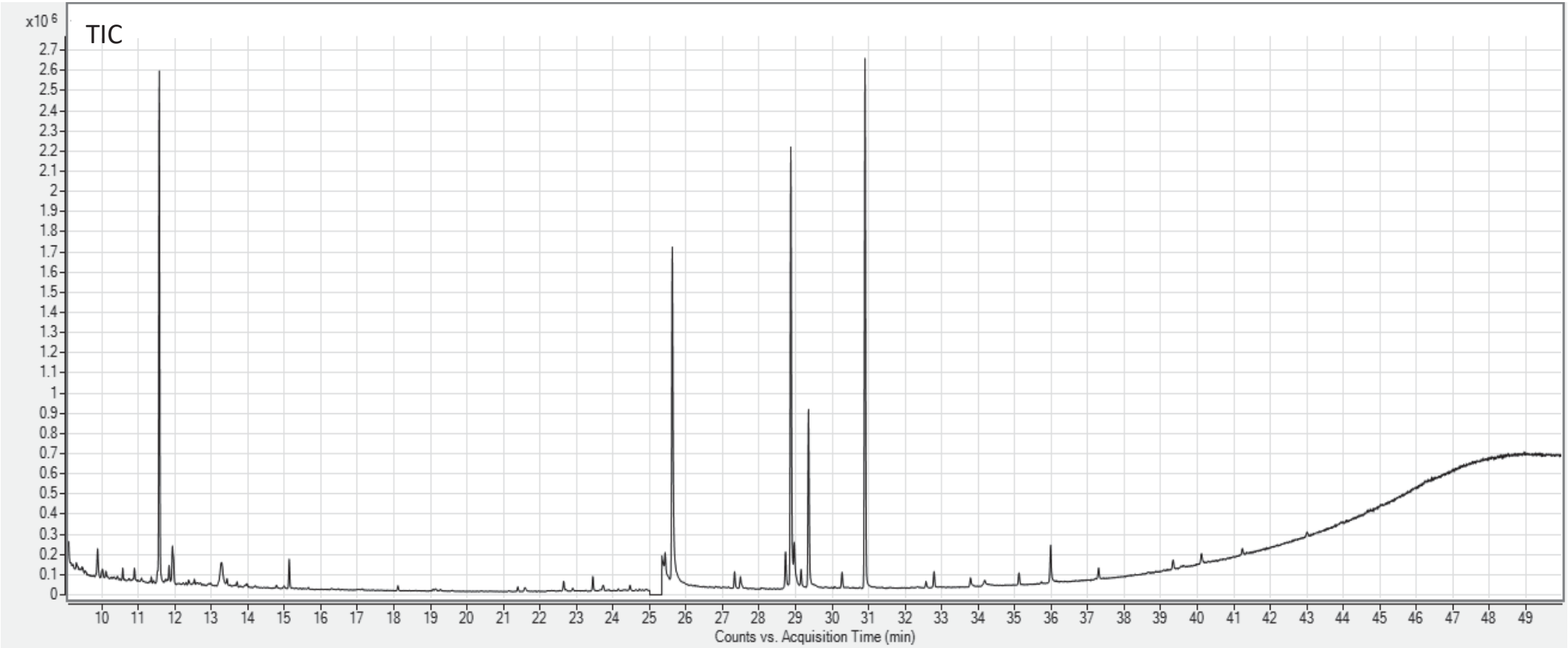


Fig. 191: Partial total ion chromatogram of the inner surface (BECS 2808) of Sample KM172– E172 (BECS 2807)

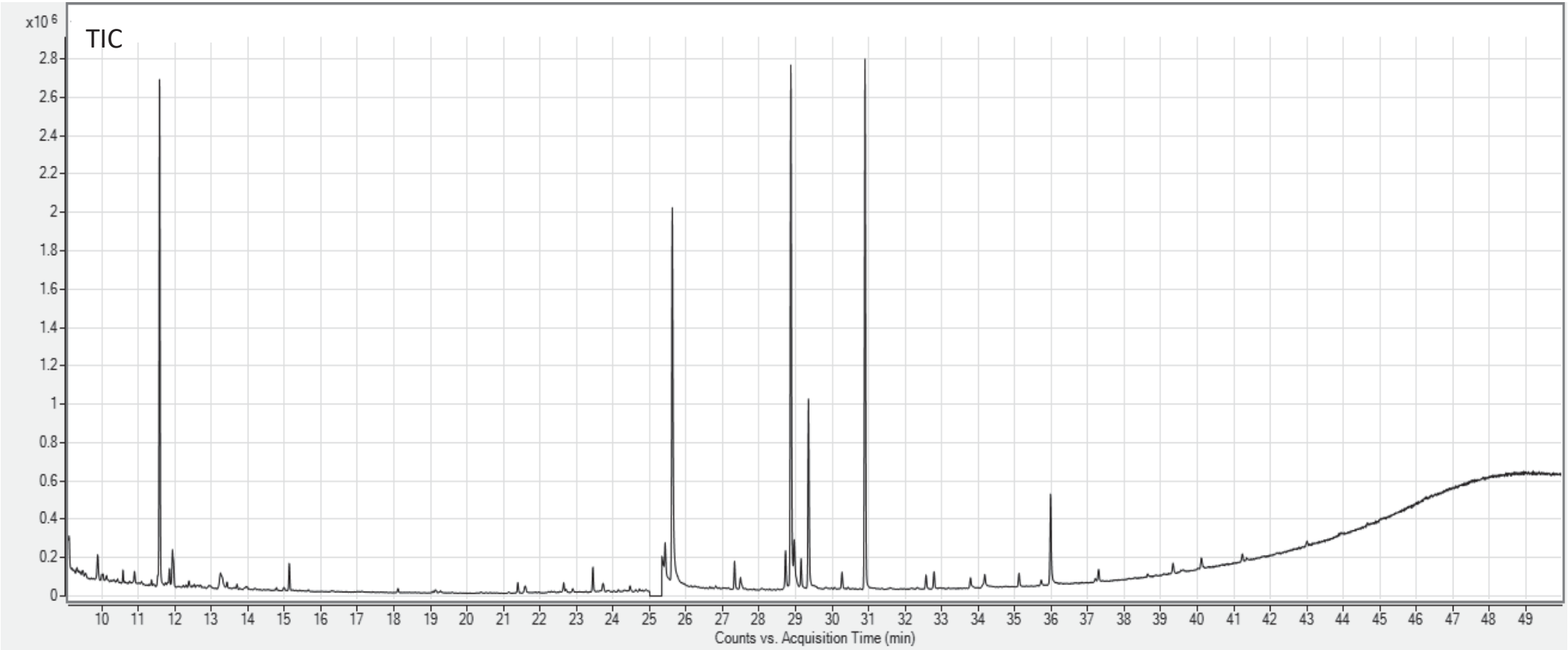


Fig. 192: Partial total ion chromatogram of the outer surface (BECS 2809) of Sample KM172– E172 (BECS 2807)

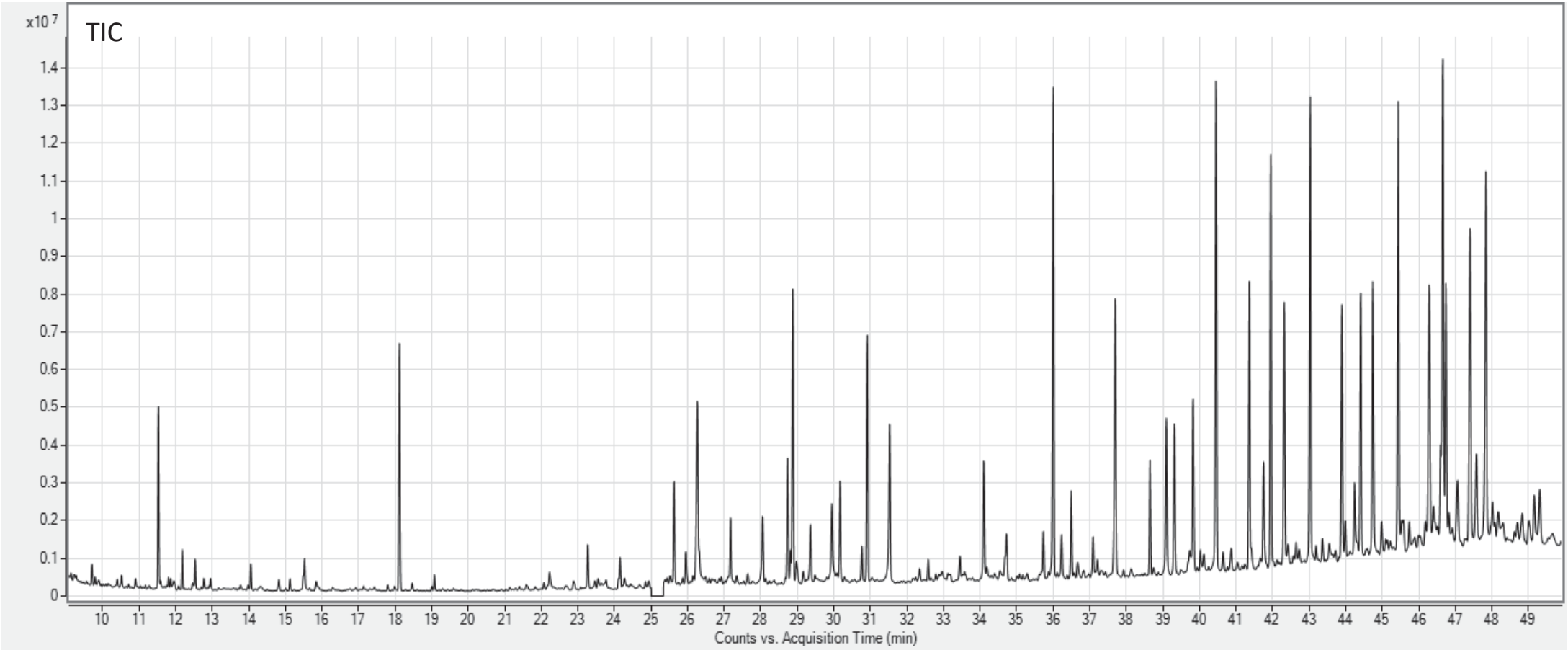


Fig. 193: Partial total ion chromatogram of the soil sample (BECS 2546) associated with Sample KM172– E172 (BECS 2807)

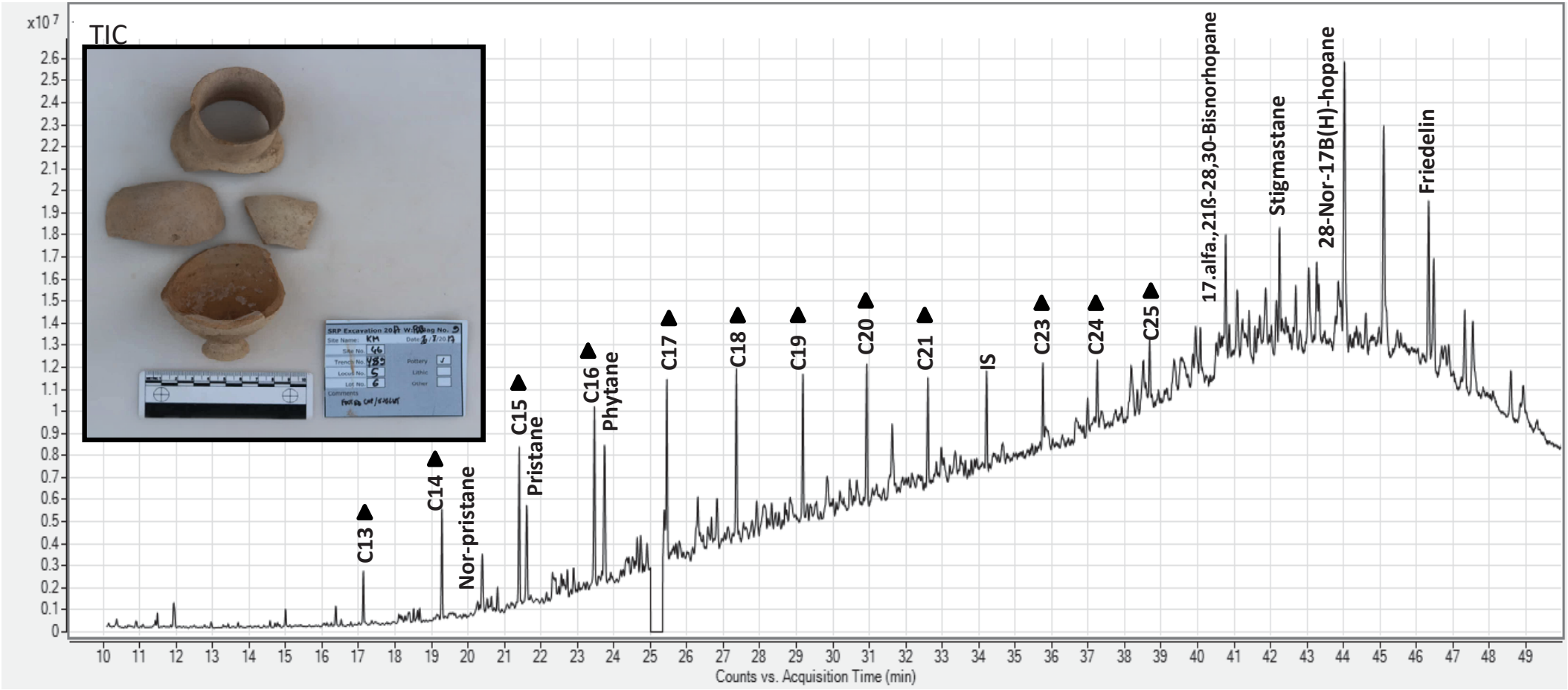


Fig. 194: Partial total ion chromatogram of Sample KM191-E191 (BECS 2732) of a footed cup in Trench Y89 (Locus 5 Lot 6): Cx:y fatty acids ★, CxOH alcohols ■ , Cx alkanes ▲ , aldehydes and amides ♦ , ketones ⬣ , **MAG** and **DAG** mono- and diacylglycerols, wax esters ● , plasticizers (cross).

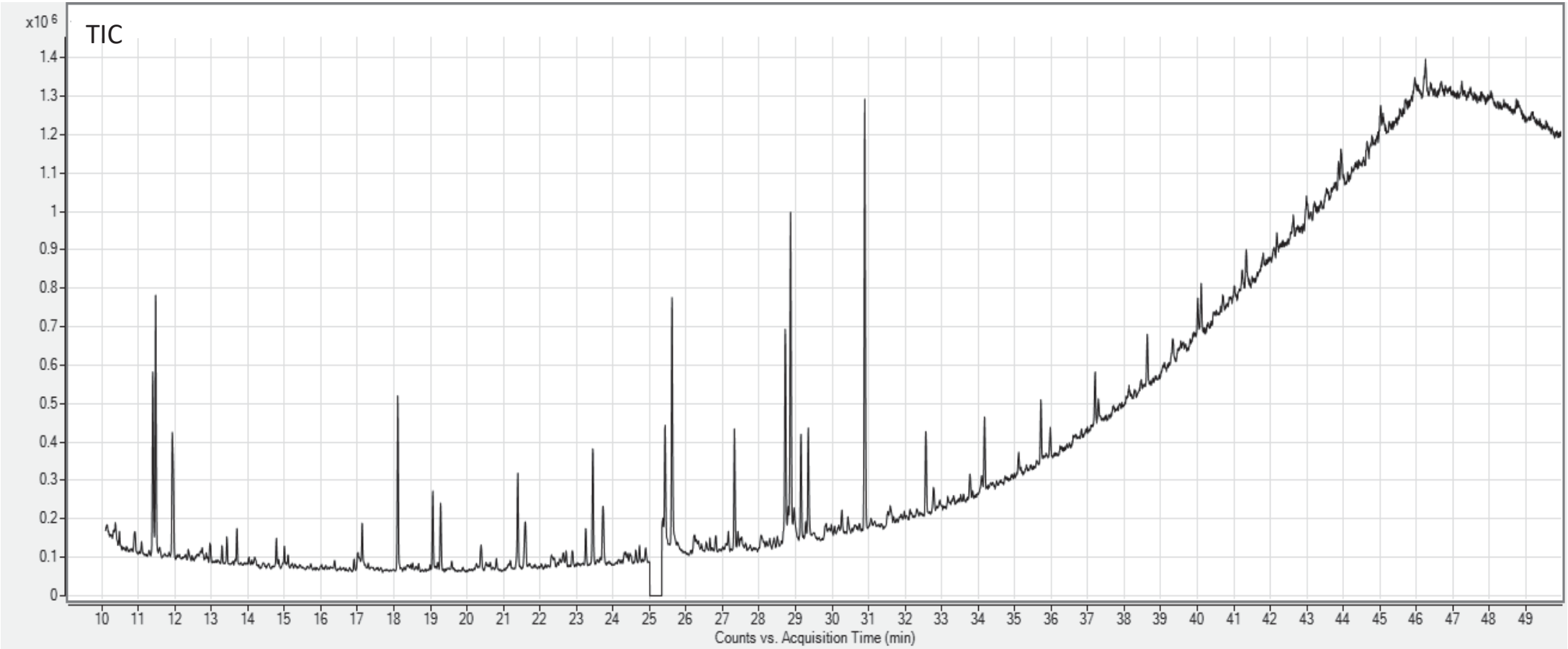


Fig. 195 : Partial total ion chromatogram of the inner surface (BECS 2733) of Sample KM191-E191 (BECS 2732)

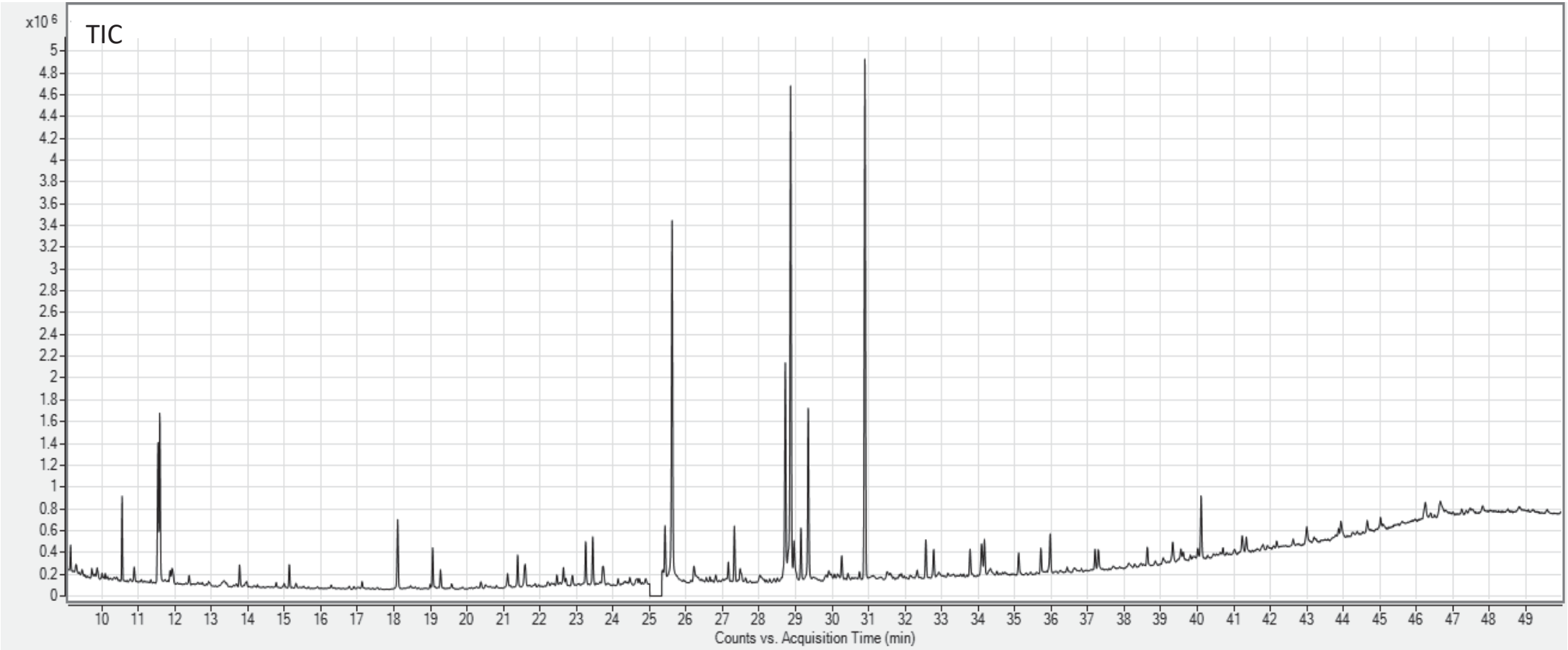


Fig. 196: Partial total ion chromatogram of the outer surface (BECS 2734) of Sample KM191-E191 (BECS 2732)

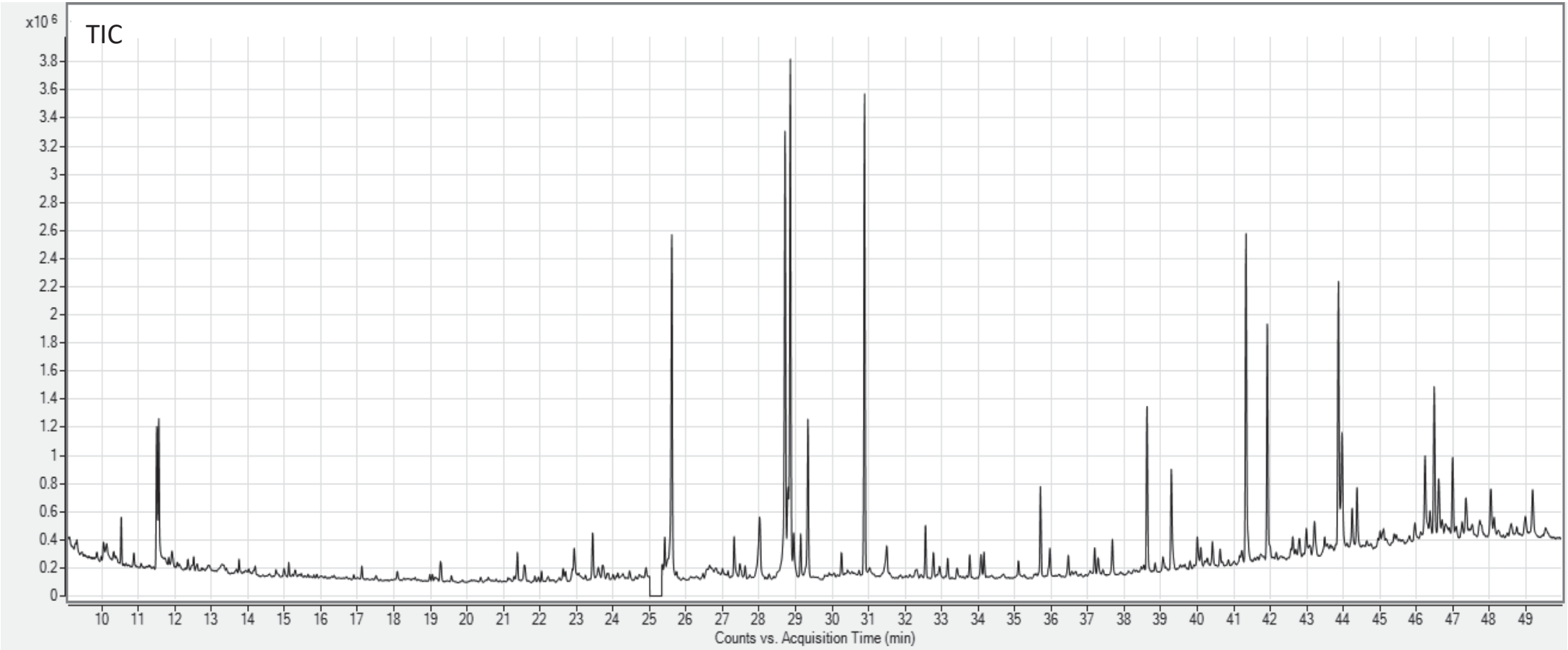


Fig. 197 : Partial total ion chromatogram of the soil sample (BECS 2819) associated with Sample KM191-E191 (BECS 2732)

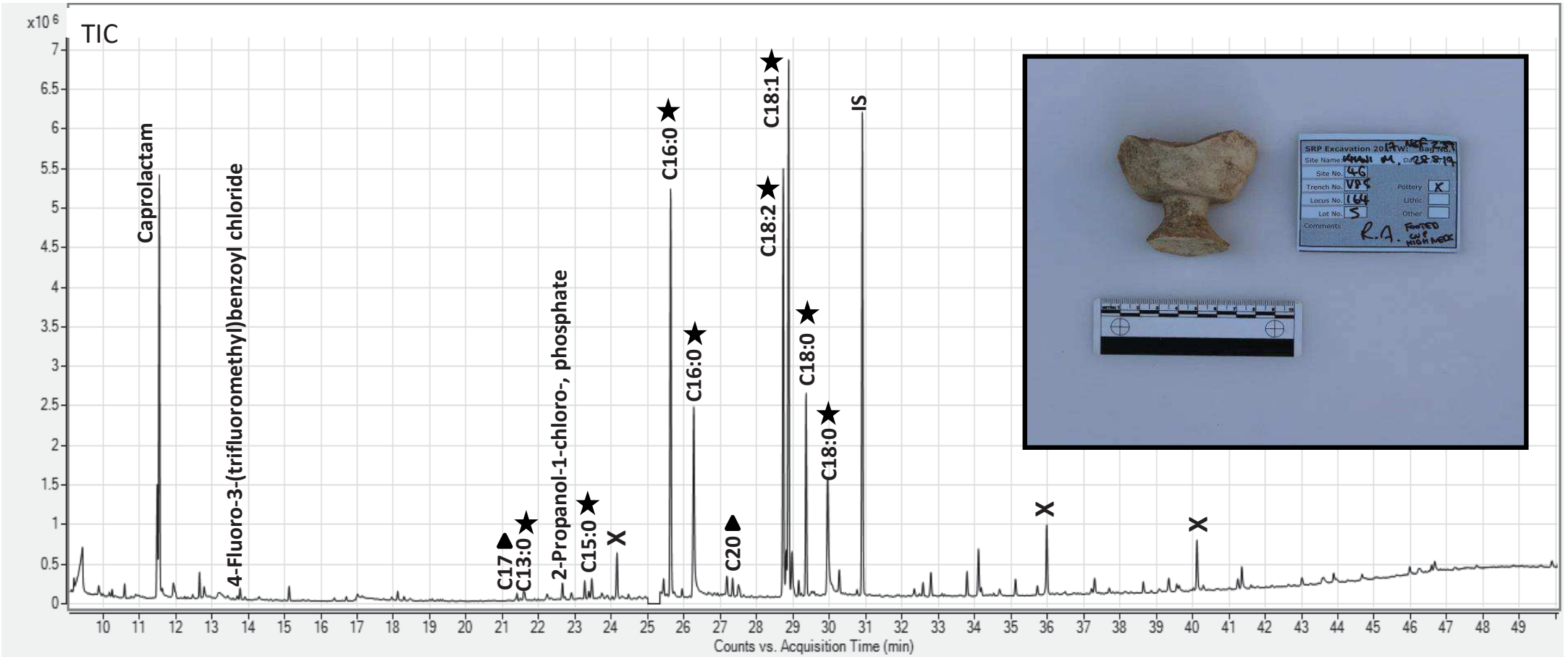


Fig. 198 : Partial total ion chromatogram of Sample KM190-E190 (BECS 2723) of a footed cup in Trench V85 (Locus 164 Lot 5): Cx:y fatty acids ★, CxOH alcohols ■ , Cx alkanes ▲ , aldehydes and amides ♦ , ketones ⬣ , **MAG** and **DAG** mono- and diacylglycerols, wax esters ● , plasticizers (cross).

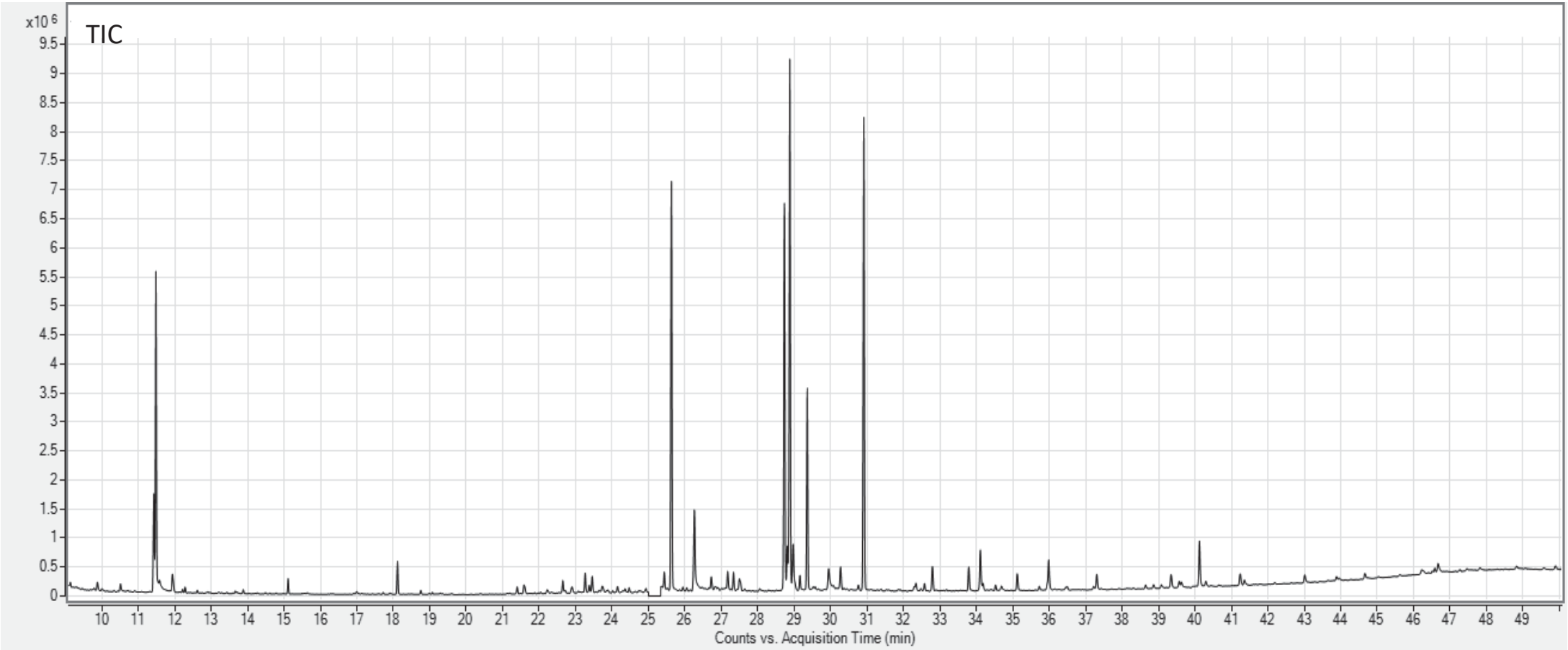


Fig. 199 : Partial total ion chromatogram of the inner surface (BECS 2724) of Sample KM190-E190 (BECS 2723)

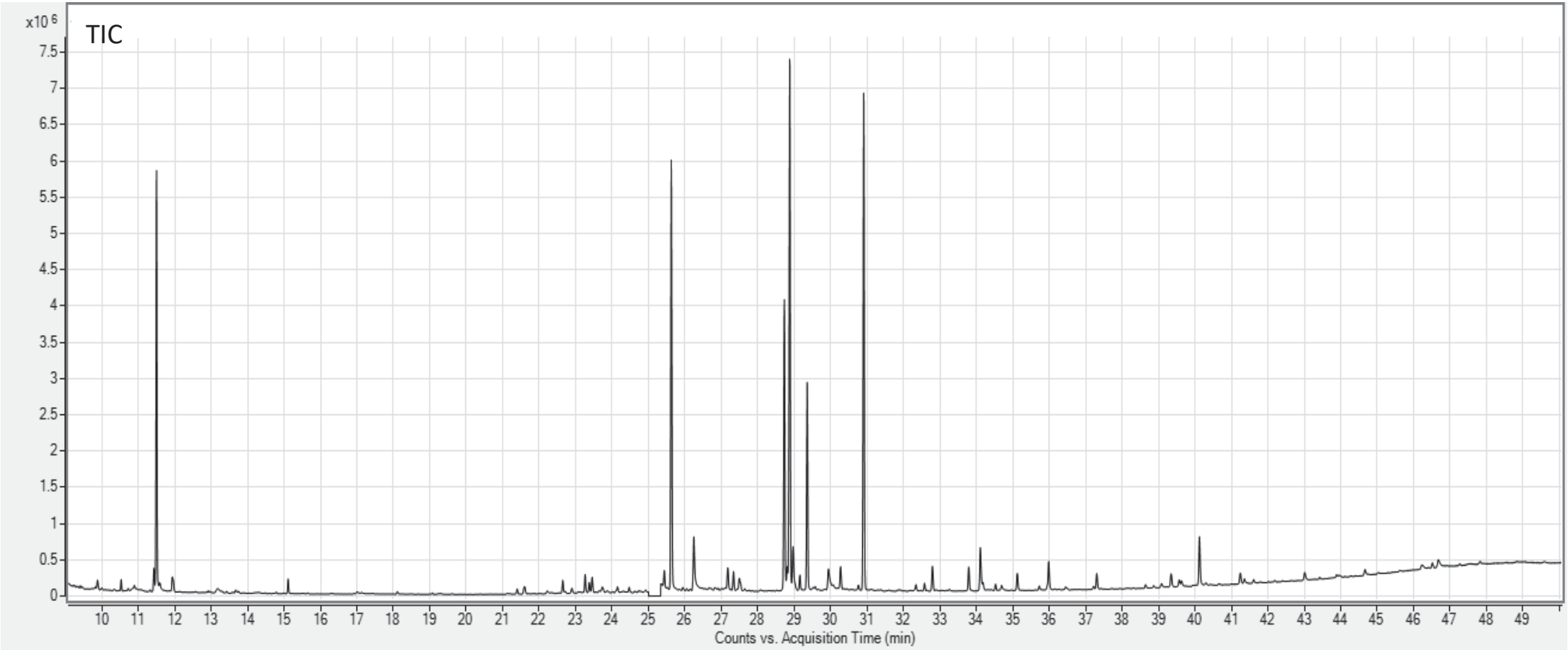


Fig. 200 : Partial total ion chromatogram of the outer surface (BECS 2725) of Sample KM190-E190 (BECS 2723)

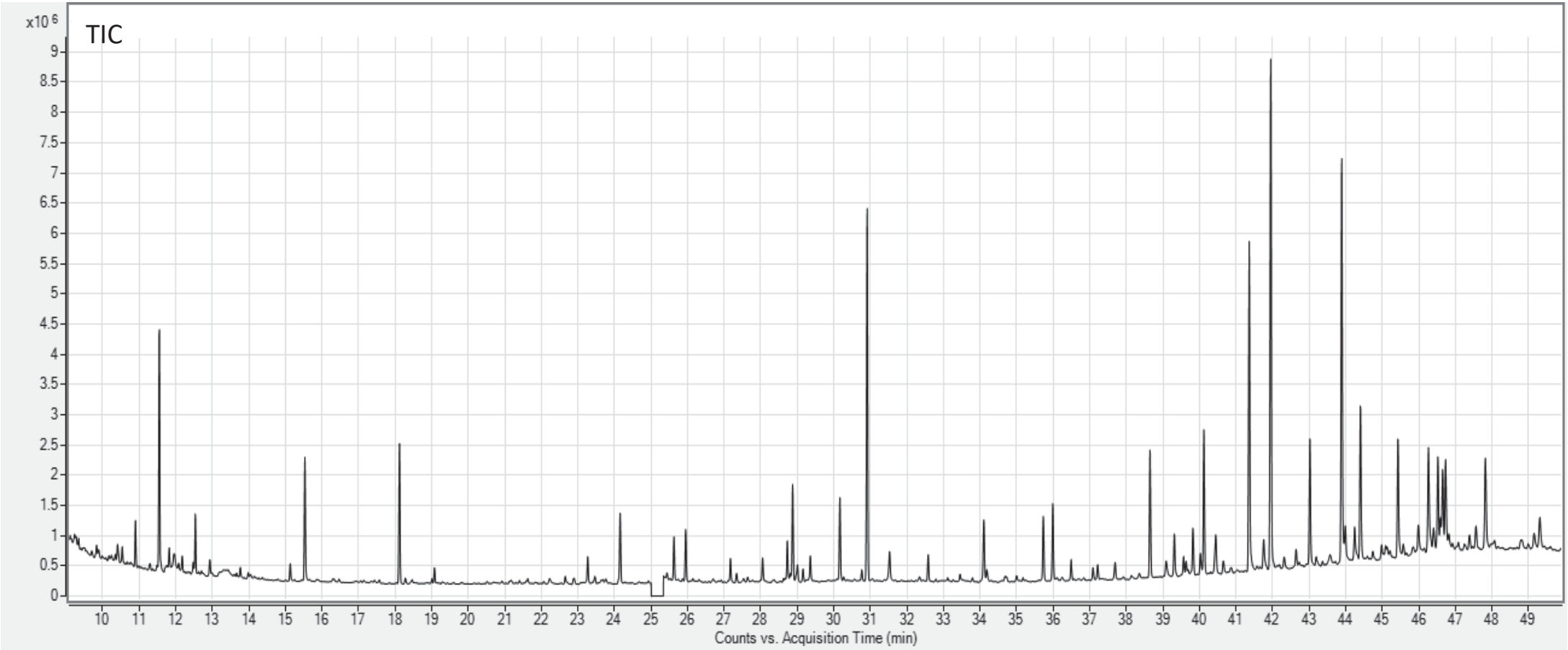


Fig. 201: Partial total ion chromatogram of the soil sample (BECS 2598) associated with Sample KM190-E190 (BECS 2723)

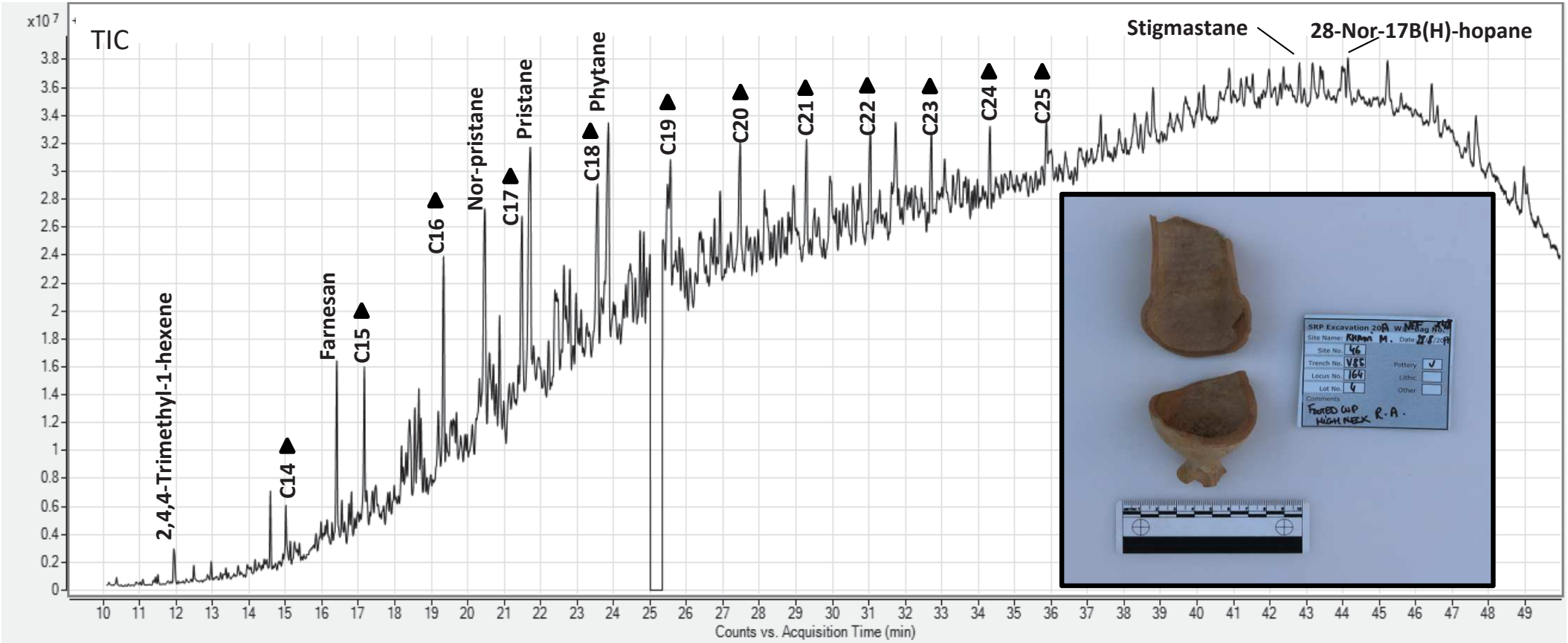


Fig. 202: Partial total ion chromatogram of Sample KM193-E193 (BECS 2608) of a footed cup in Trench V85 (Locus 164 Lot 4): Cx:y fatty acids ★, CxOH alcohols ■ , Cx alkanes ▲ , aldehydes and amides ♦ , ketones ⬟ , **MAG** and **DAG** mono- and diacylglycerols, wax esters ● , plasticizers (cross).

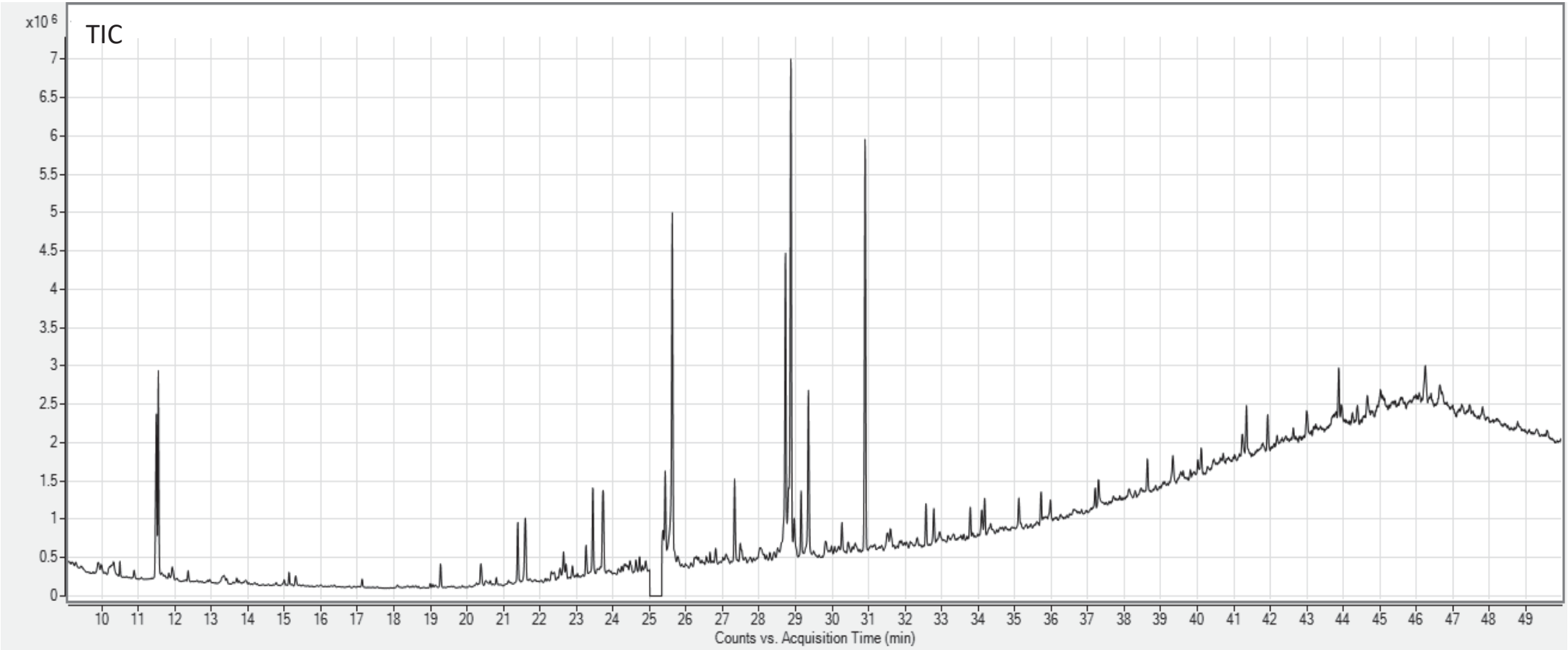


Fig. 203: Partial total ion chromatogram of the inner surface (BECS 2609) of Sample KM193-E193 (BECS 2608)

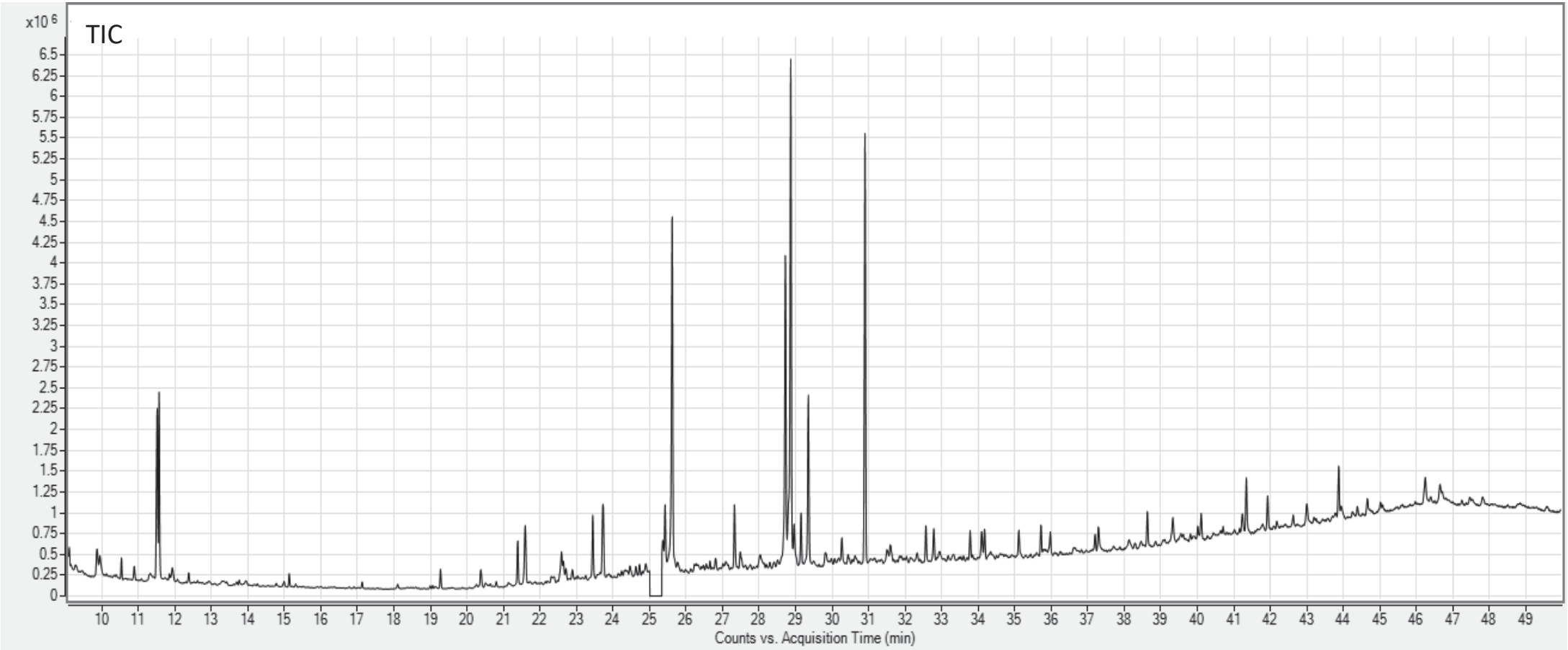


Fig. 204: Partial total ion chromatogram of the outer surface (BECS 2610) of Sample KM193-E193 (BECS 2608)

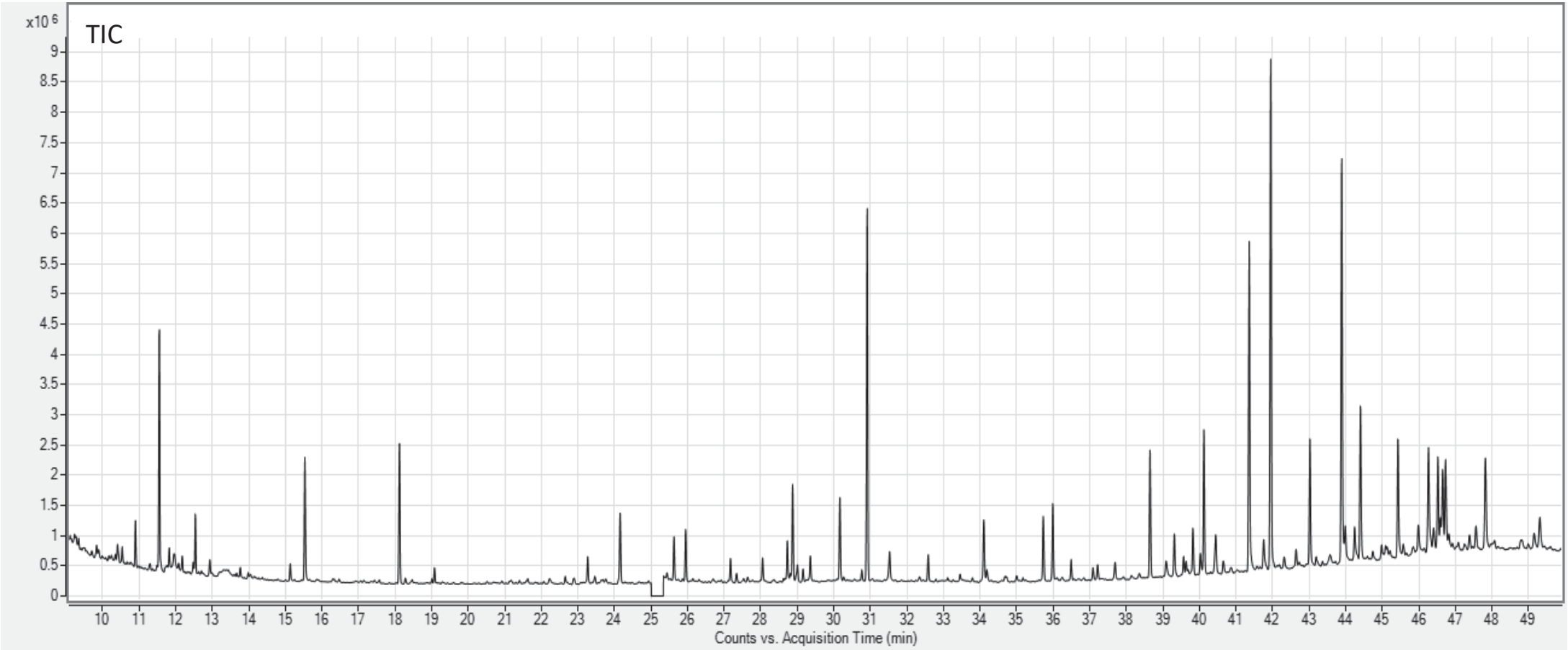


Fig. 205 : Partial total ion chromatogram of the soil sample (BECS 2598) associated with Sample KM193-E193 (BECS 2608)

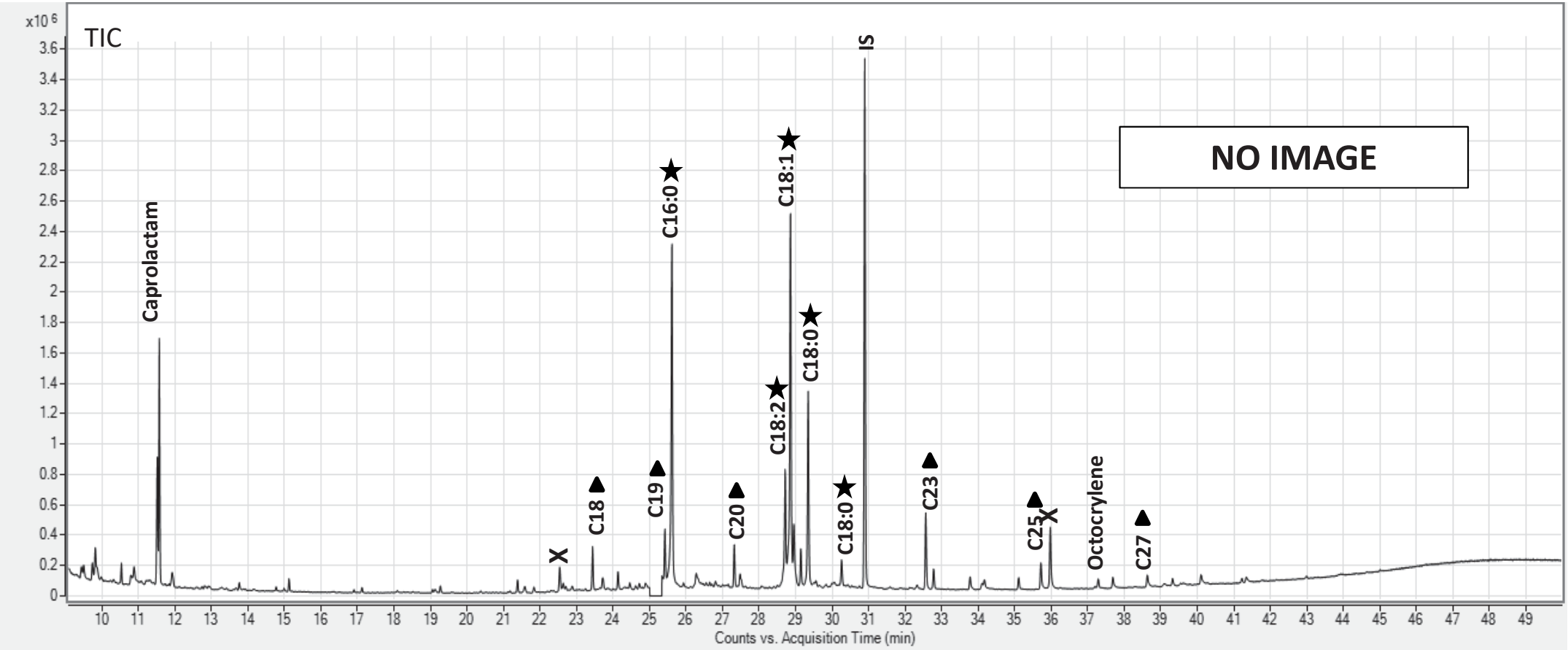


Fig. 206: Partial total ion chromatogram of Sample KM281-E281 (BECS 2761) of a footed cup in Trench Y89 (Locus 6 Lot 1): Cx:y fatty acids ★, CxOH alcohols ■ , Cx alkanes ▲ , aldehydes and amides ♦ , ketones ⬣ , **MAG** and **DAG** mono- and diacylglycerols, wax esters ● , plasticizers (cross).

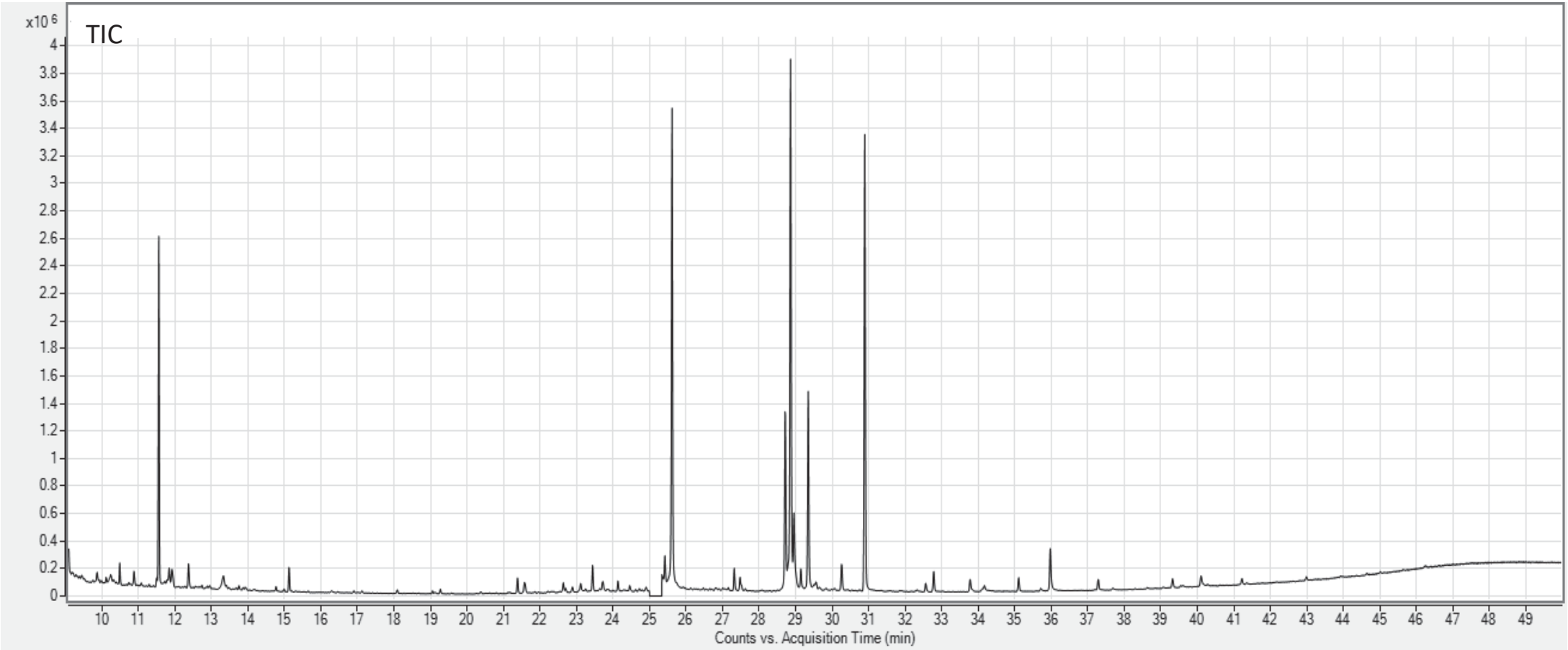


Fig. 207 : Partial total ion chromatogram of the inner surface (BECS 2762) of Sample KM281-E281 (BECS 2761)

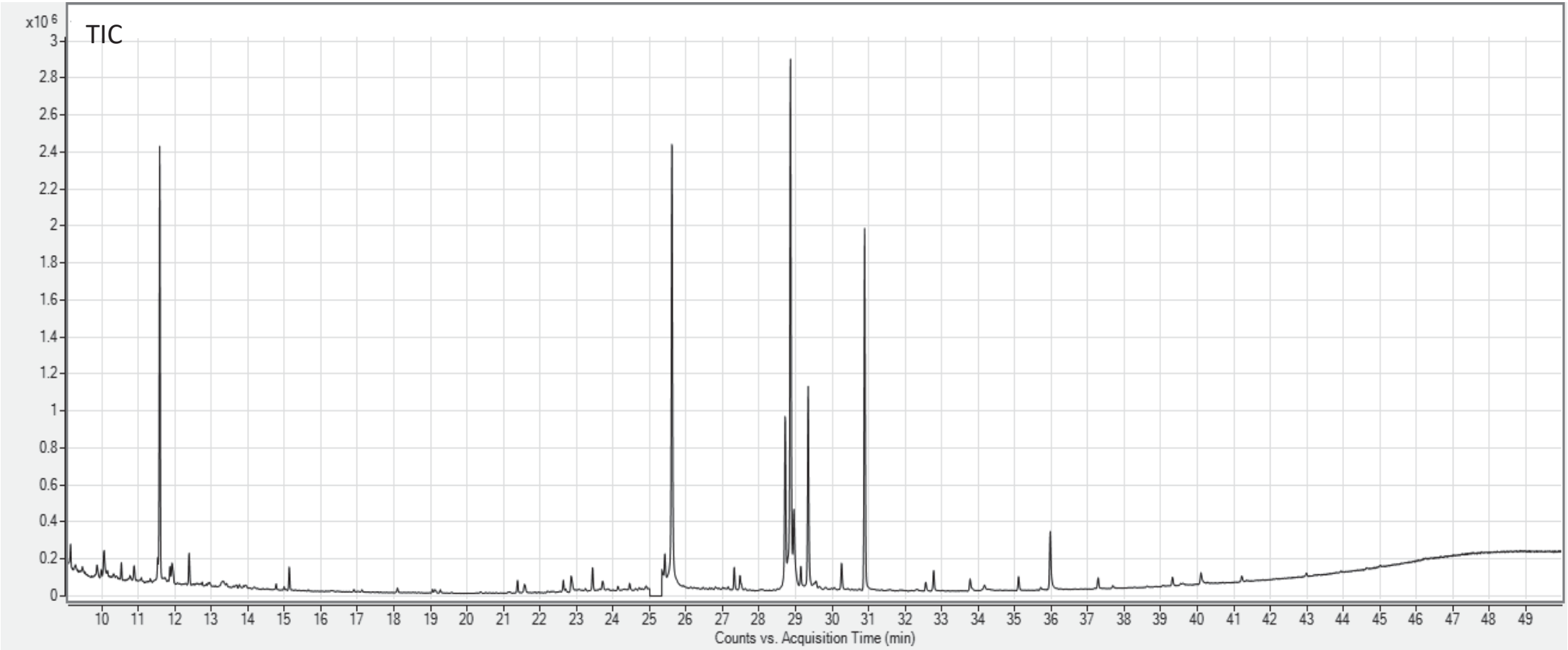


Fig. 208: Partial total ion chromatogram of the outer surface (BECS 2763) of Sample KM281-E281 (BECS 2761)

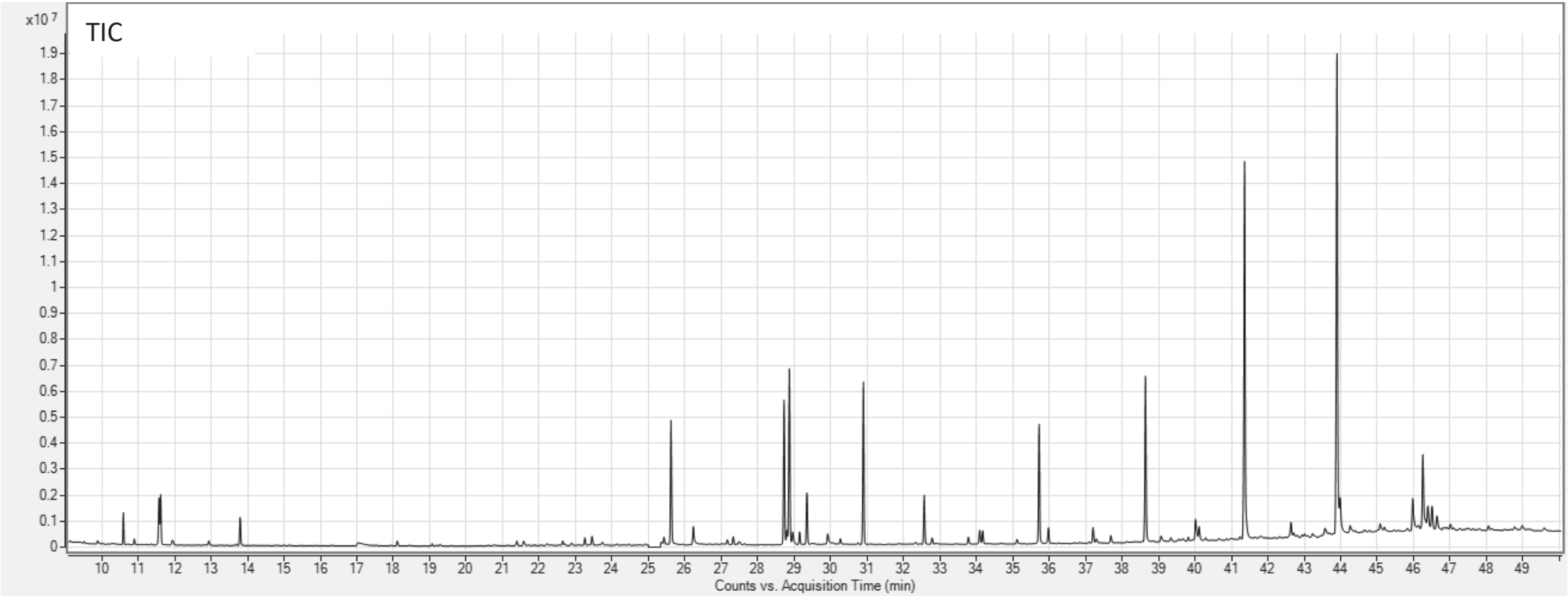


Fig. 113 : Partial total ion chromatogram of the soil sample (BECS 2745) associated with Sample KM281-E281 (BECS 2761)

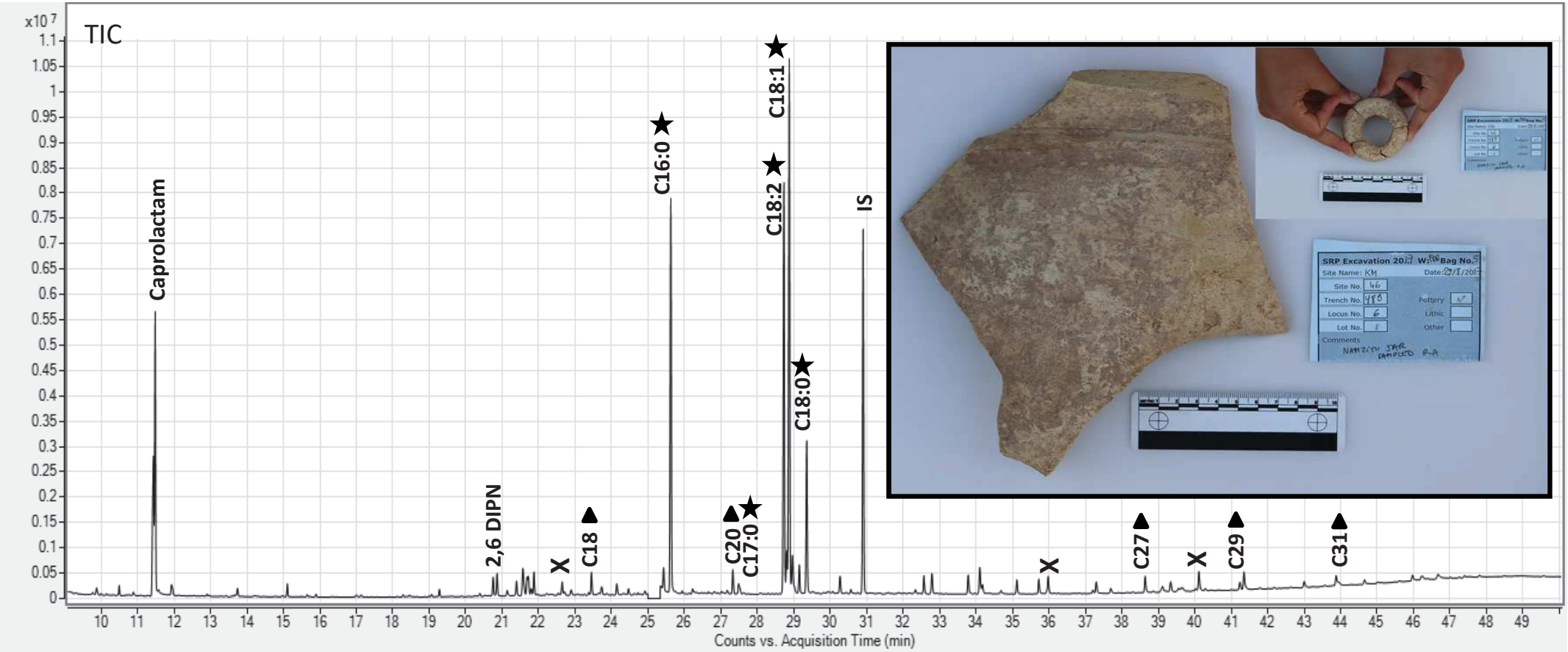


Fig. 210: Partial total ion chromatogram of Sample KM280-E280 (BECS 2752) of a namzitu in Trench Y89 (Locus 6 Lot 1): Cx:y fatty acids ★, CxOH alcohols ■ , Cx alkanes ▲ , aldehydes and amides ♦ , ketones ● , **MAG** and **DAG** mono- and diacylglycerols, wax esters ● , plasticizers (cross).

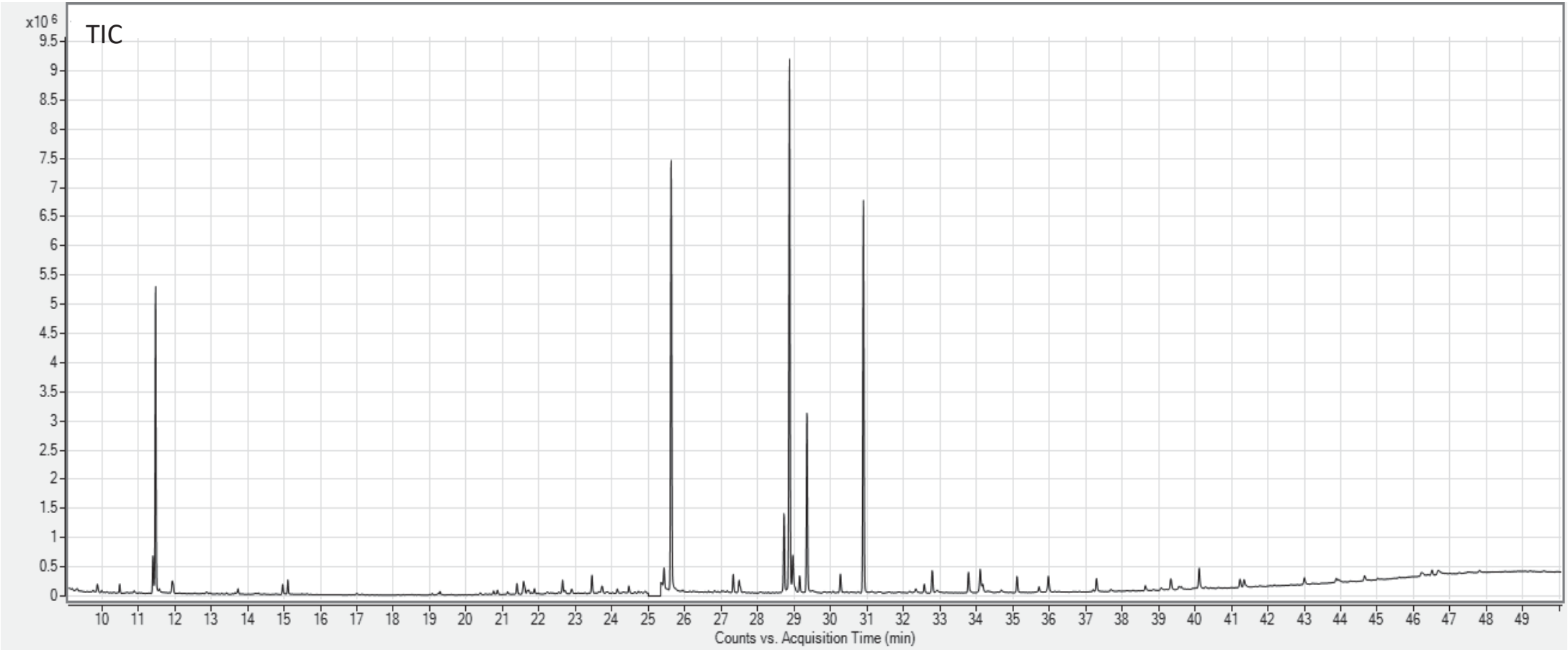


Fig. 211: Partial total ion chromatogram of the inner surface (BECS 2762) of Sample KM280-E280 (BECS 2752)

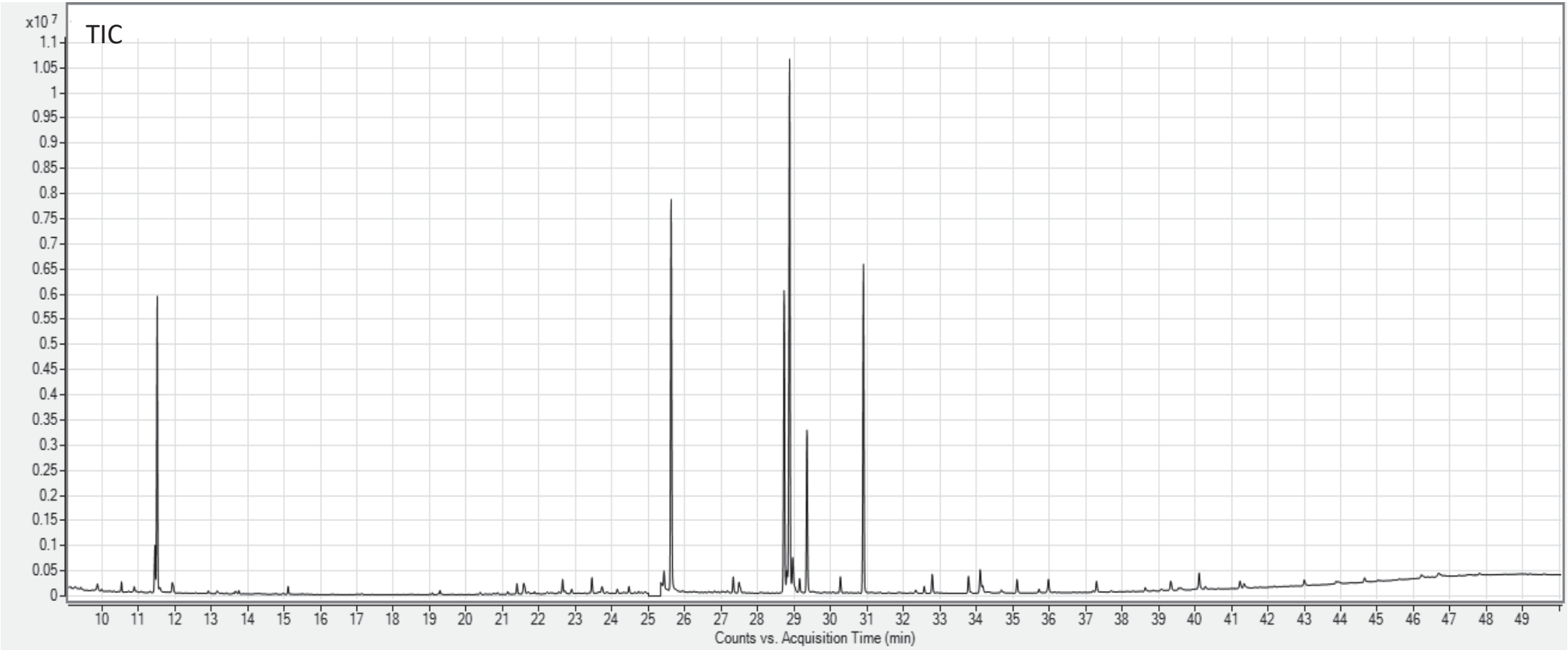


Fig. 212: Partial total ion chromatogram of the outer surface (BECS 2762) of Sample KM280-E280 (BECS 2752)

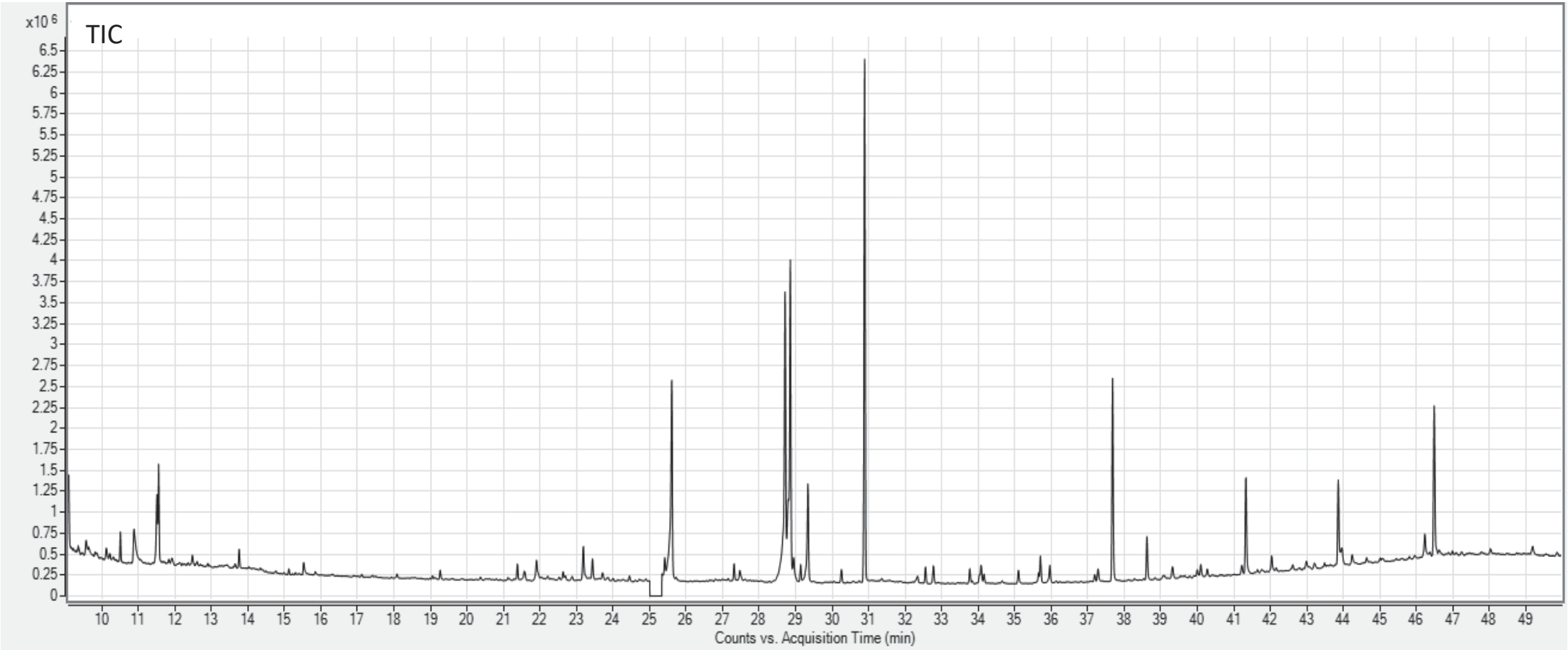


Fig. 213 : Partial total ion chromatogram of the soil sample (BECS 2820) associated with Sample KM280-E280 (BECS 2752)

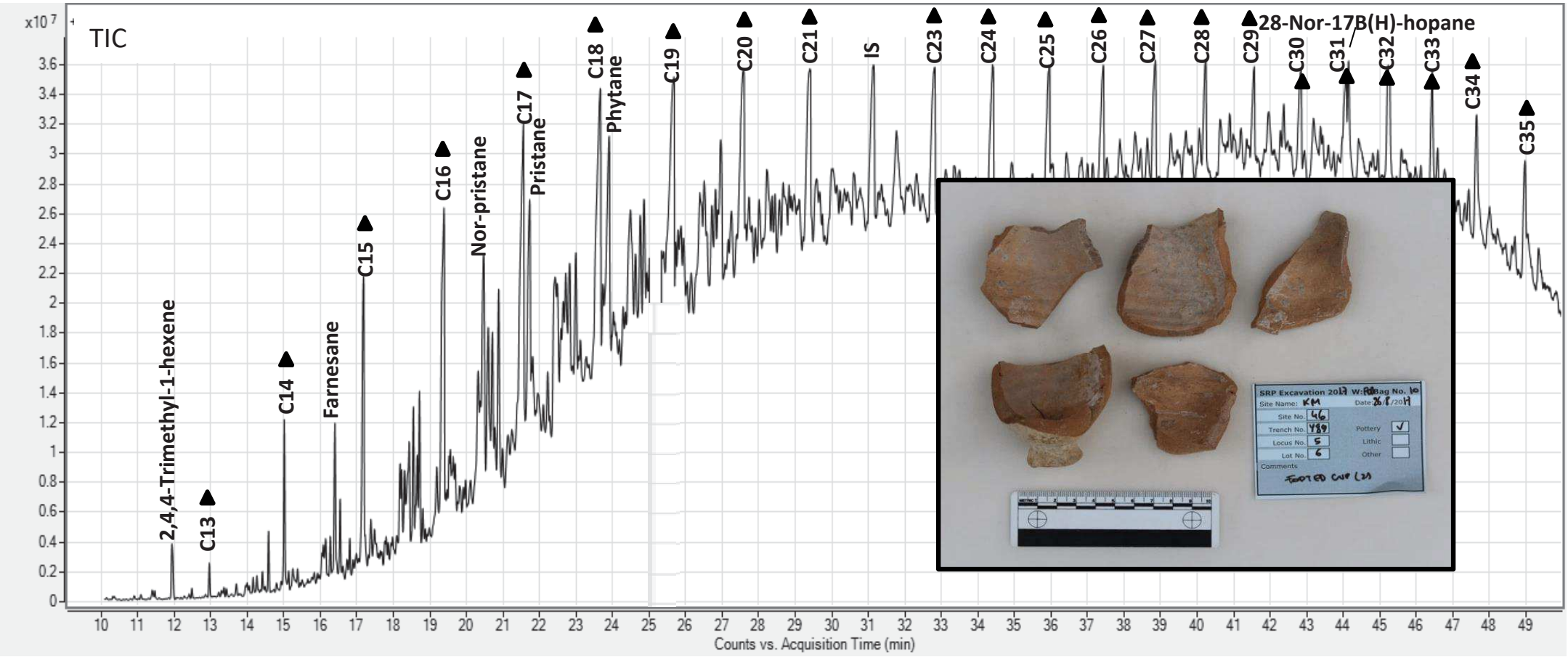


Fig. 214 : Partial total ion chromatogram of Sample KM196-E196 (BECS 2746) of a footed cup in Trench Y89 (Locus 5 Lot 6): Cx:y fatty acids ★, CxOH alcohols ■ , Cx alkanes ▲ , aldehydes and amides ♦ , ketones ● , **MAG** and **DAG** mono- and diacylglycerols, wax esters ● , plasticizers (cross).

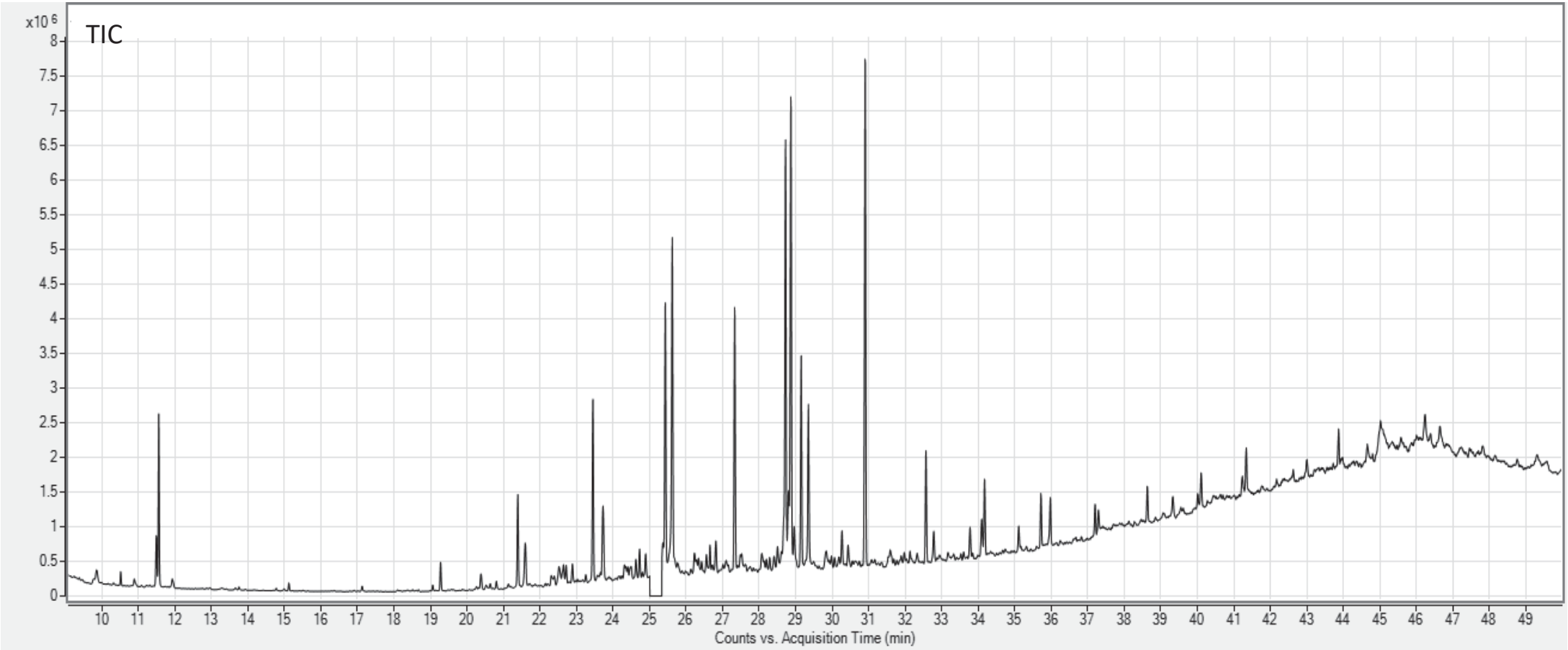


Fig. 215: Partial total ion chromatogram of the inner surface (BECS 2747) of Sample KM196-E196 (BECS 2746)

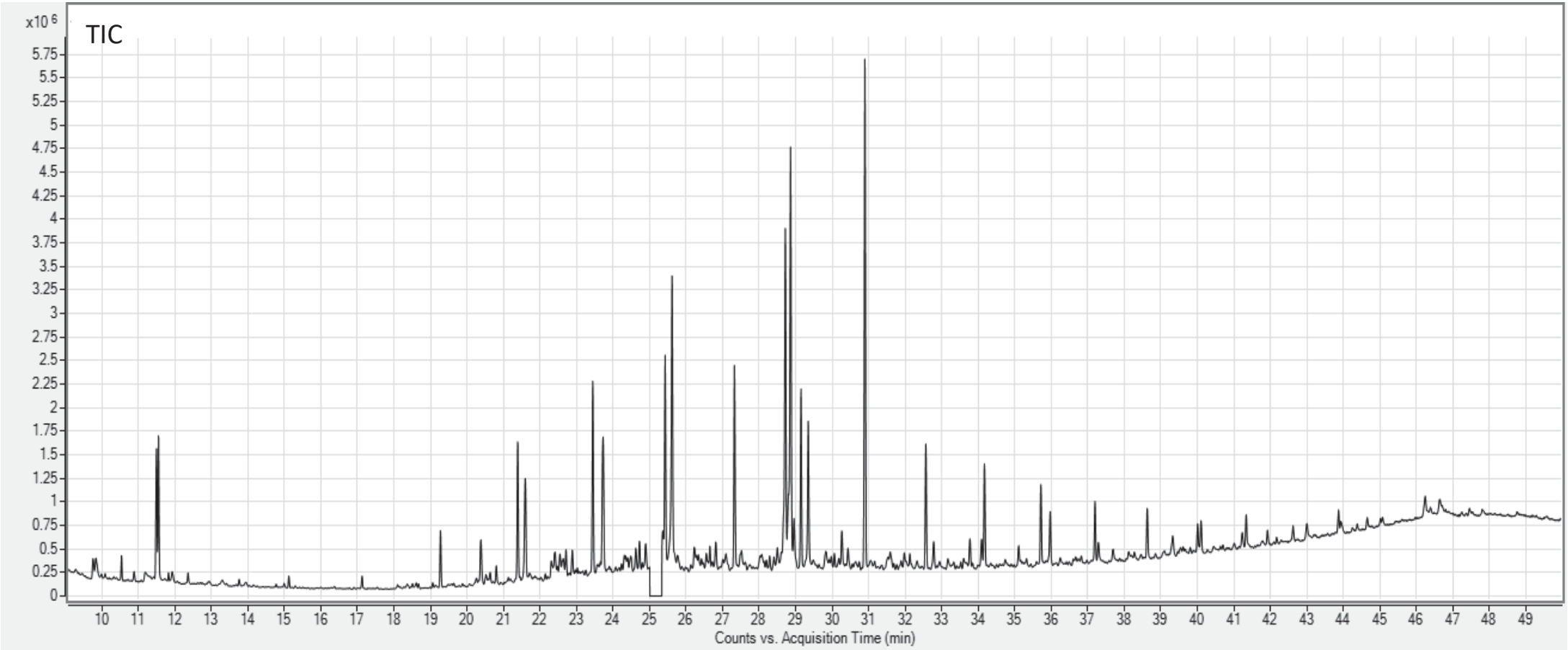


Fig. 216: Partial total ion chromatogram of the outer surface (BECS 2748) of Sample KM196-E196 (BECS 2746)

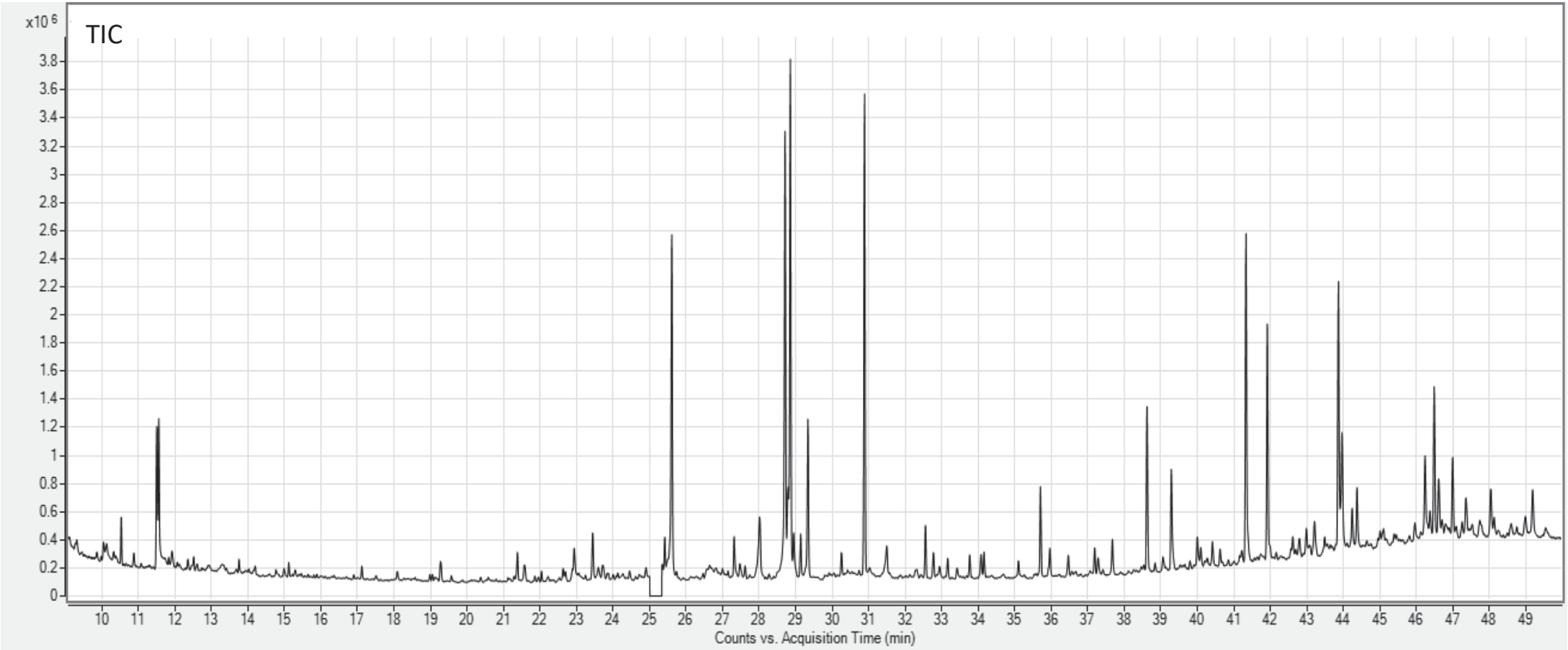


Fig. 217: Partial total ion chromatogram of the soil sample (BECS 2819) associated with Sample KM196-E196 (BECS 2746)

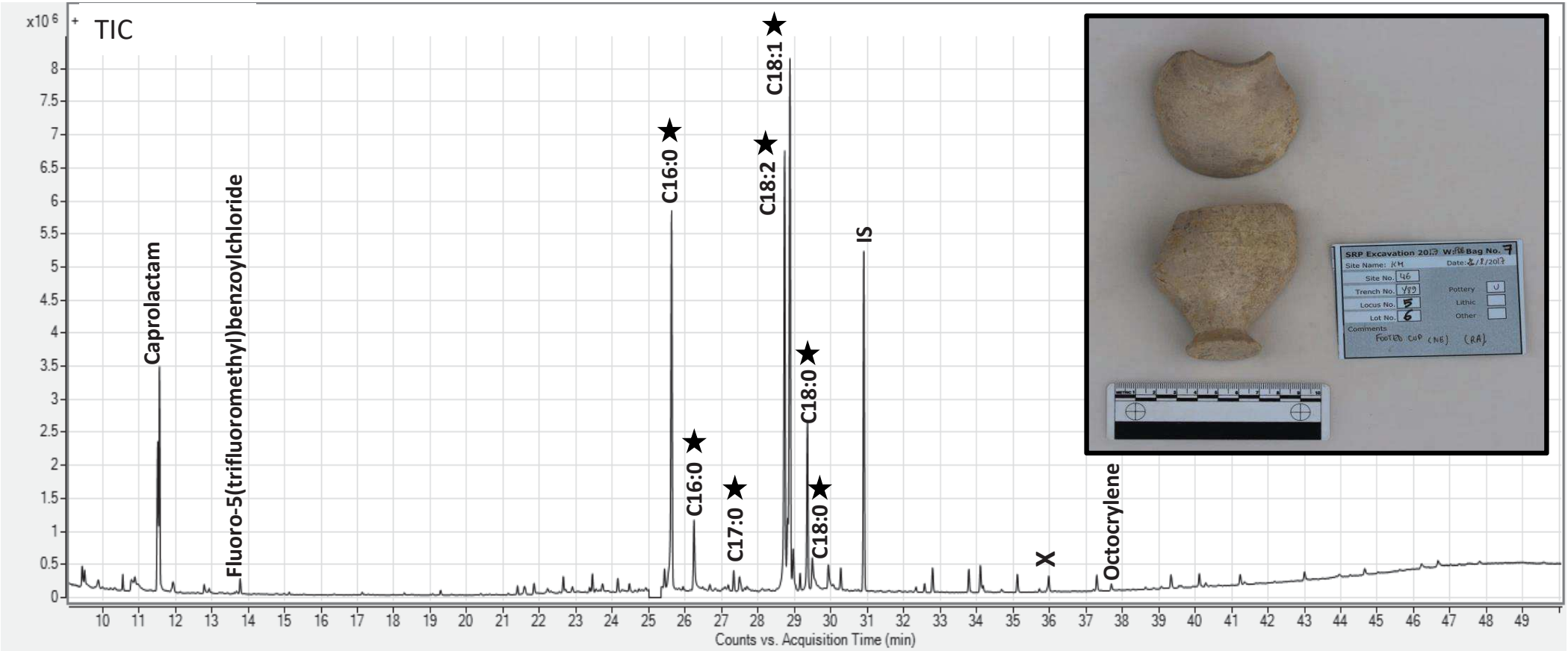


Fig. 218: Partial total ion chromatogram of Sample KM156-E156 (BECS 2742) of a footed cup in Trench Y89 (Locus 5 Lot 6): Cx:y fatty acids ★, CxOH alcohols ■ , Cx alkanes ▲ , aldehydes and amides ♦ , ketones ⬟ , **MAG** and **DAG** mono- and diacylglycerols, wax esters ● , plasticizers (cross).

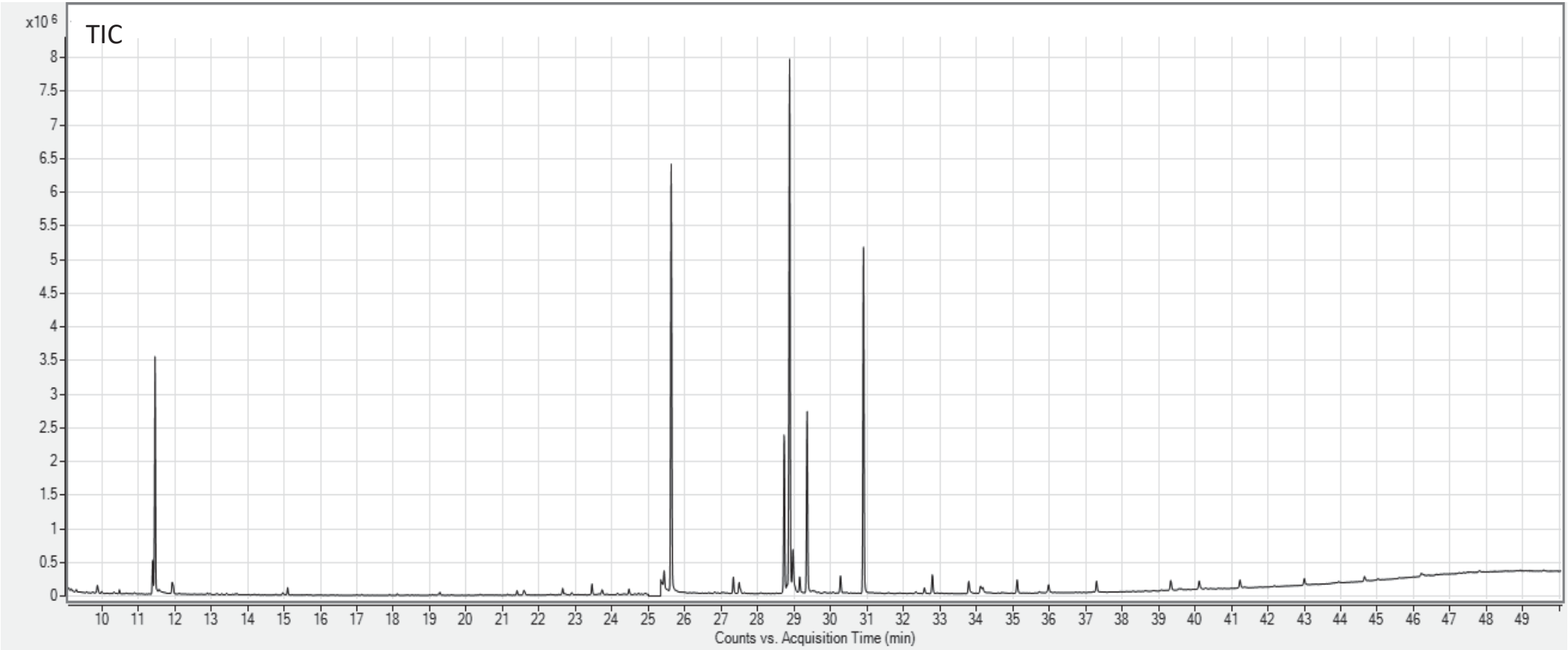


Fig. 219 : Partial total ion chromatogram of the inner surface (BECS 2743) of Sample KM156-E156 (BECS 2742)

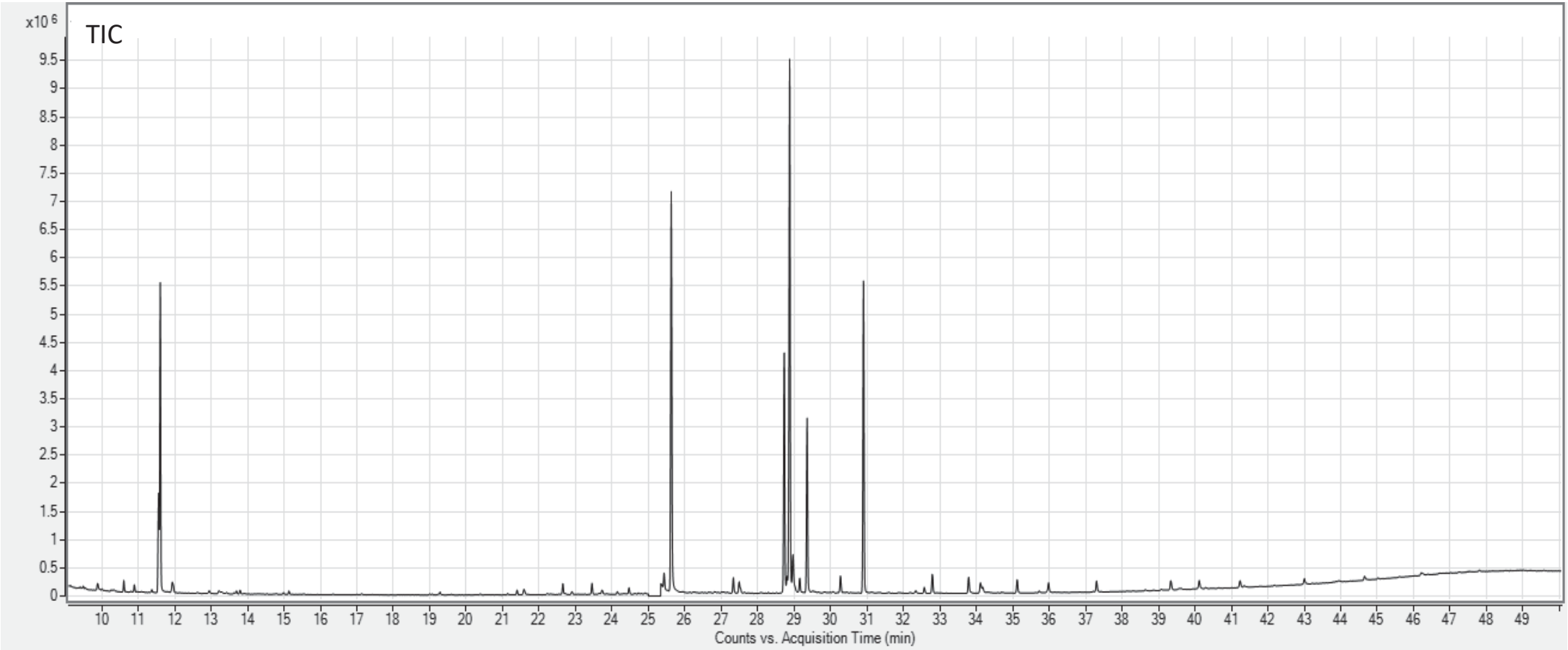


Fig. 220 : Partial total ion chromatogram of the outer surface (BECS 2744) of Sample KM156-E156 (BECS 2742)

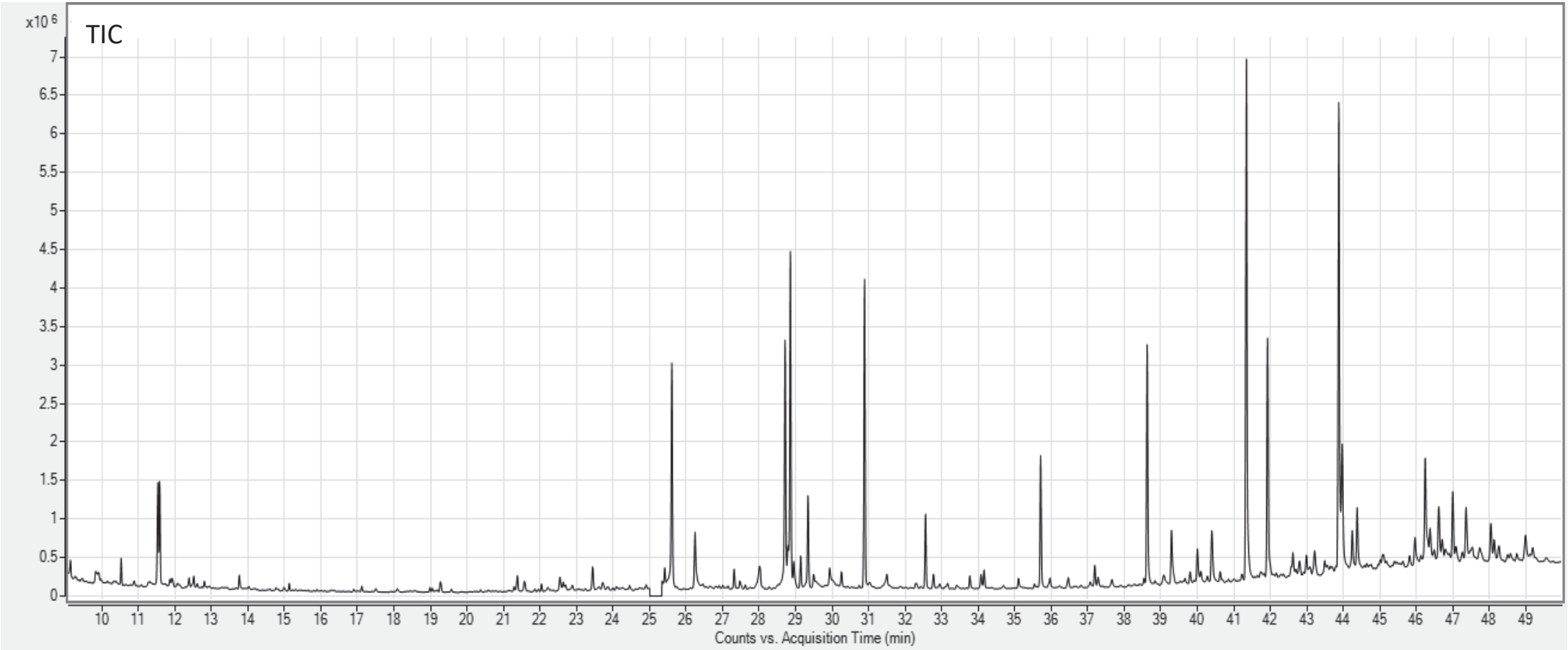


Fig. 221 : Partial total ion chromatogram of the soil sample (BECS 2816) associated with Sample KM156-E156 (BECS 2742)

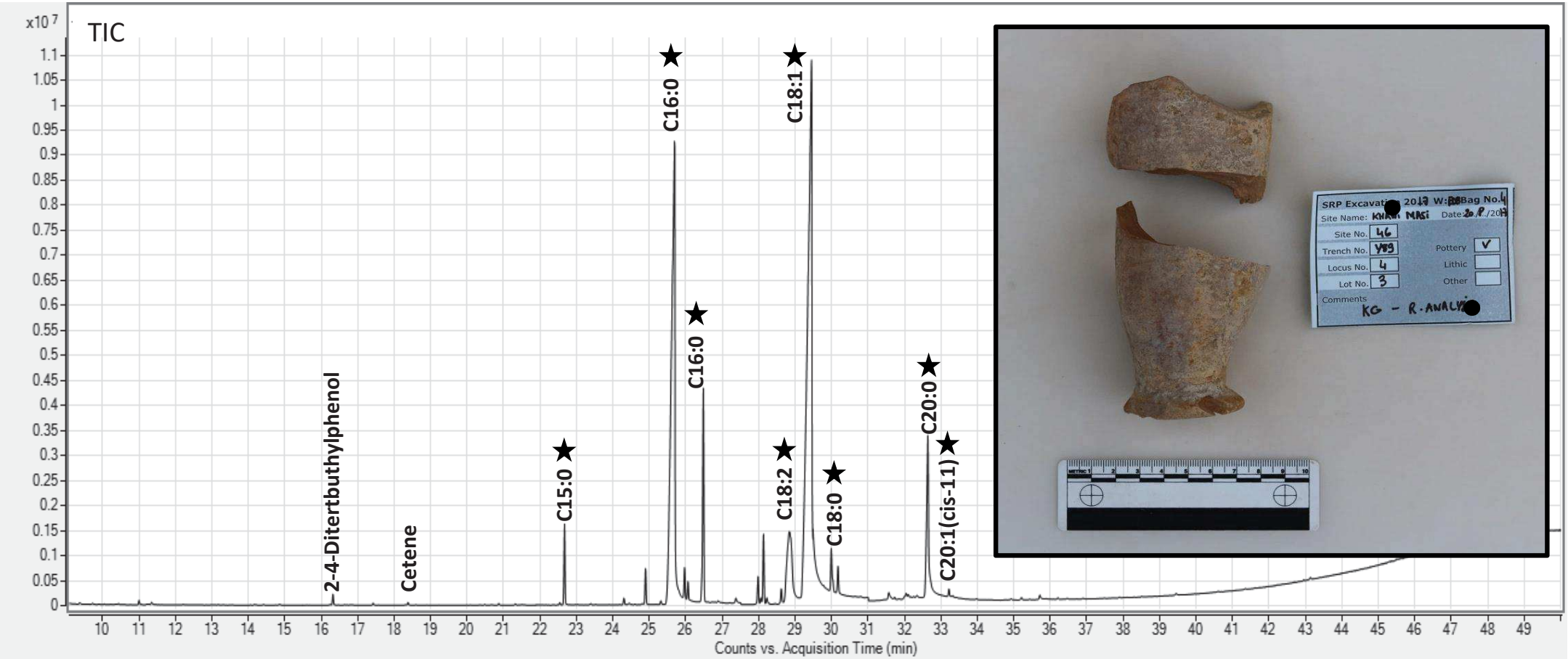


Fig. 222 : Partial total ion chromatogram of Sample KM148-E148 (BECS 2328) of a goblet in Trench Y89 (Locus 4 Lot 3): Cx:y fatty acids ★, CxOH alcohols ■ , Cx alkanes ▲ , aldehydes and amides ♦ , ketones ⬟ , **MAG** and **DAG** mono- and diacylglycerols, wax esters ● , plasticizers (cross).

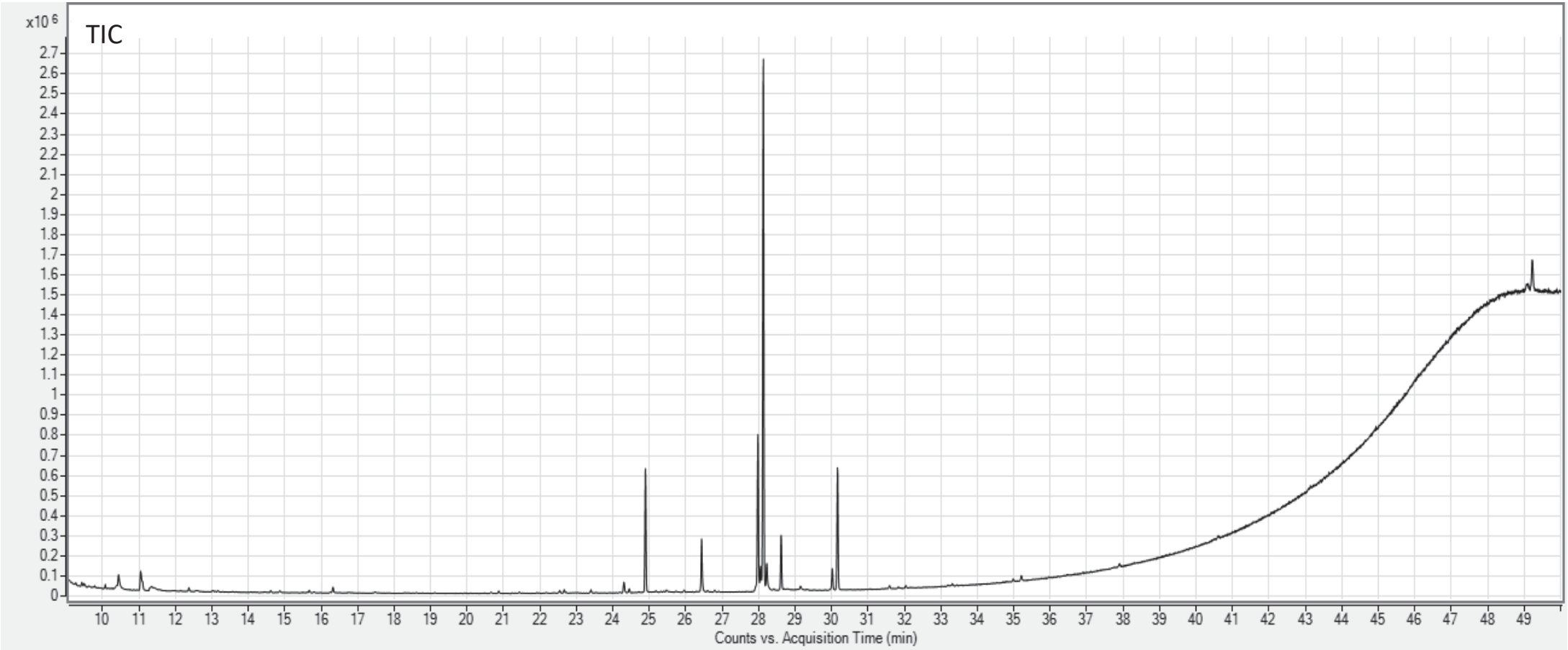


Fig. 223: Partial total ion chromatogram of the inner surface (BECS 2329) of Sample KM148-E148 (BECS 2328)

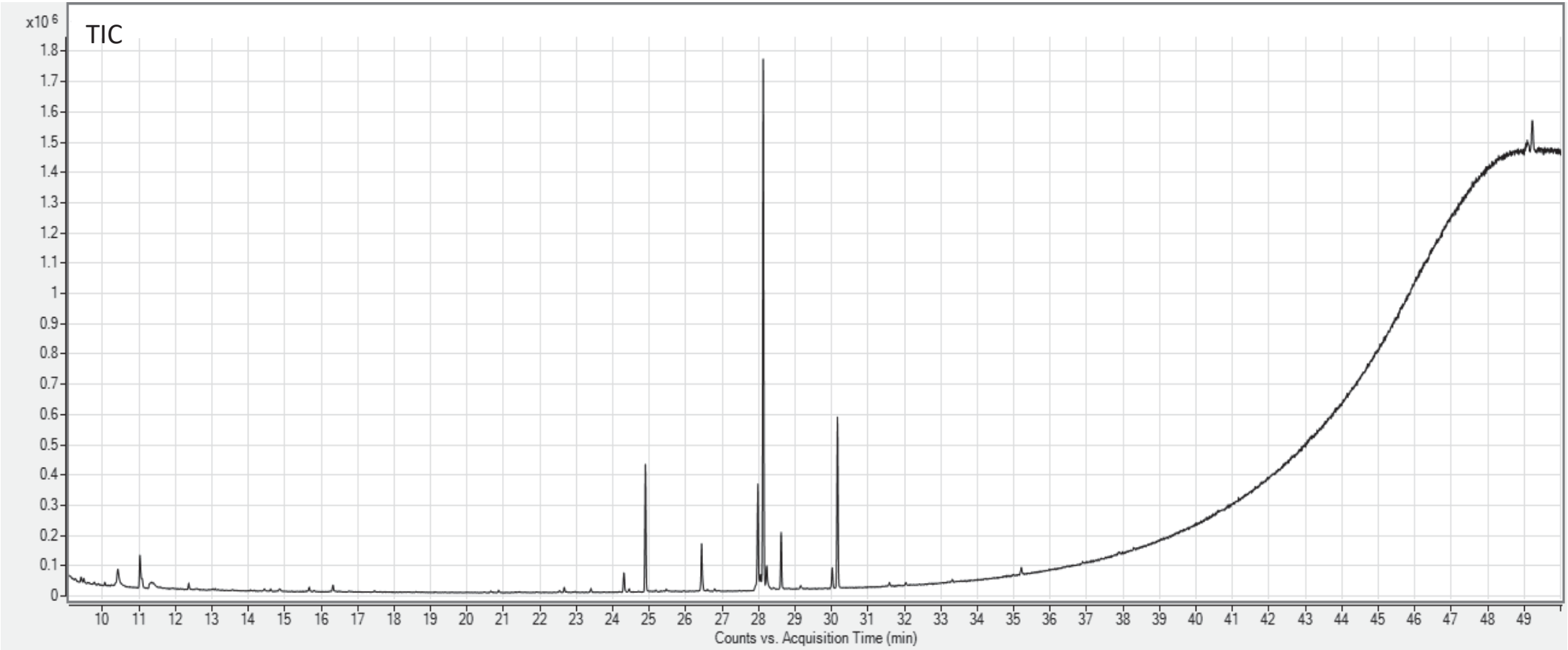


Fig. 224: Partial total ion chromatogram of the outer surface (BECS 2330) of Sample KM148-E148 (BECS 2328)

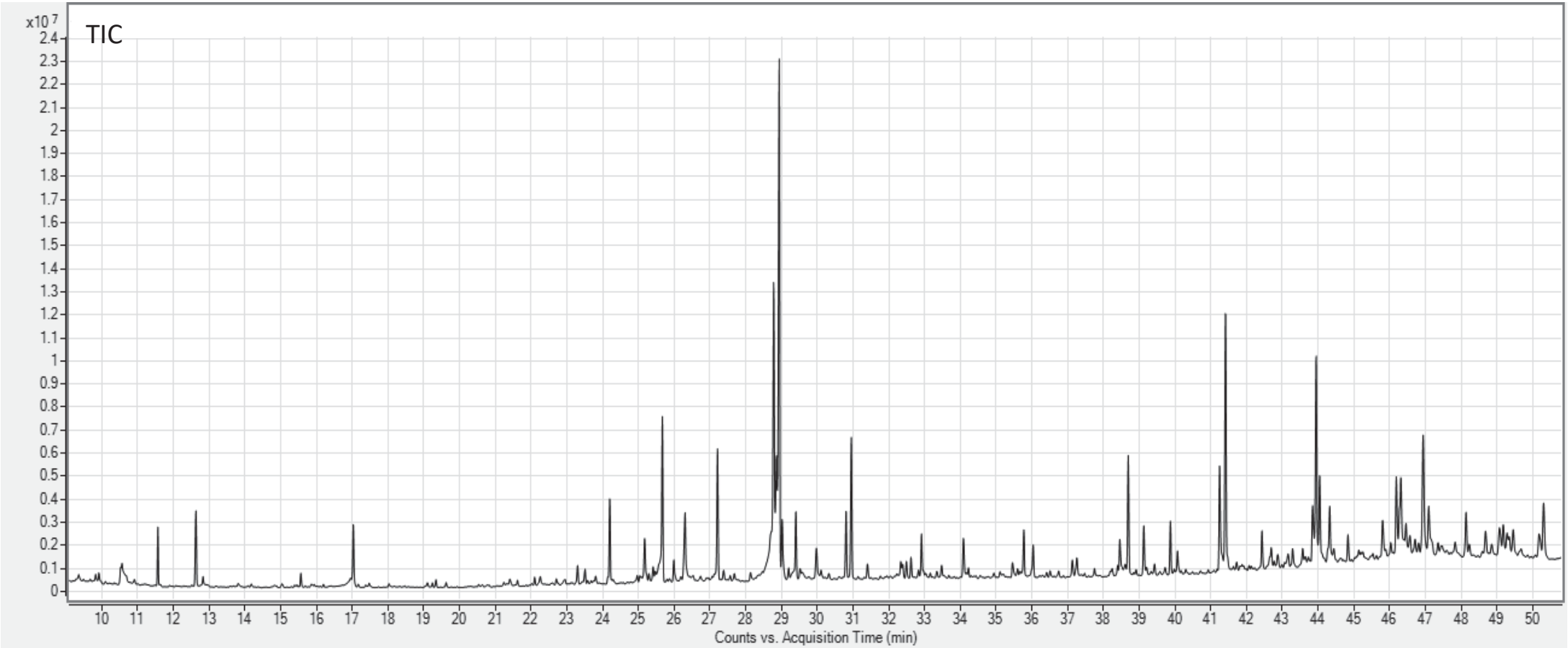


Fig. 225 : Partial total ion chromatogram of the soil sample (BECS 2302) associated with Sample KM148-E148 (BECS 2328)

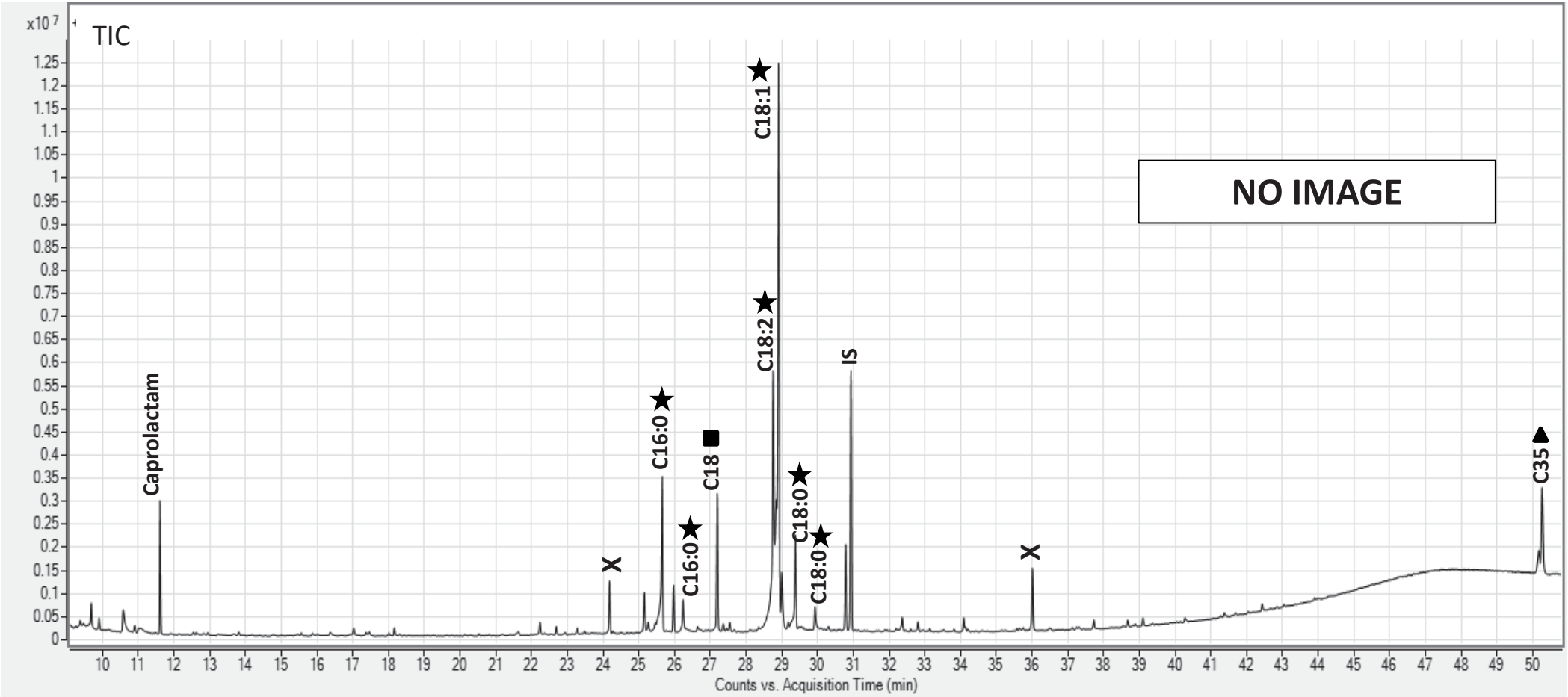


Fig. 226: Partial total ion chromatogram of Sample KM149-E149 (BECS 2332) of a large elongated vessel in Trench V85 (Locus 103 Lot 1): Cx:y fatty acids ★, CxOH alcohols ■ , Cx alkanes ▲ , aldehydes and amides ♦ , ketones ⬟ , **MAG** and **DAG** mono- and diacylglycerols, wax esters ● , plasticizers (cross).

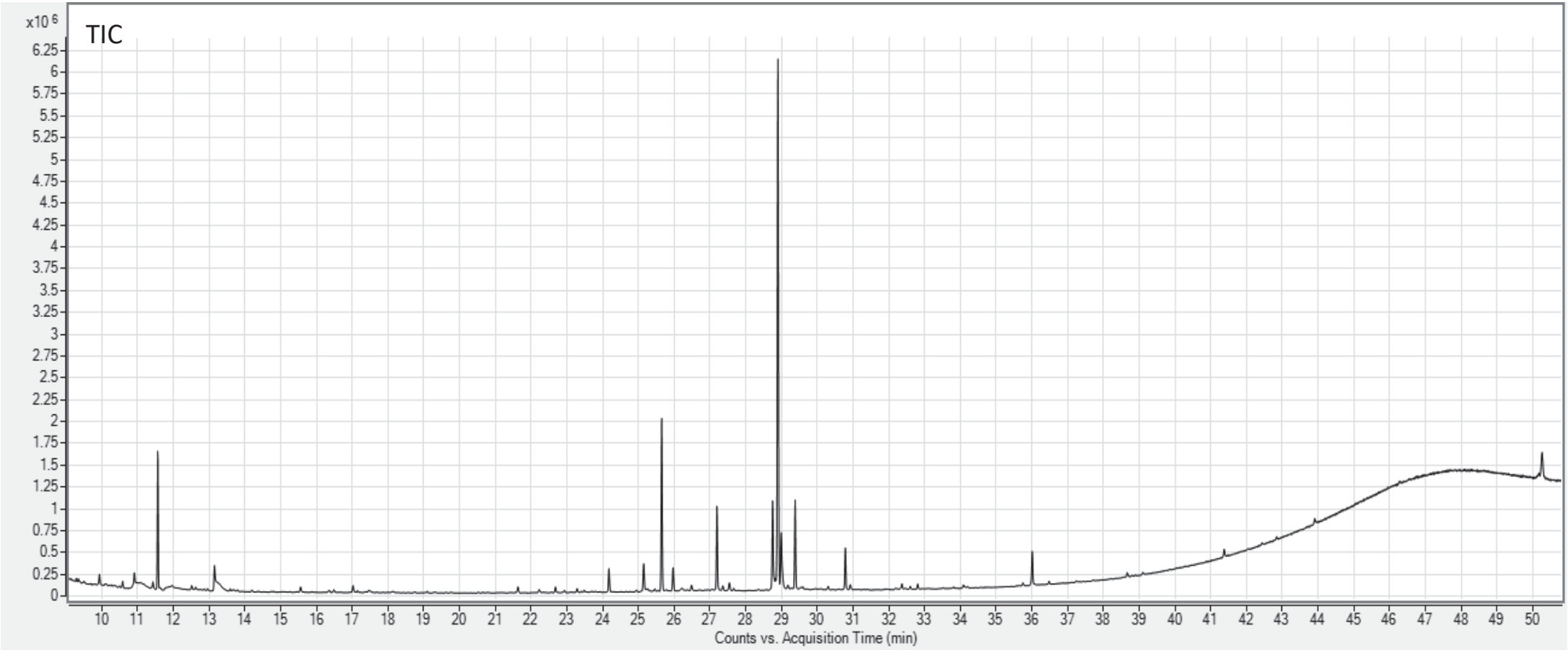


Fig. 227: Partial total ion chromatogram of the inner surface (BECS 2333) of Sample KM149-E149 (BECS 2332)

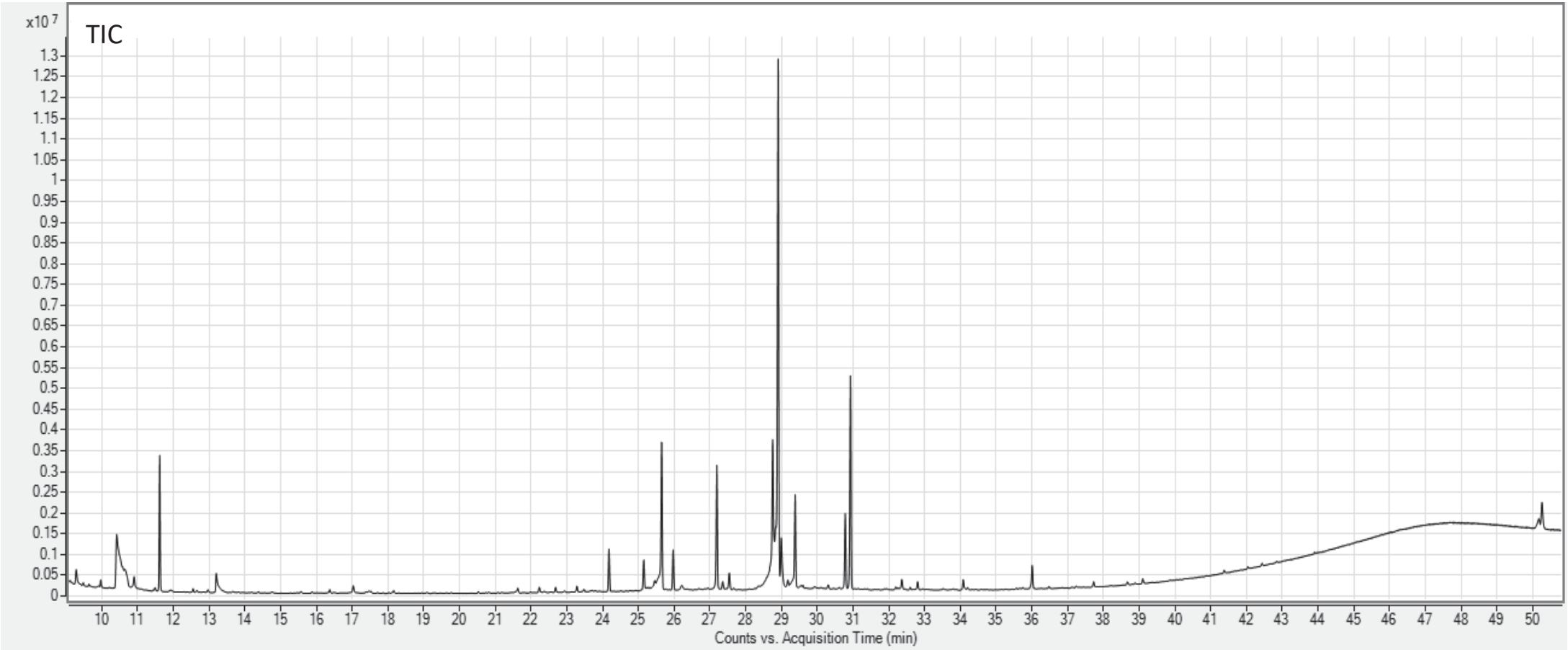


Fig. 228 : Partial total ion chromatogram of the outer surface (BECS 2334) of Sample KM149-E149 (BECS 2332)

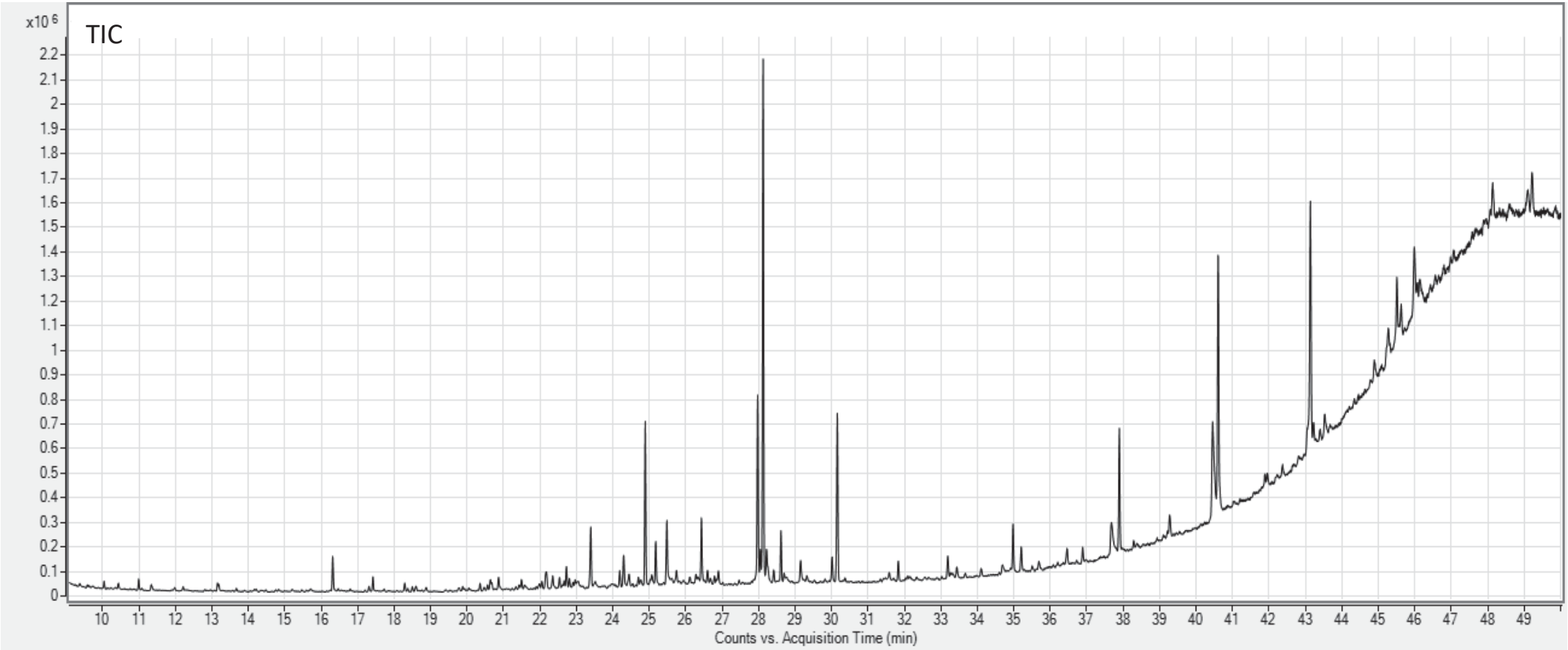


Fig. 229: Partial total ion chromatogram of the soil sample (BECS 2335) associated with Sample KM149-E149 (BECS 2332)

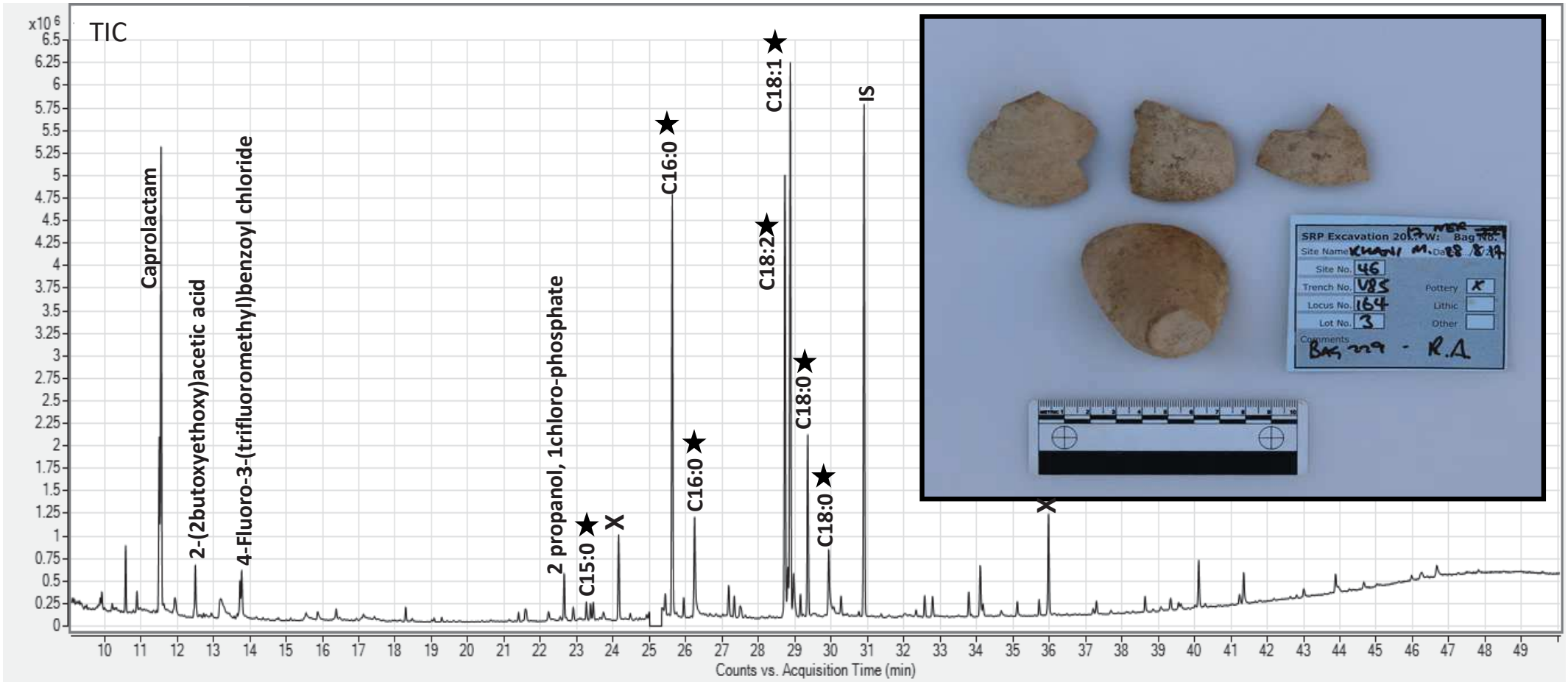


Fig. 230 : Partial total ion chromatogram of Sample KM154-E154 (BECS 2739) of a footed cup in Trench V85 (Locus 164 Lot 3): Cx:y fatty acids ★, CxOH alcohols ■ , Cx alkanes ▲ , aldehydes and amides ♦ , ketones ● , **MAG** and **DAG** mono- and diacylglycerols, wax esters ● , plasticizers (cross).

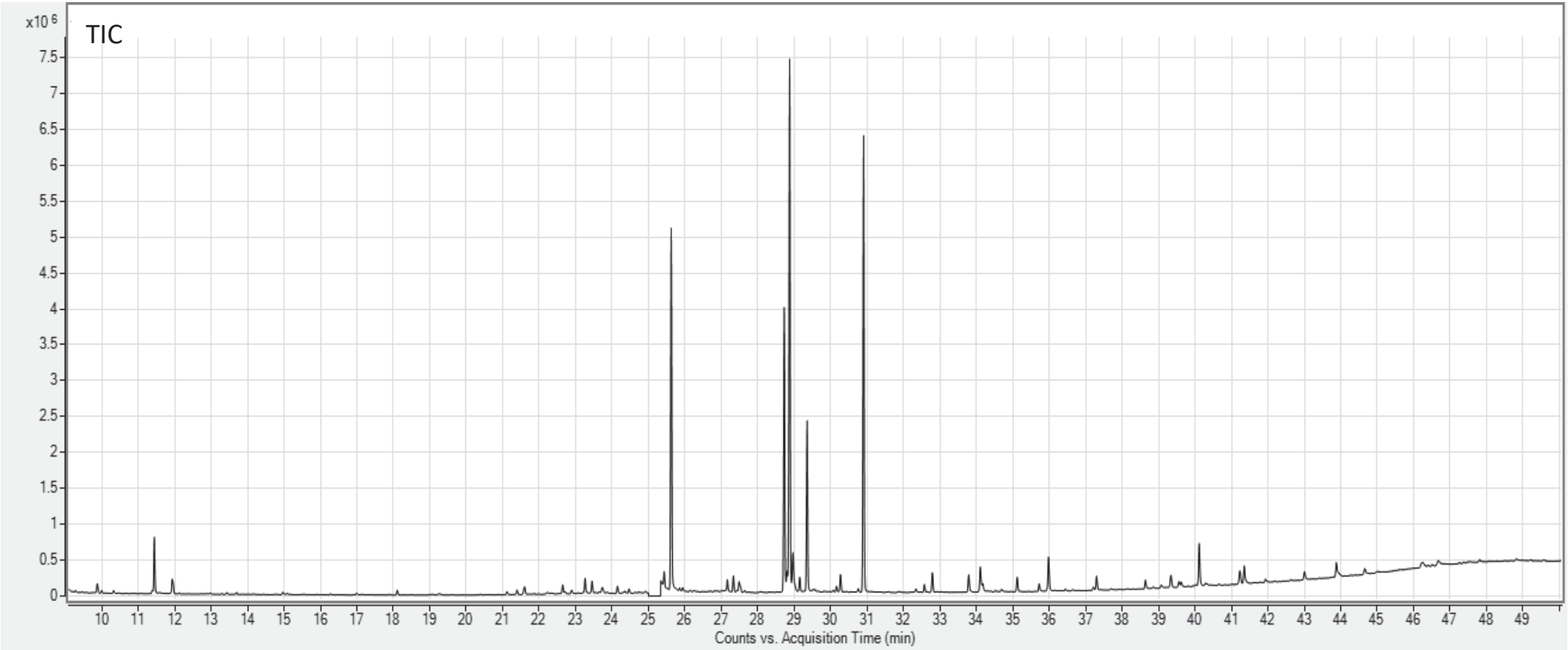


Fig. 231 : Partial total ion chromatogram of the inner surface (BECS 2740) of Sample KM154-E154 (BECS 2739)

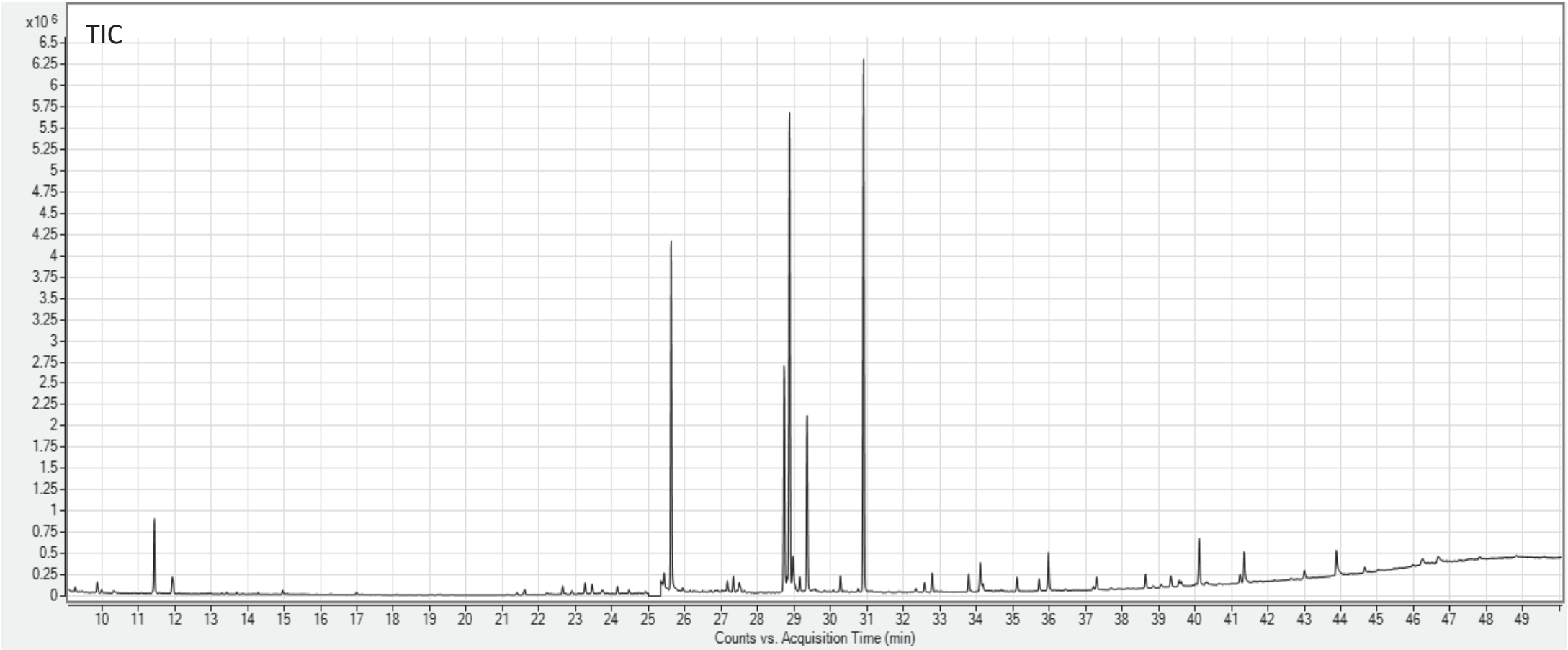


Fig. 232 : Partial total ion chromatogram of the outer surface (BECS 2741) of Sample KM154-E154 (BECS 2739)

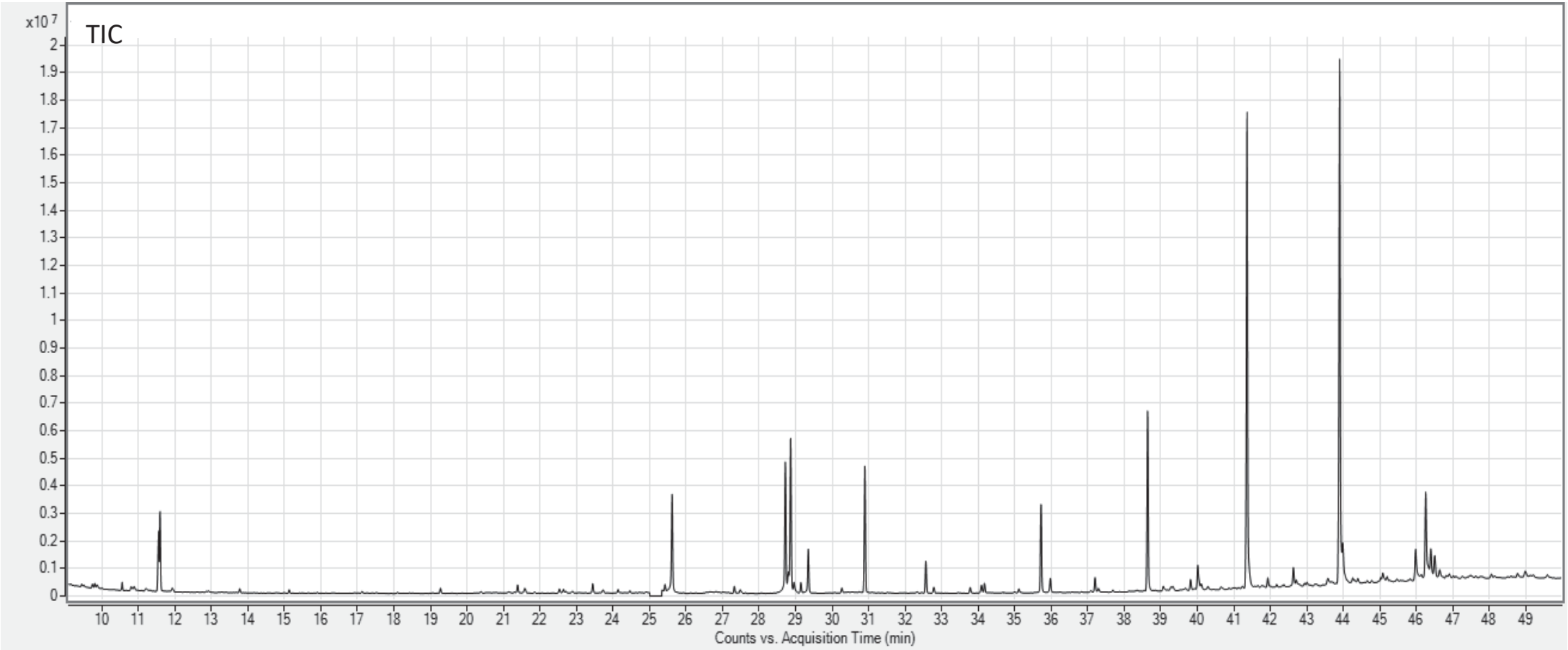


Fig. 233: Partial total ion chromatogram of the soil sample (BECS 2597) associated with Sample KM154-E154 (BECS 2739)

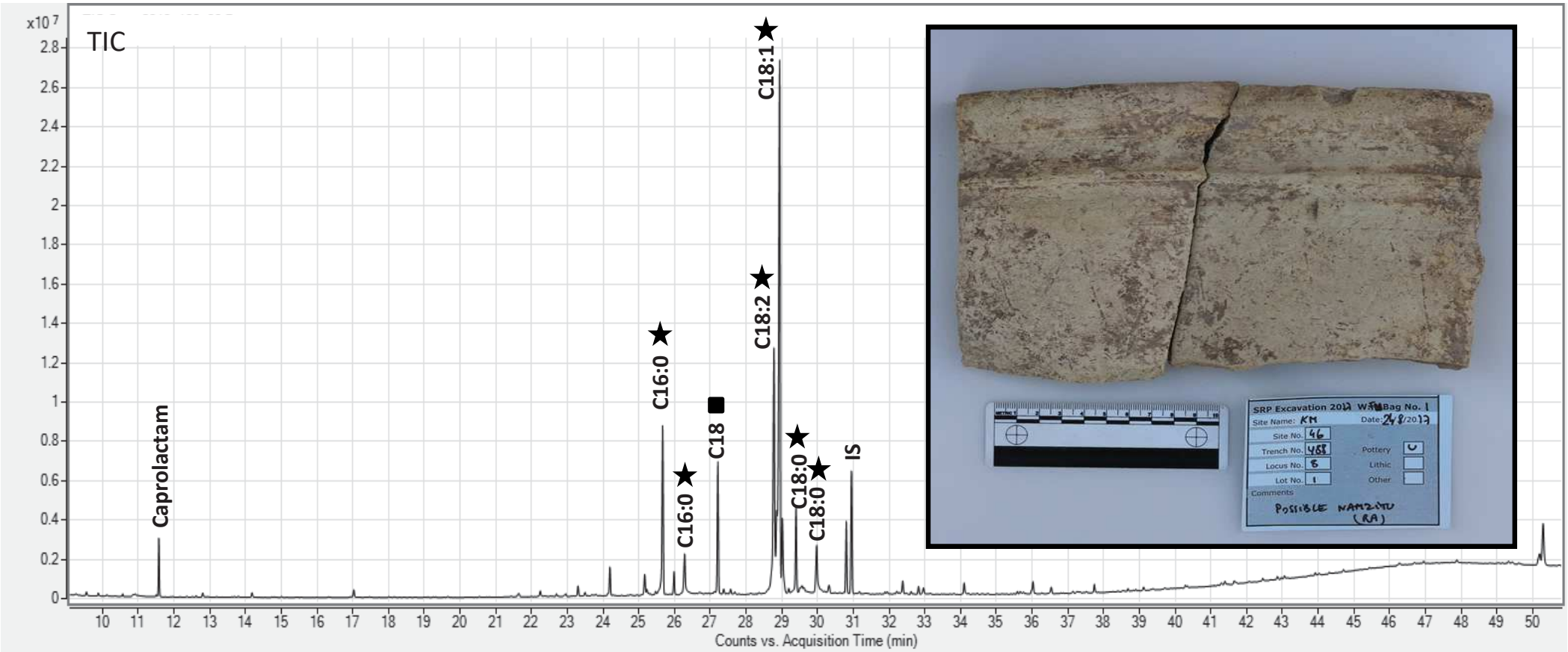


Fig. 234 : Partial total ion chromatogram of Sample KM130-E130 (BECS 2313) of a footed cup in Trench Y88 (Locus 108 Lot 1): Cx:y fatty acids ★, CxOH alcohols ■ , Cx alkanes ▲ , aldehydes and amides ♦ , ketones ⬢ , **MAG** and **DAG** mono- and diacylglycerols, wax esters ● , plasticizers (cross).

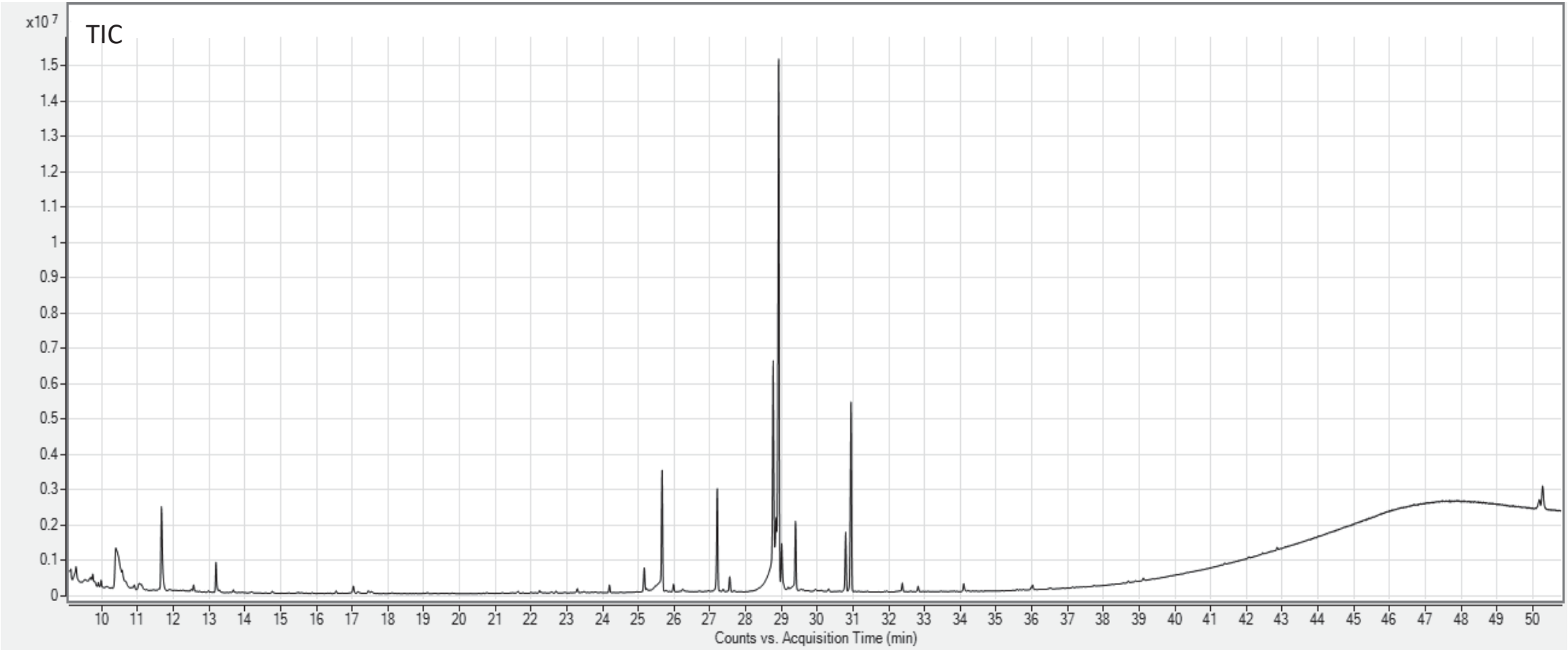


Fig. 235: Partial total ion chromatogram of the inner surface (BECS 2314) of Sample KM130-E130 (BECS 2313)

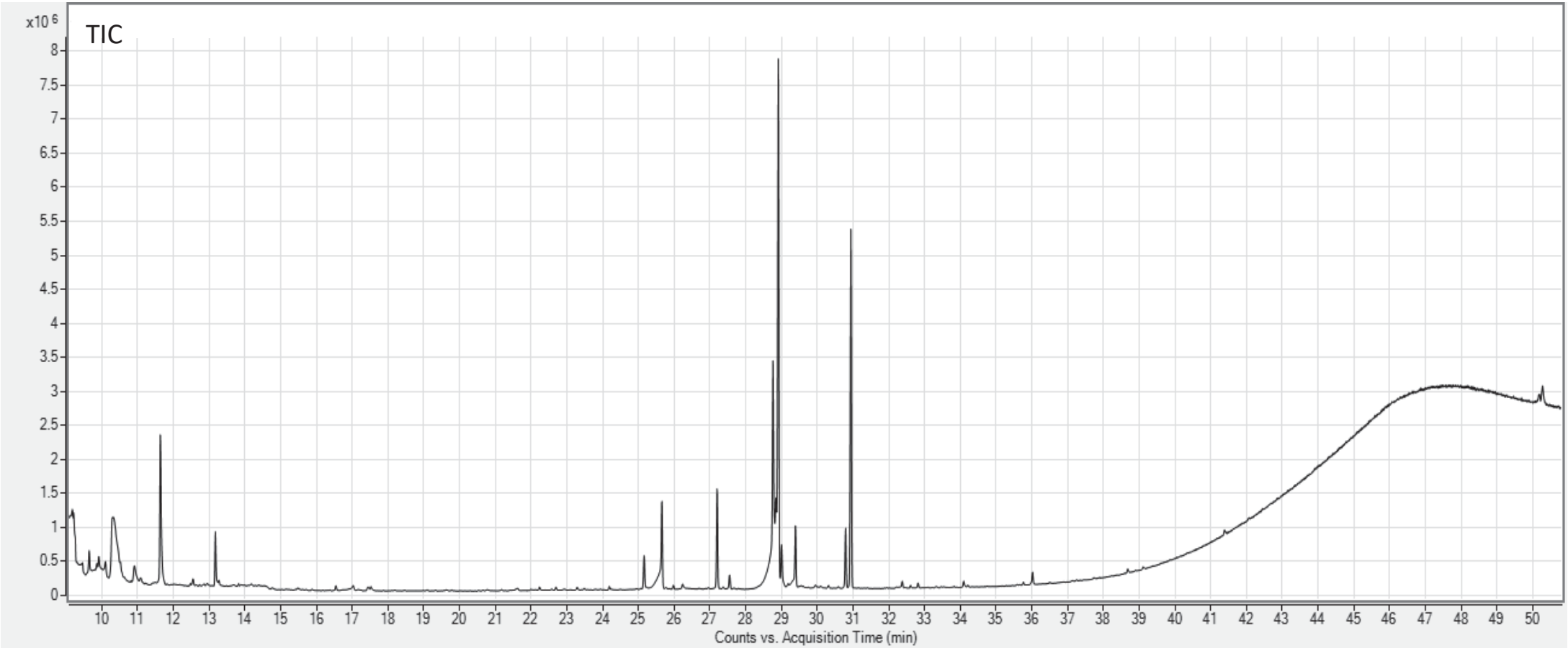


Fig. 236 : Partial total ion chromatogram of the outer surface (BECS 2315) of Sample KM130-E130 (BECS 2313)

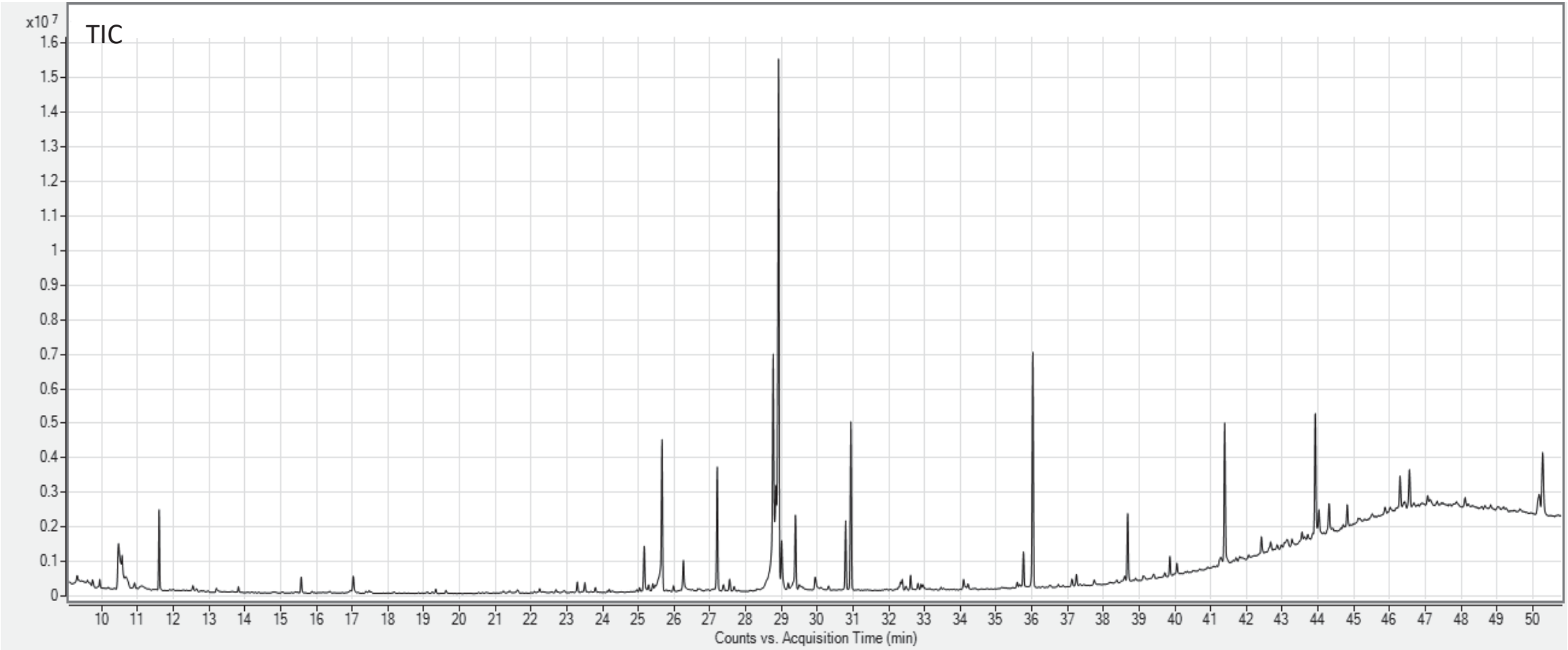


Fig. 237: Partial total ion chromatogram of the soil sample (BECS 2316) associated with Sample KM130-E130 (BECS 2313)

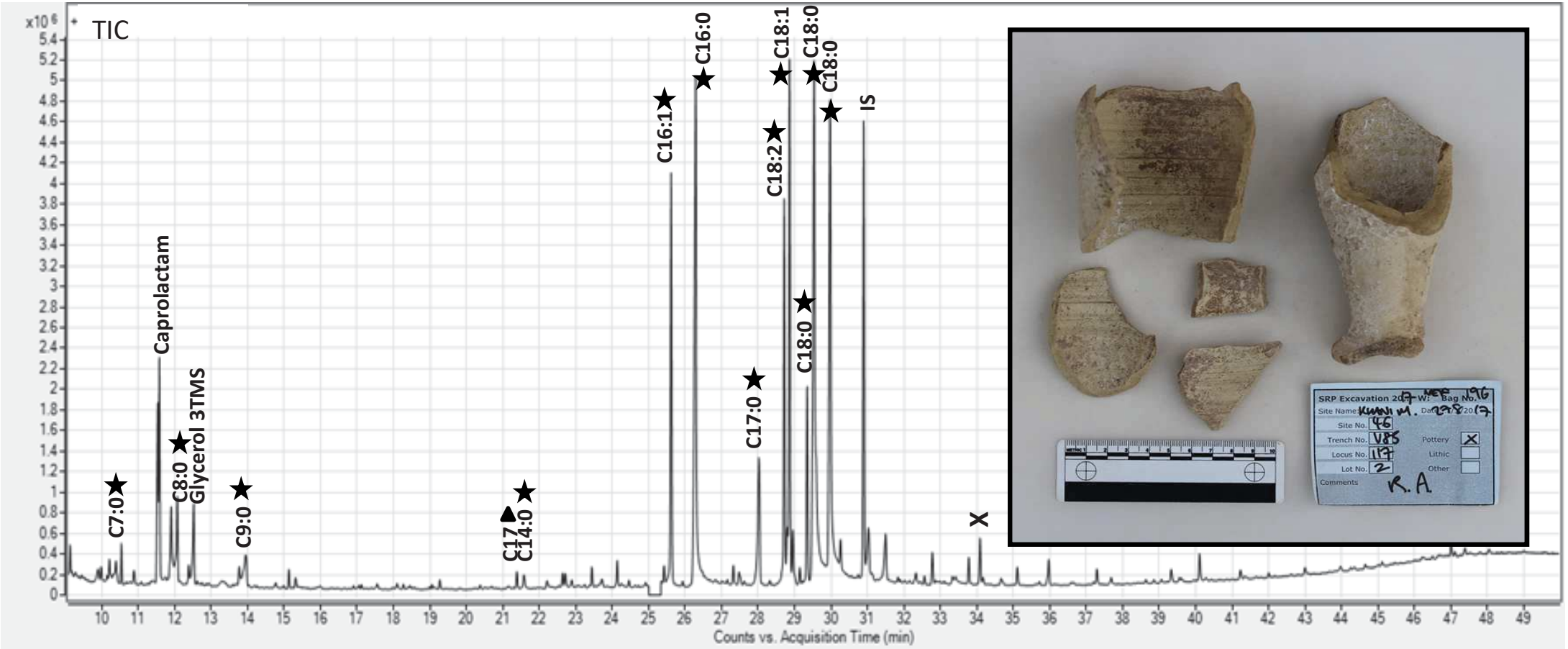


Fig. 238 : Partial total ion chromatogram of Sample KM203-E203 (BECS 2758) of a goblet in Trench V85 (Locus 117 Lot 2): Cx:y fatty acids ★, CxOH alcohols ■ , Cx alkanes ▲ , aldehydes and amides ♦ , ketones ⬟ , **MAG** and **DAG** mono- and diacylglycerols, wax esters ● , plasticizers (cross).

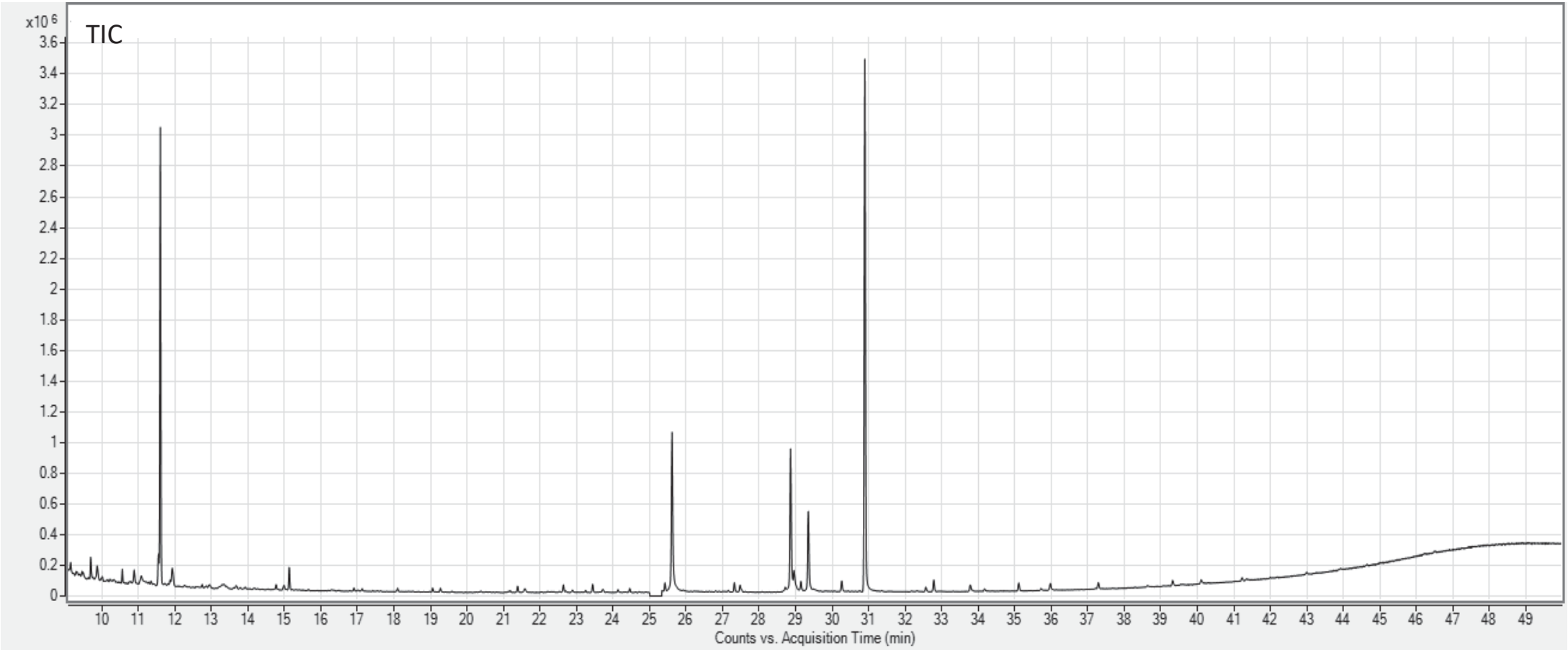


Fig. 239: Partial total ion chromatogram of the inner surface (BECS 2759) of Sample KM203-E203 (BECS 2758)

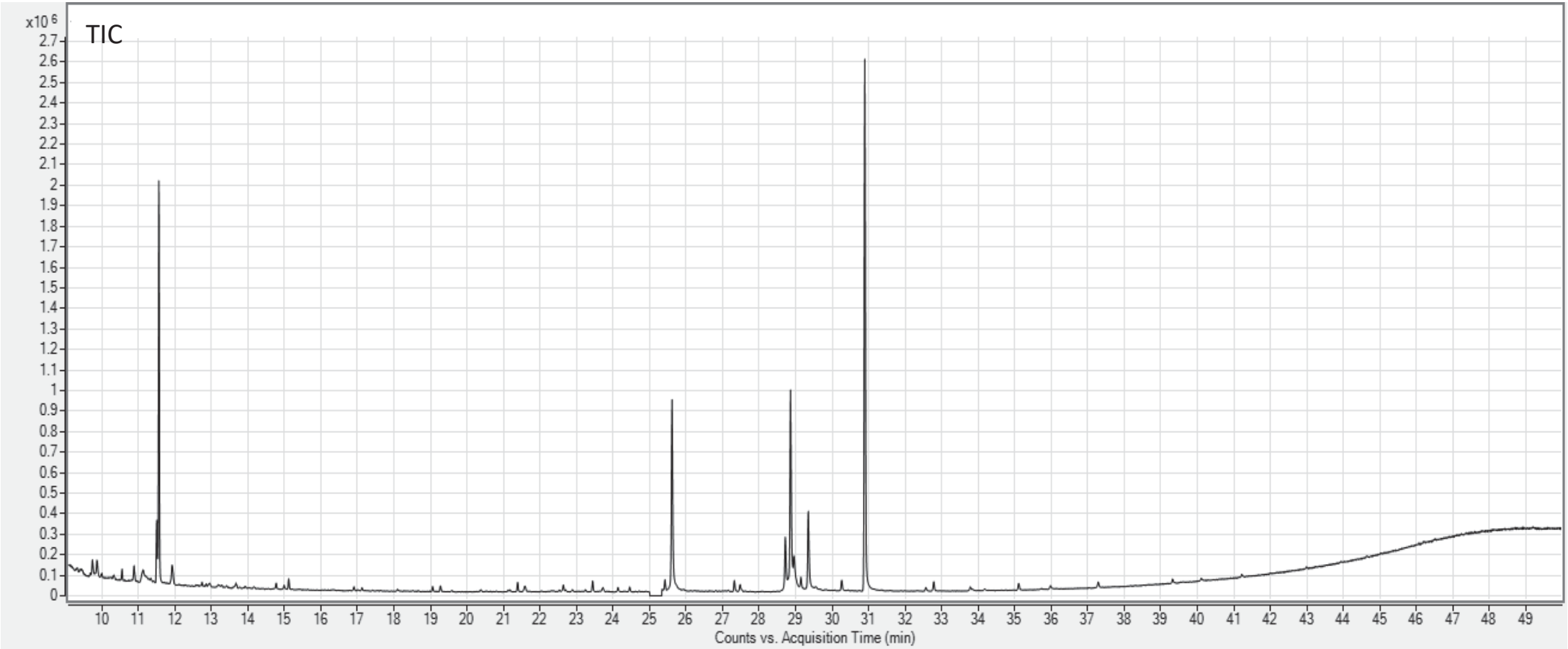


Fig. 240: Partial total ion chromatogram of the outer surface (BECS 2760) of Sample KM203-E203 (BECS 2758)

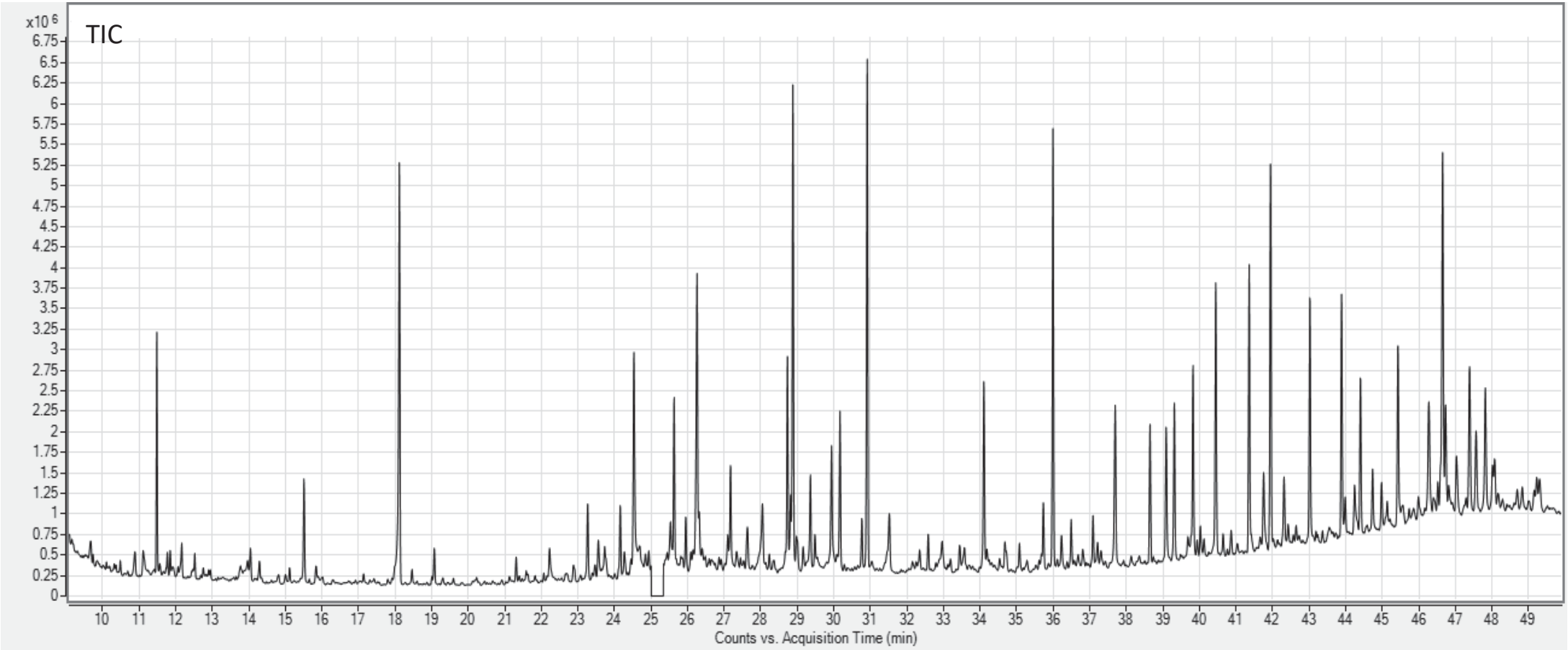


Fig. 241: Partial total ion chromatogram of the soil sample (BECS 2543) associated with Sample KM203-E203 (BECS 2758)

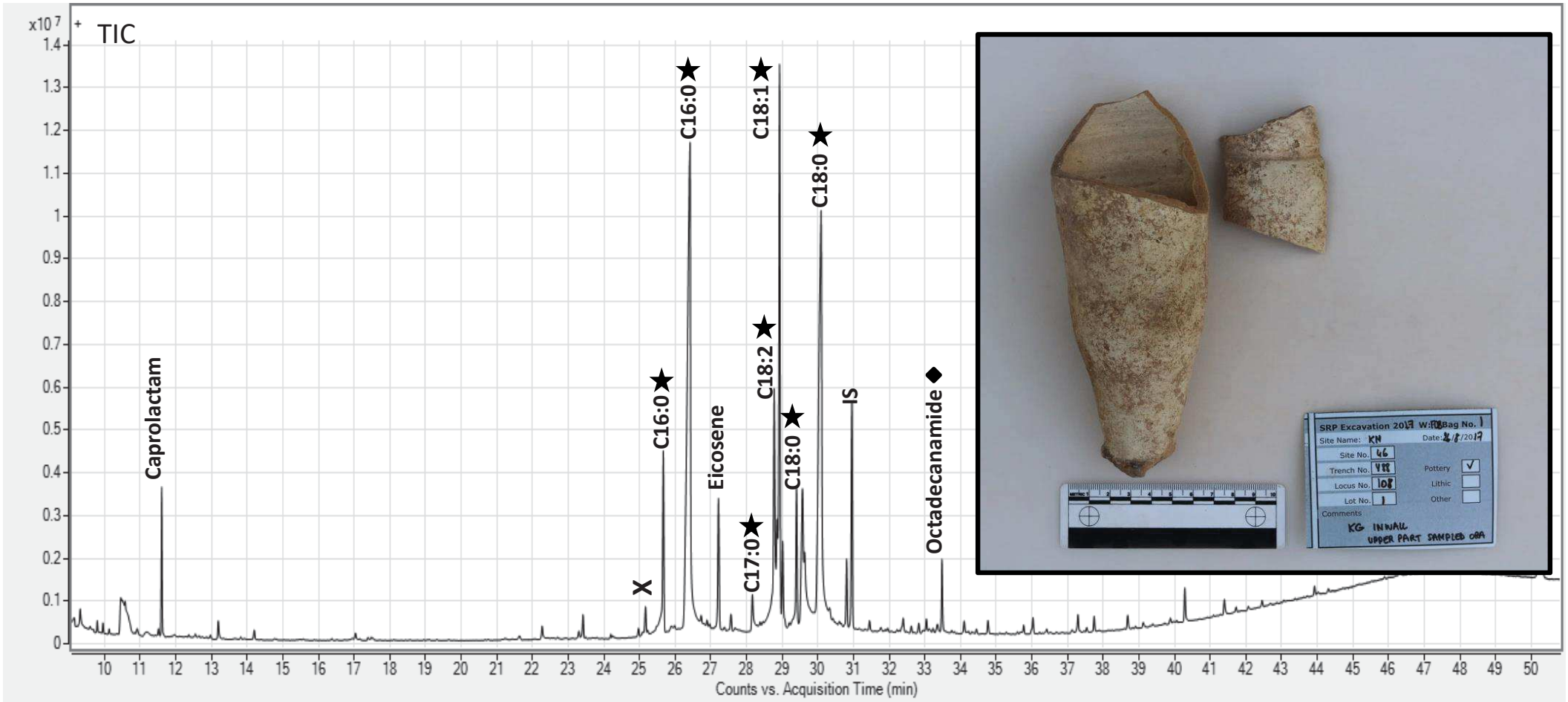


Fig. 242 : Partial total ion chromatogram of Sample KM132-E132 (BECS 2309) of a goblet in Trench Y88 (Locus 108 Lot 1): Cx:y fatty acids ★, CxOH alcohols ■ , Cx alkanes ▲ , aldehydes and amides ♦ , ketones ● , **MAG** and **DAG** mono- and diacylglycerols, wax esters ● , plasticizers (cross).

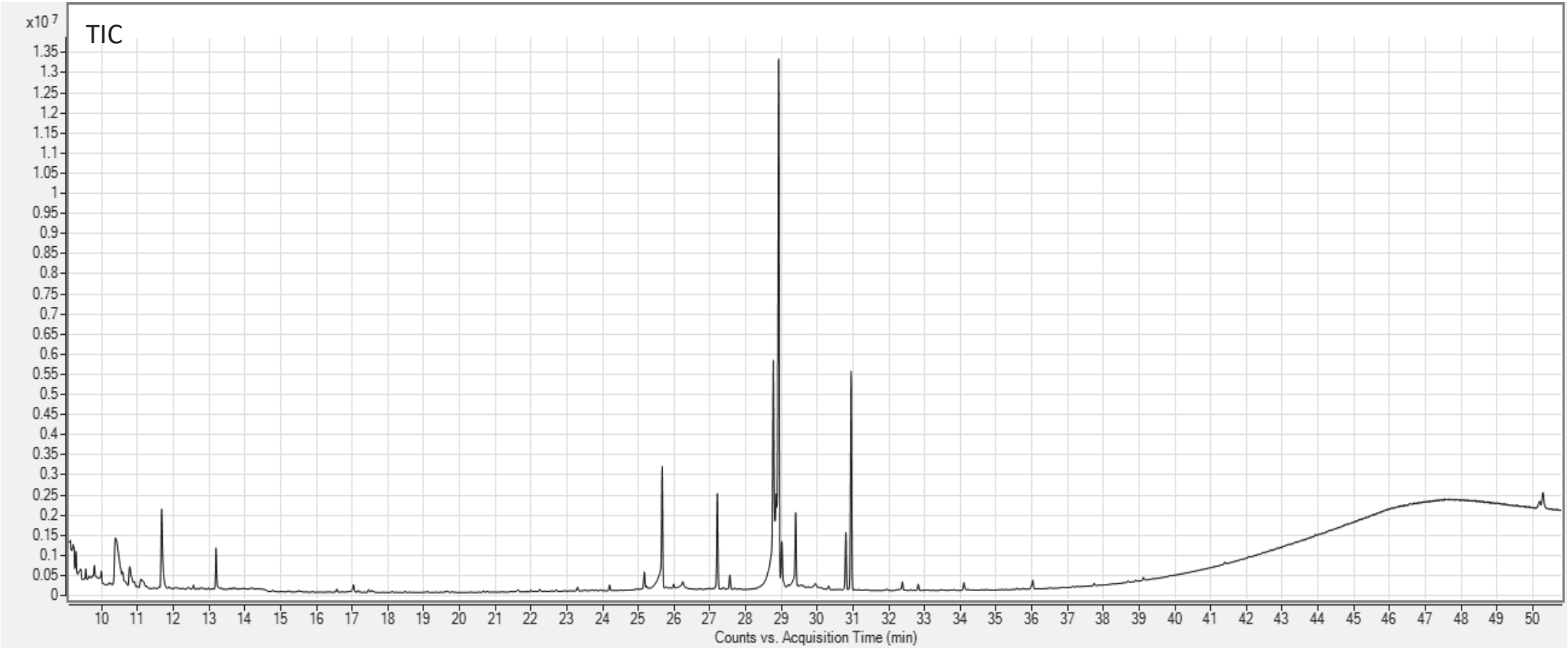


Fig. 243: Partial total ion chromatogram of the inner surface (BECS 2310) of Sample KM132-E132 (BECS 2309)

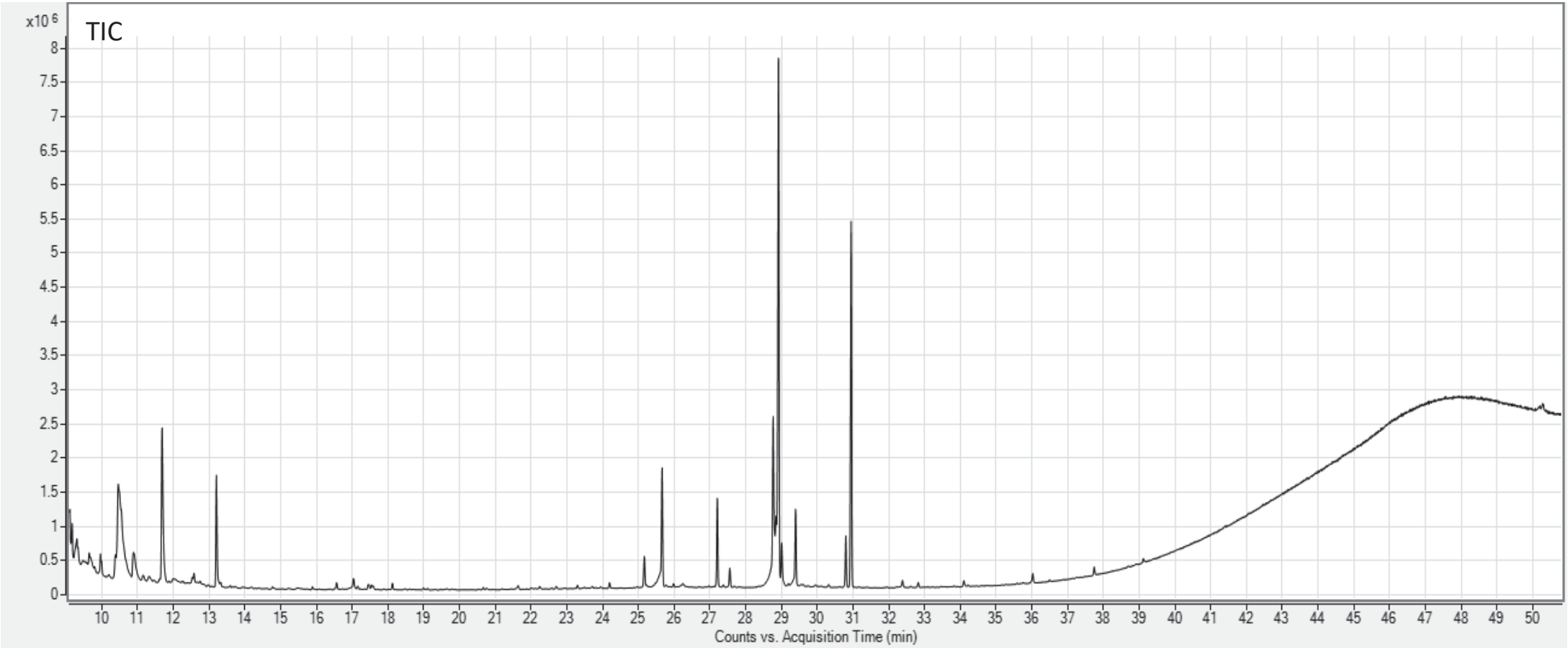


Fig. 244 : Partial total ion chromatogram of the inner surface (BECS 2311) of Sample KM132-E132 (BECS 2309)

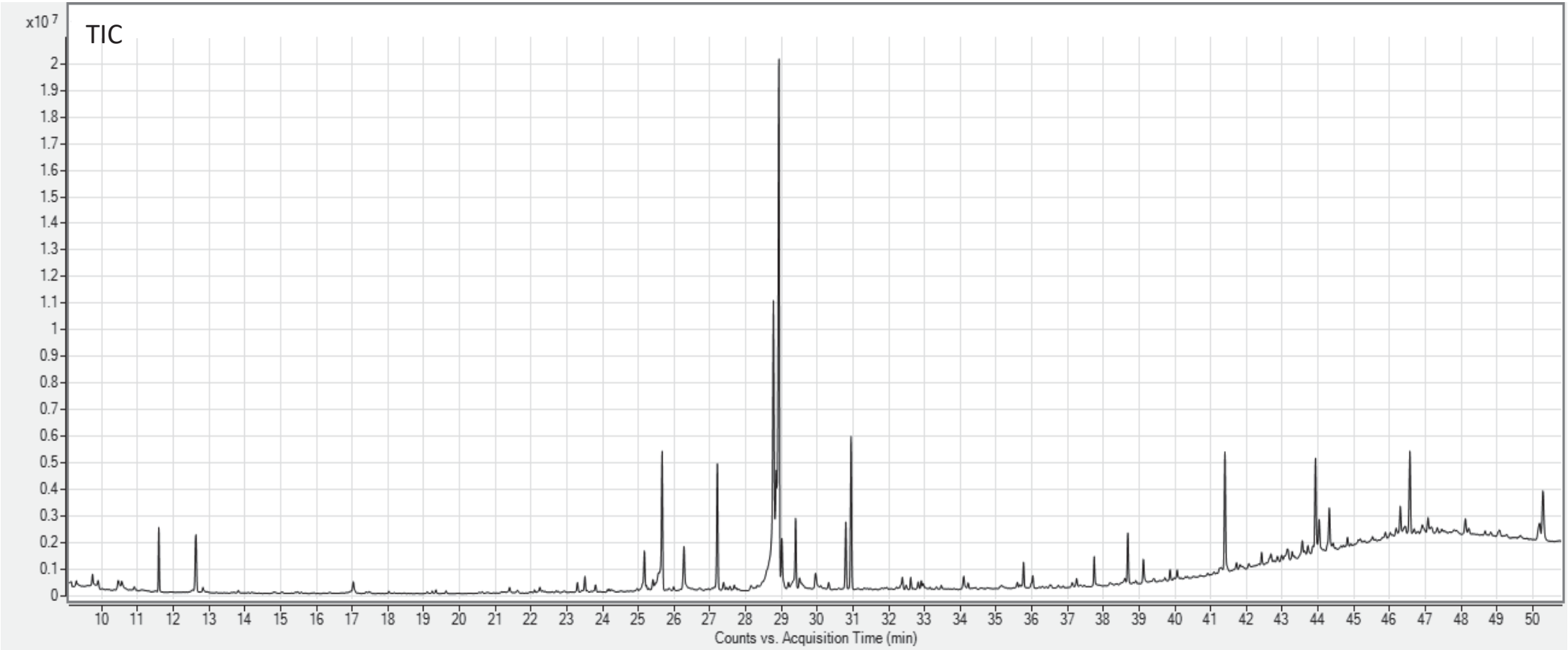


Fig. 245: Partial total ion chromatogram of the soil sample (BECS 2312) associated with Sample KM132-E132 (BECS 2309)

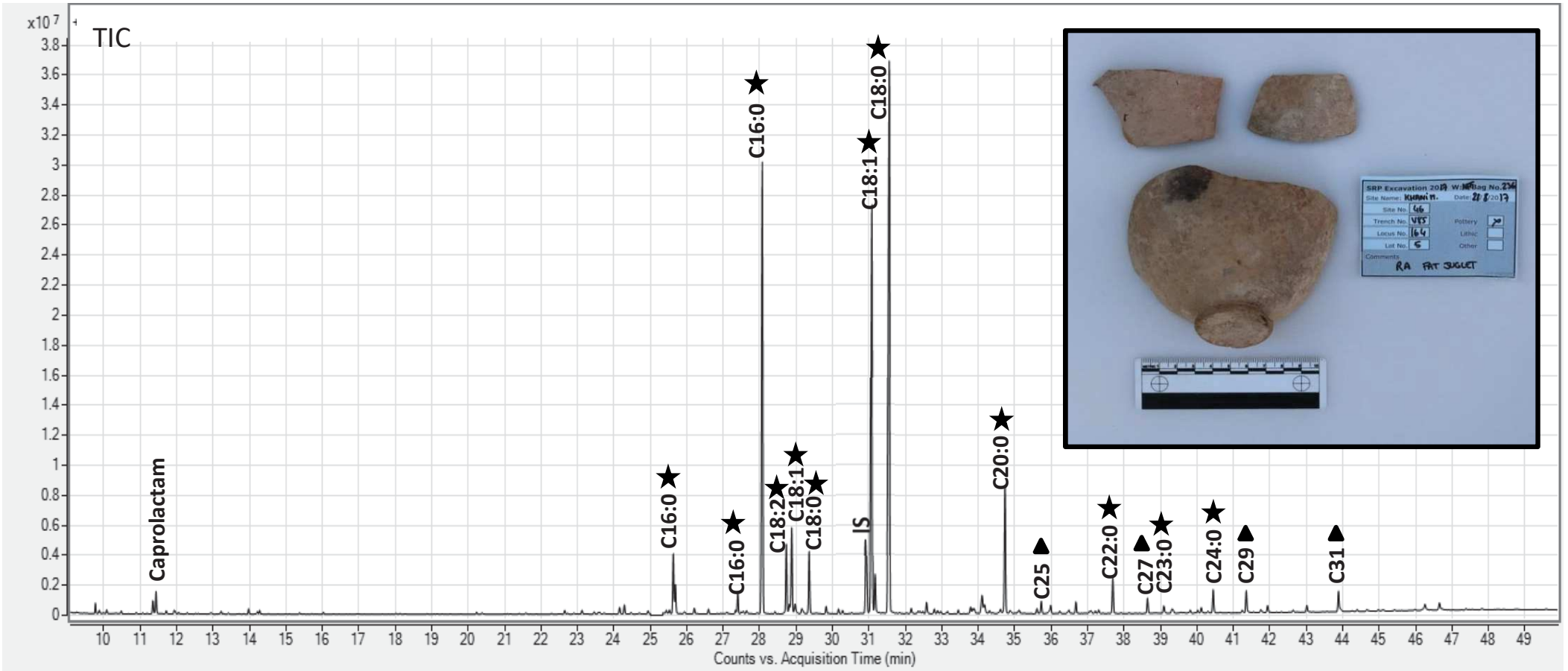


Fig. 246: Partial total ion chromatogram of Sample KM165-E165 (BECS 2602) of a juglet in Trench V85 (Locus 164 Lot 5): Cx:y fatty acids ★, CxOH alcohols ■ , Cx alkanes ▲ , aldehydes and amides ♦ , ketones ⬟ , **MAG** and **DAG** mono- and diacylglycerols, wax esters ● , plasticizers (cross).

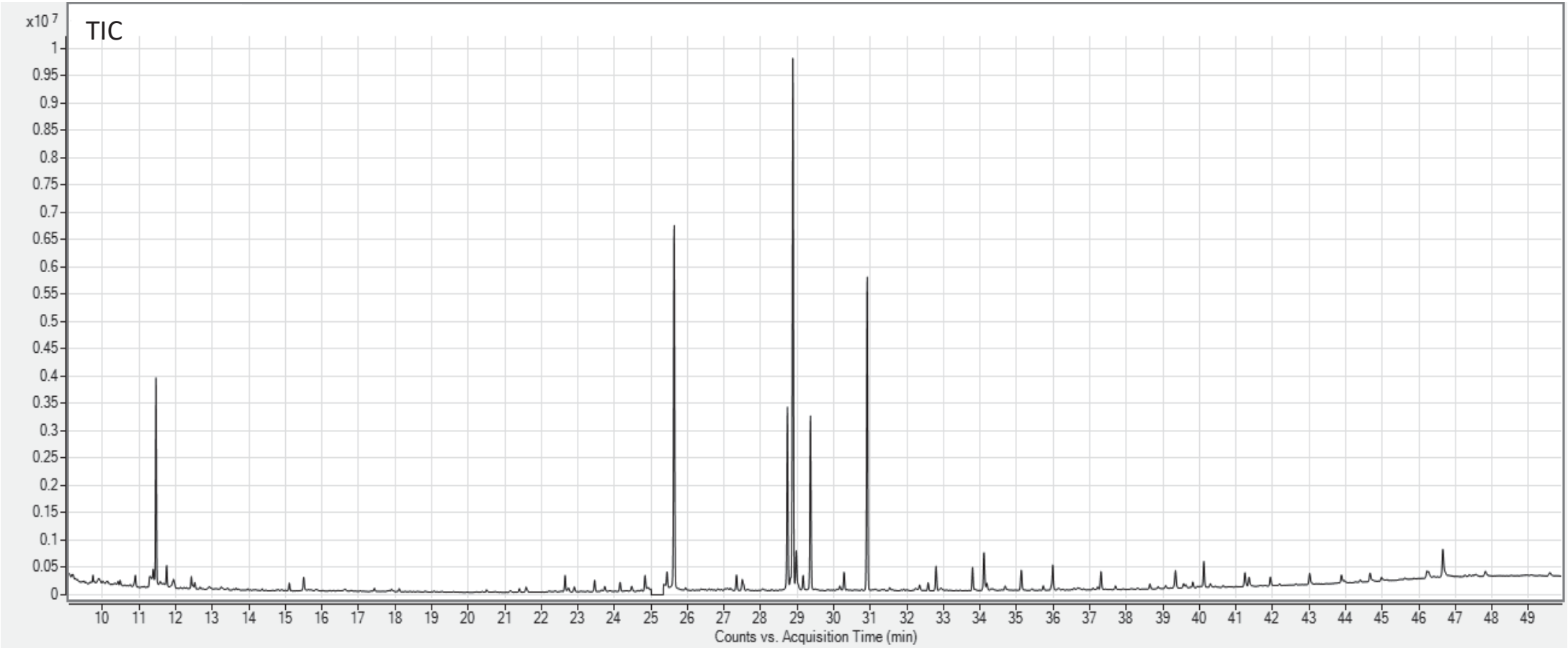


Fig. 247: Partial total ion chromatogram of the inner surface (BECS 2603) of Sample KM165-E165 (BECS 2602)

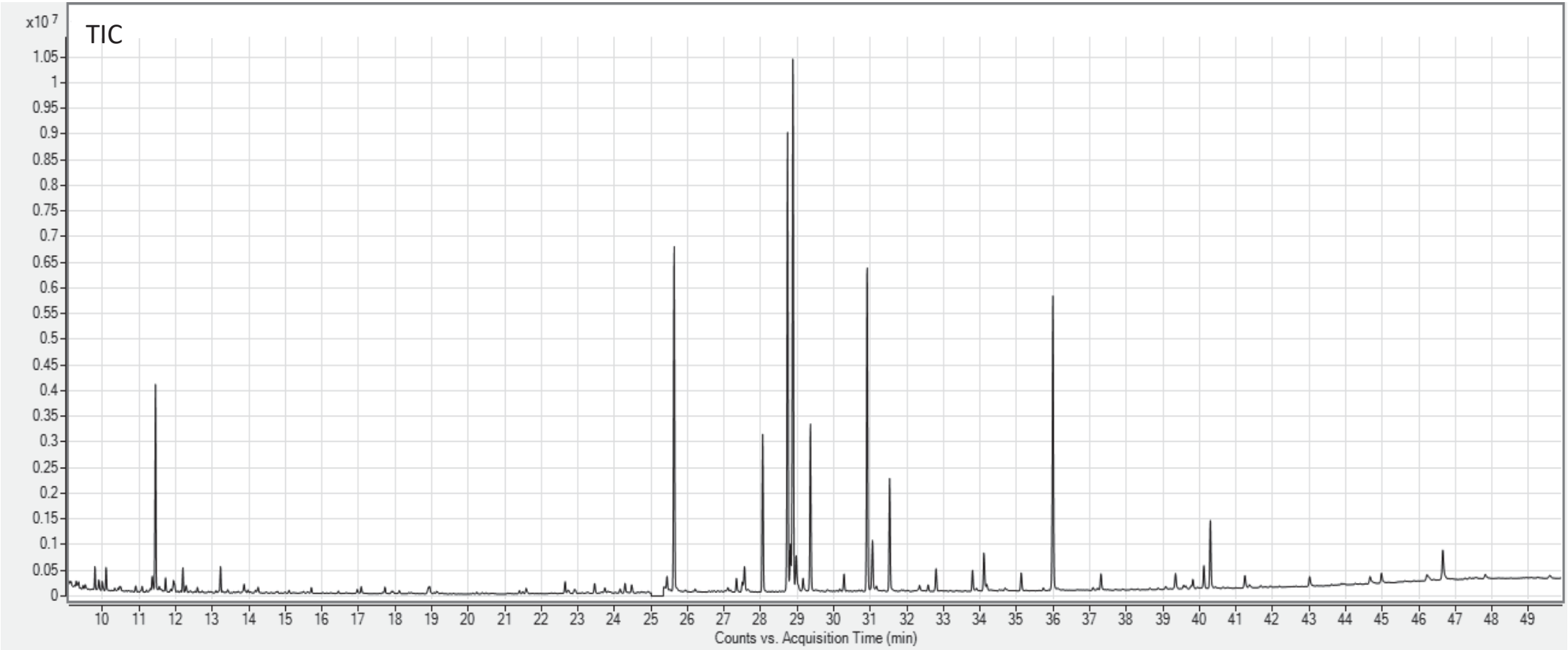


Fig. 248 : Partial total ion chromatogram of the outer surface (BECS 2604) of Sample KM165-E165 (BECS 2602)

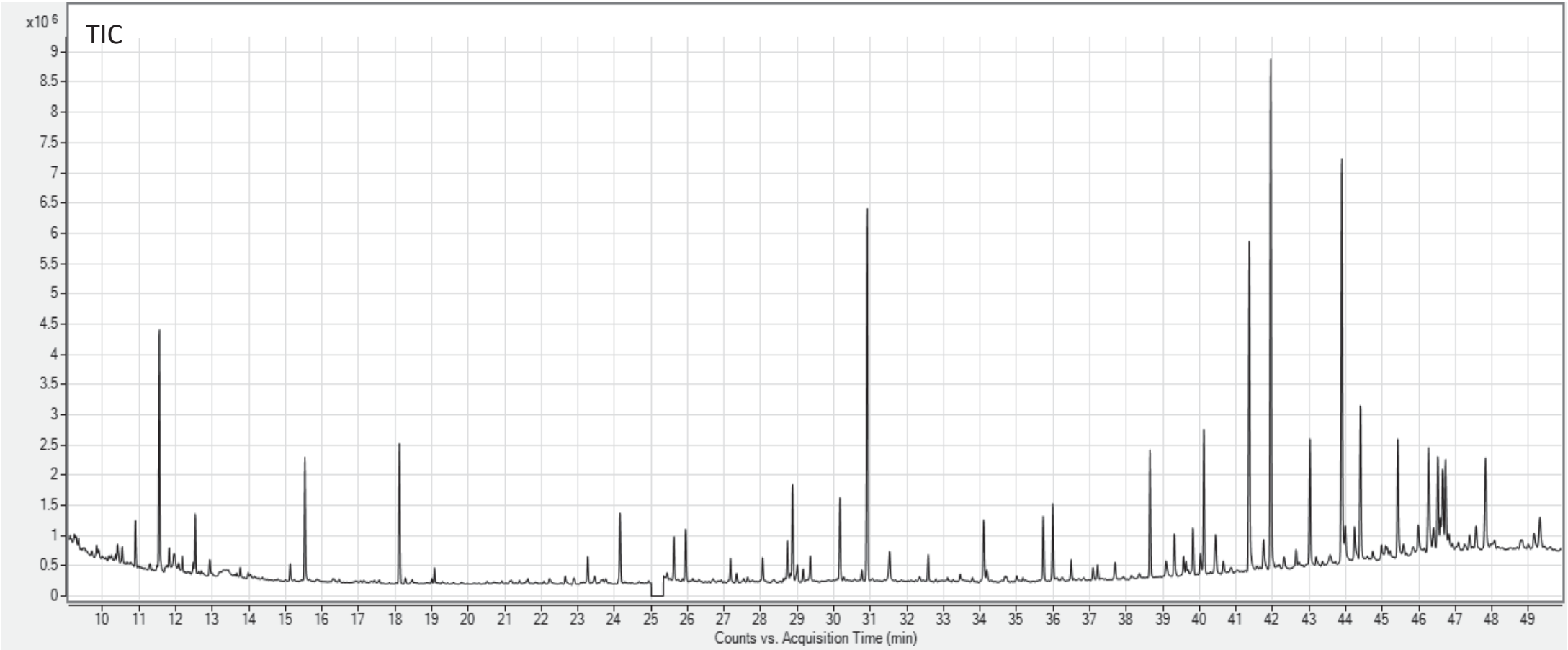


Fig. 249: Partial total ion chromatogram of the soil sample (BECS 2598) associated with Sample KM165-E165 (BECS 2602)

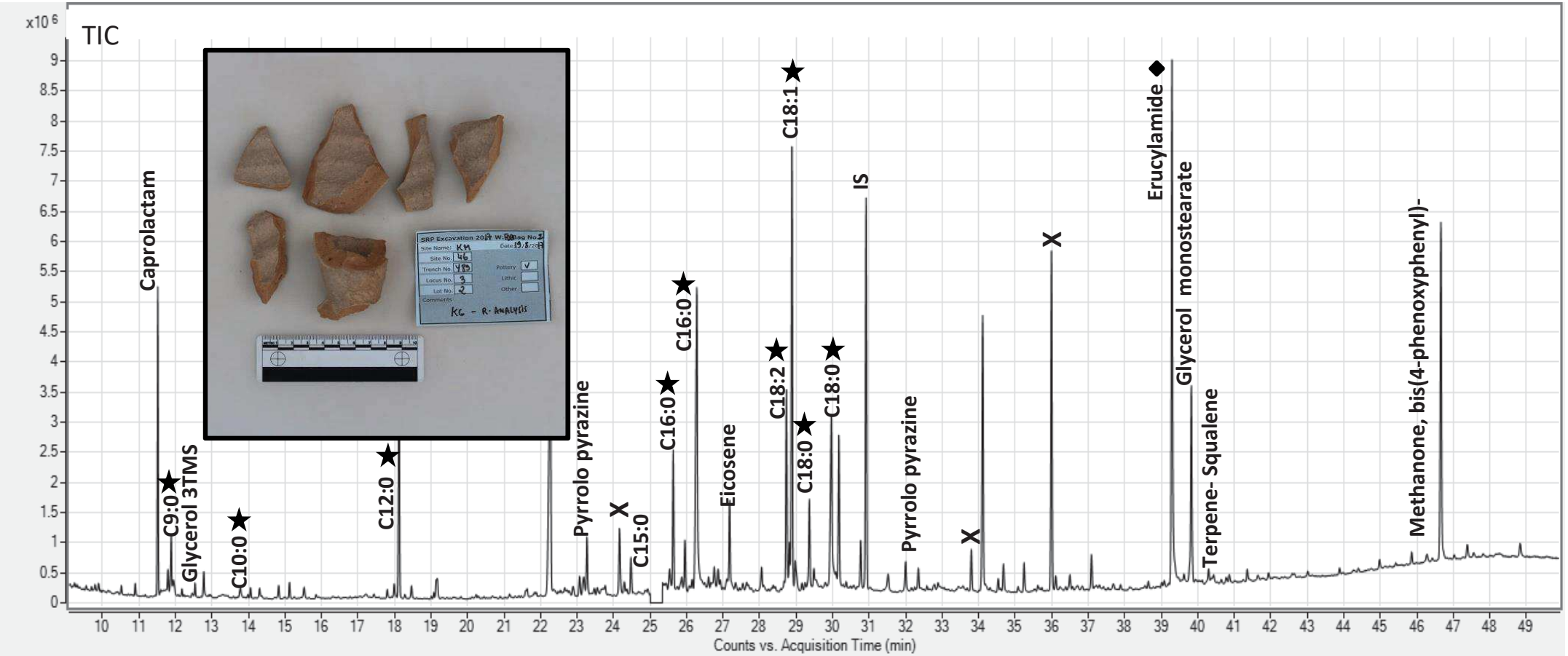


Fig. 250: Partial total ion chromatogram of Sample KM181-E181 (BECS 2537) of a goblet in Trench Y89 (Locus 3 Lot 2): Cx:y fatty acids ★, CxOH alcohols ■ , Cx alkanes ▲ , aldehydes and amides ♦ , ketones ● , **MAG** and **DAG** mono- and diacylglycerols, wax esters ● , plasticizers (cross).

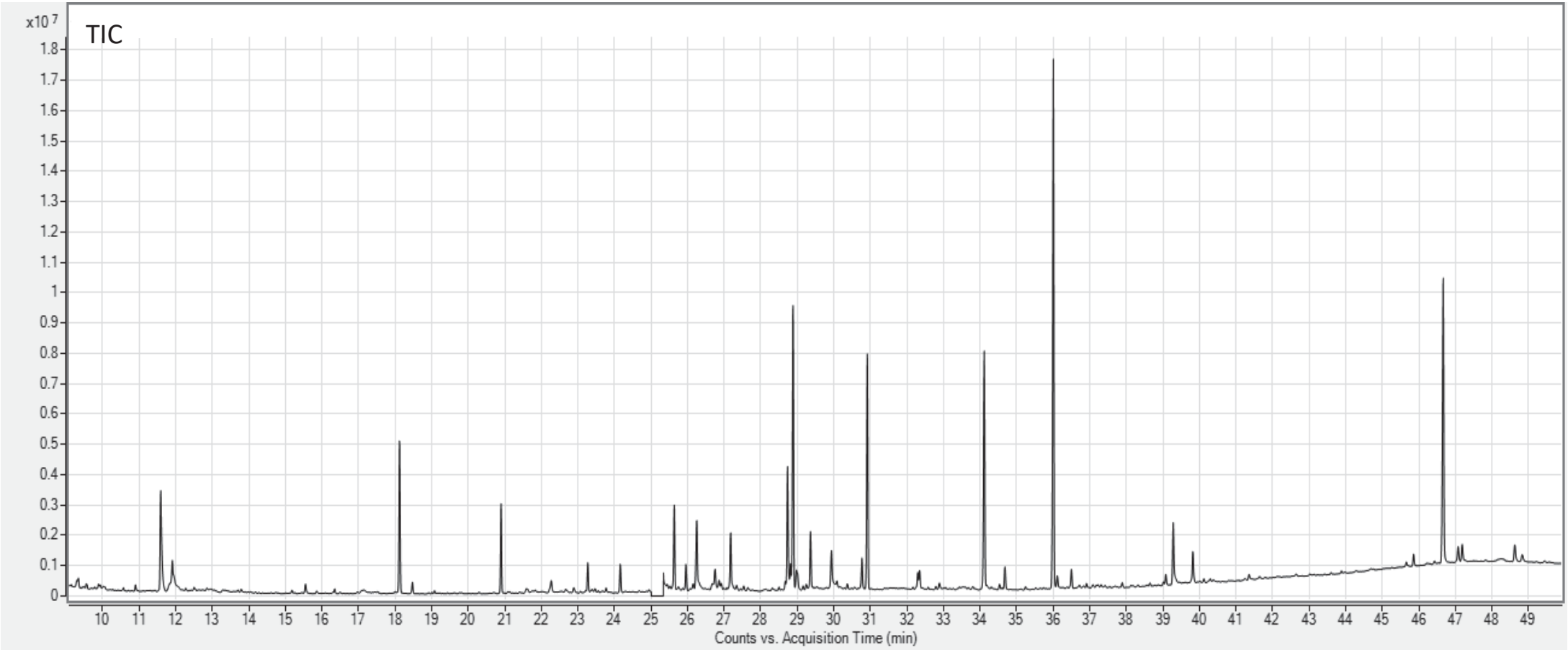


Fig. 251: Partial total ion chromatogram of the inner surface (BECS 2538) of Sample KM165-E165 (BECS 2537)

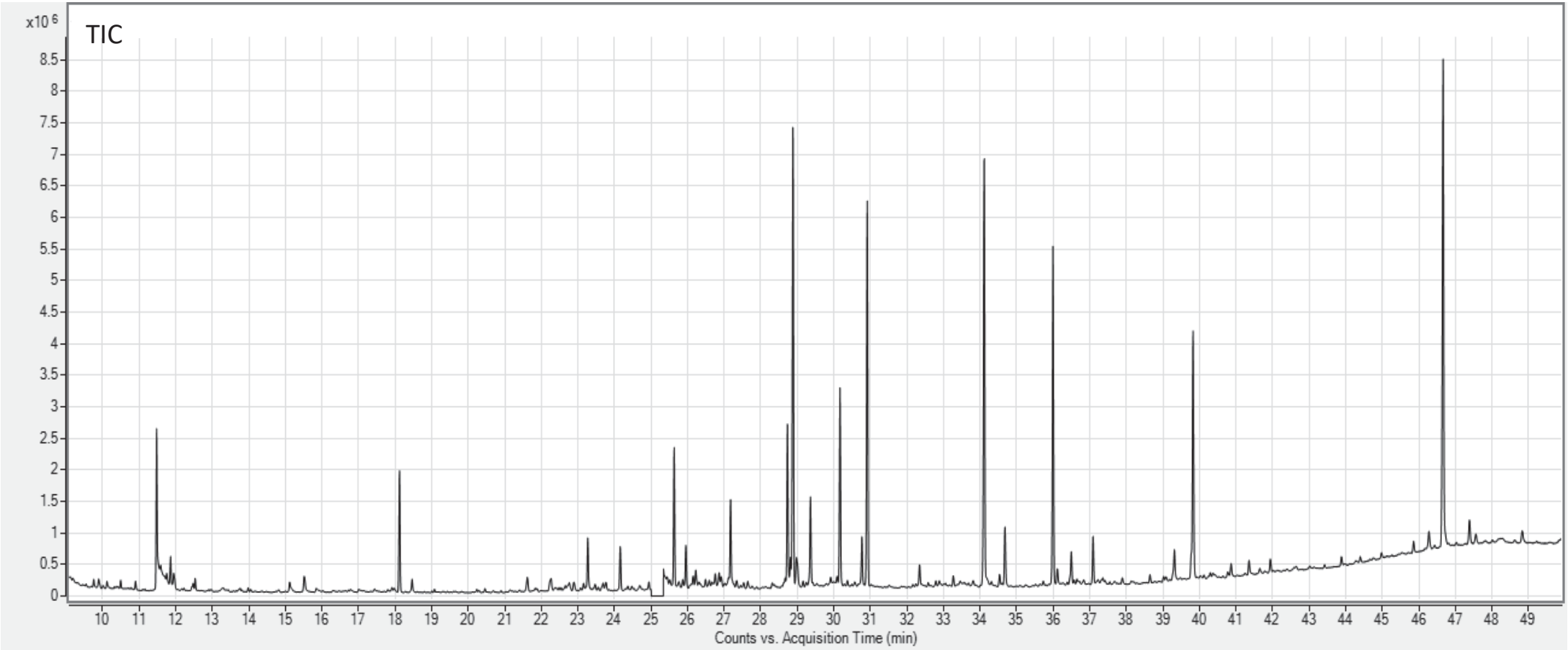


Fig. 252: Partial total ion chromatogram of the outer surface (BECS 2539) of Sample KM165-E165 (BECS 2537)

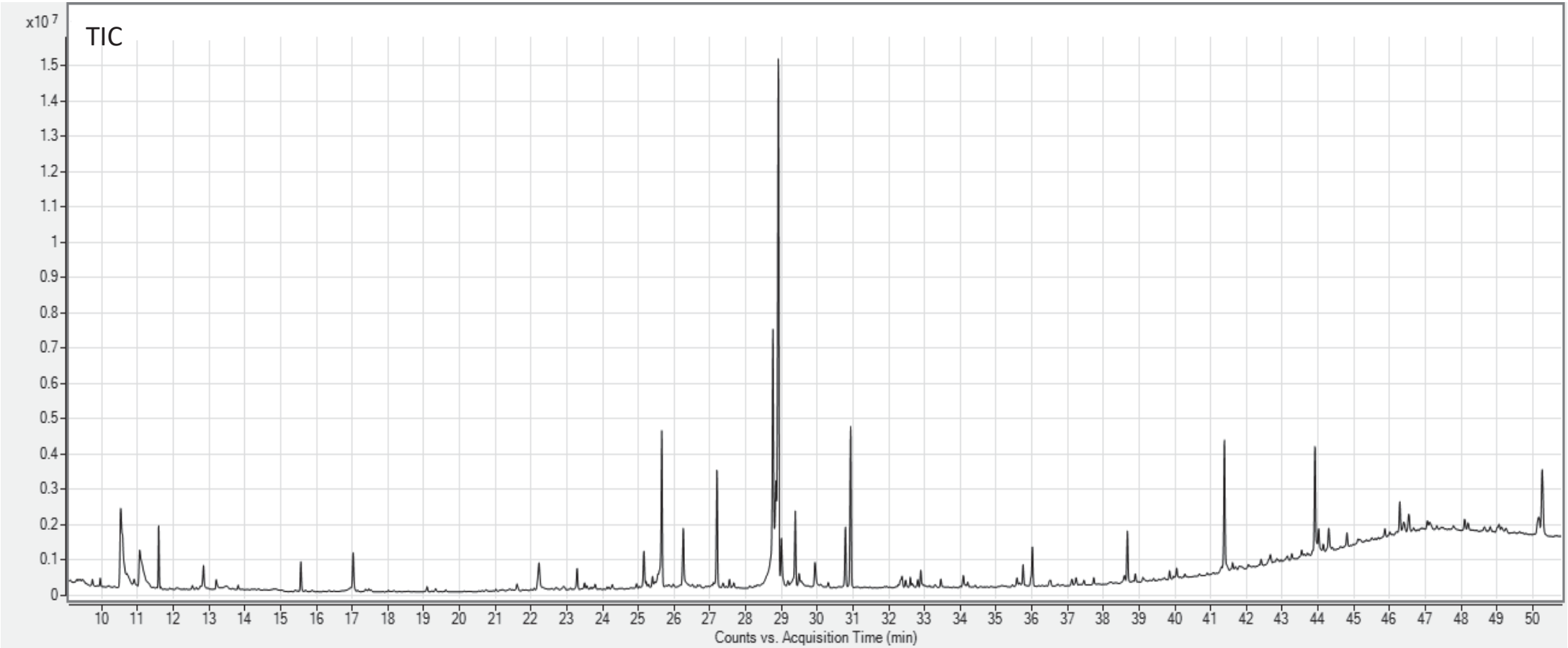


Fig. 253: Partial total ion chromatogram of the soil sample (BECS 2331) associated with Sample KM165-E165 (BECS 2537)

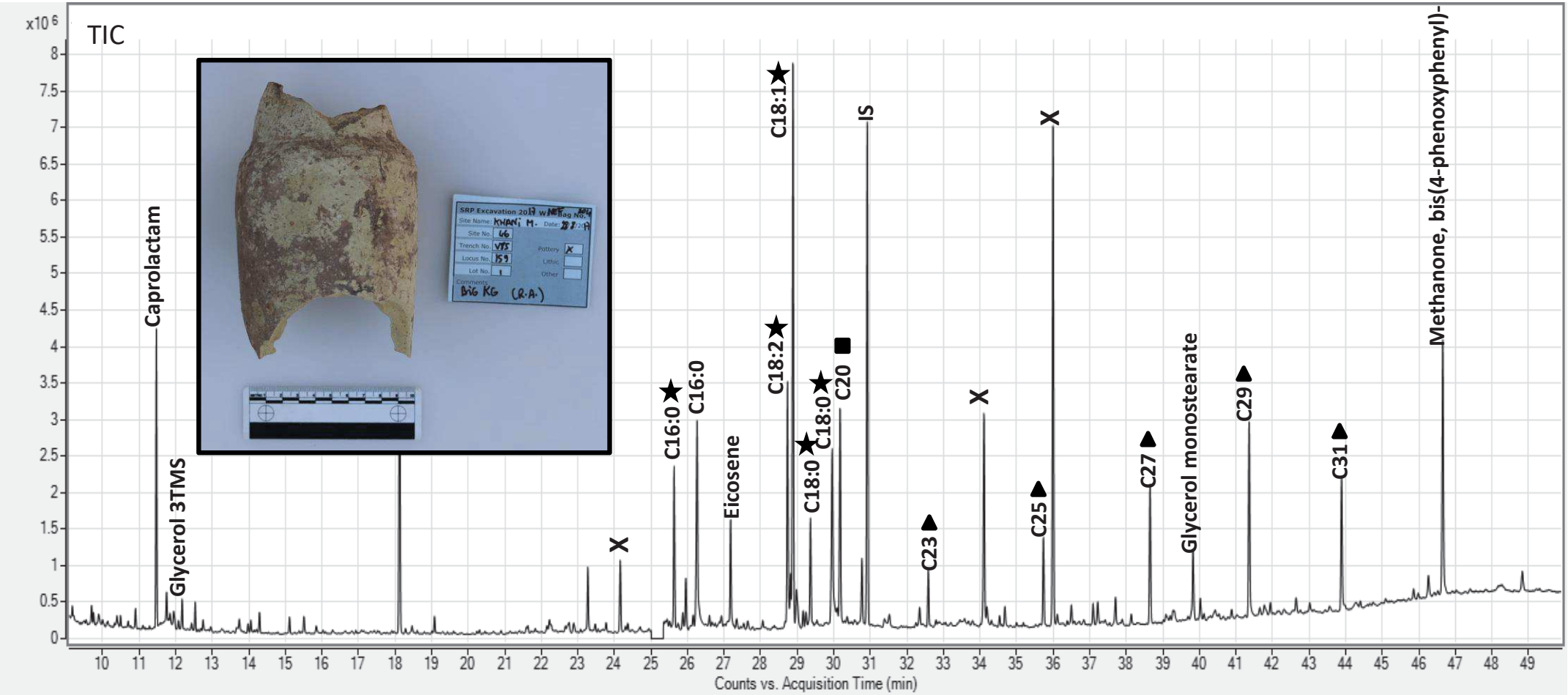


Fig. 254 : Partial total ion chromatogram of Sample KM186-E186 (BECS 2534) of a goblet in Trench V85 (Locus 159 Lot 1): Cx:y fatty acids ★, CxOH alcohols ■ , Cx alkanes ▲ , aldehydes and amides ♦ , ketones ● , **MAG** and **DAG** mono- and diacylglycerols, wax esters ● , plasticizers (cross).

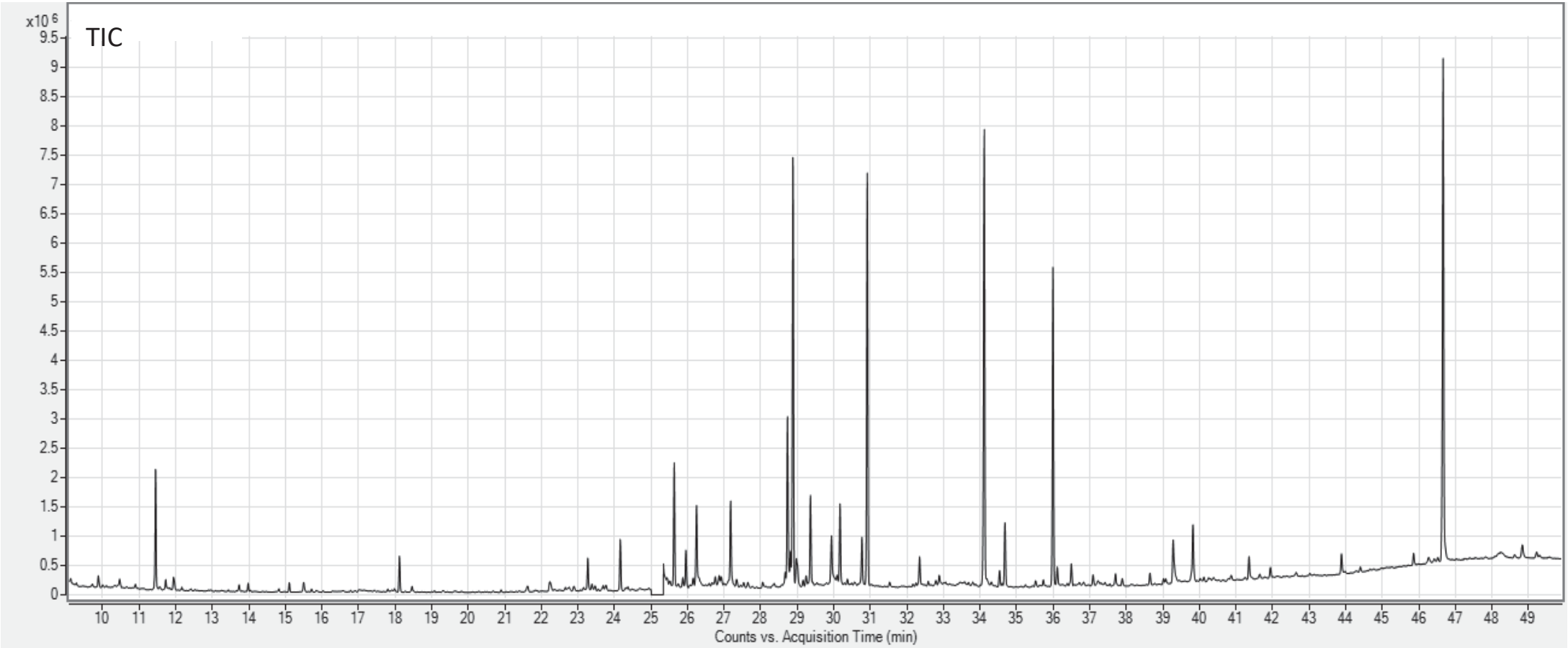


Fig. 255: Partial total ion chromatogram of the inner surface (BECS 2535) of Sample KM186-E186 (BECS 2534)

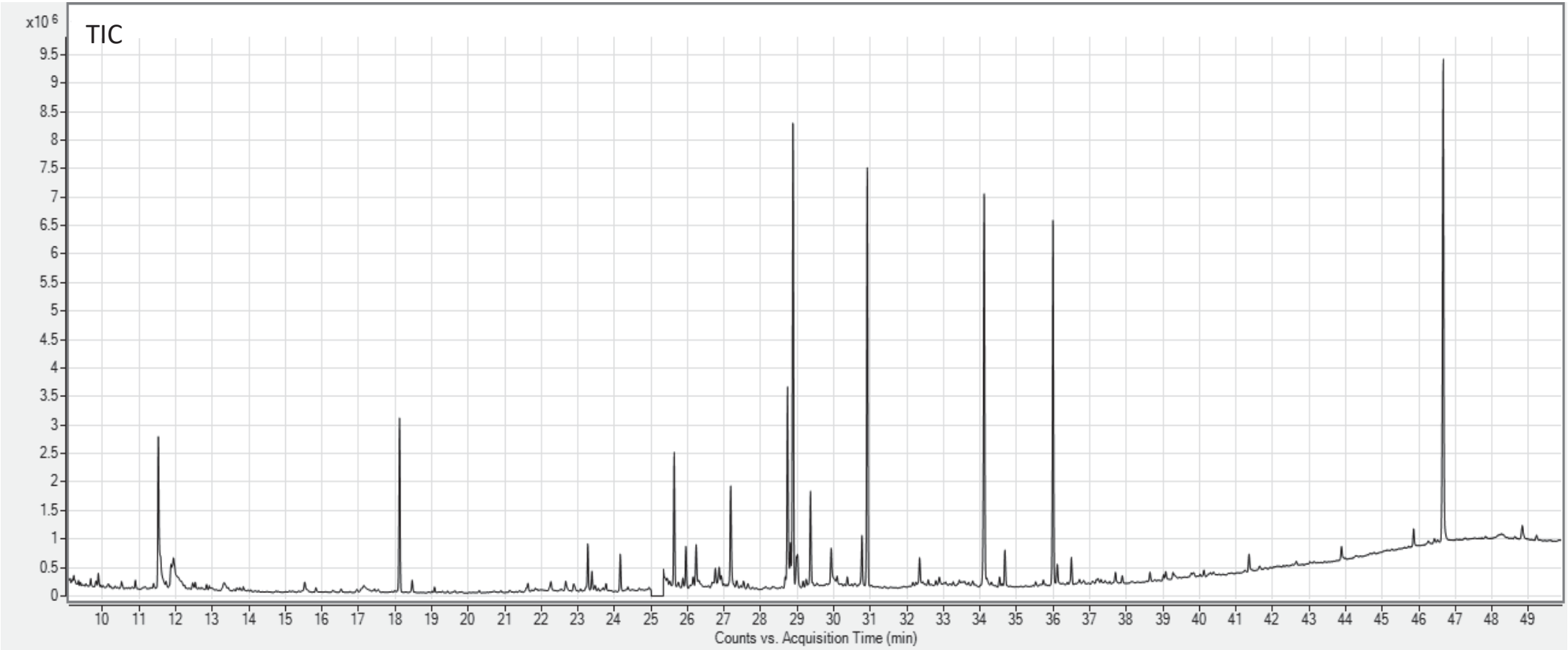


Fig. 256 : Partial total ion chromatogram of the outer surface (BECS 2536) of Sample KM186-E186 (BECS 2534)

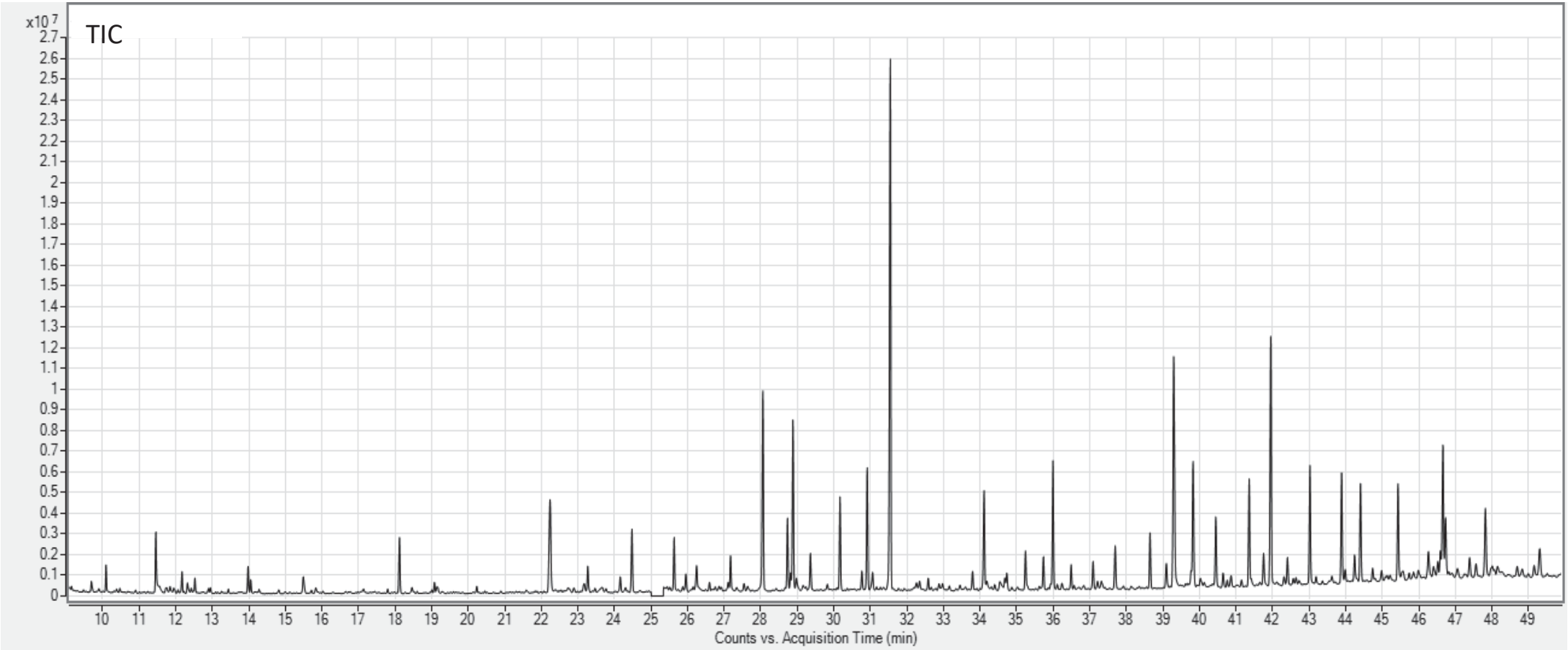


Fig. 257: Partial total ion chromatogram of the soil sample (BECS 2545) associated with Sample KM181-E181 (BECS 2534)

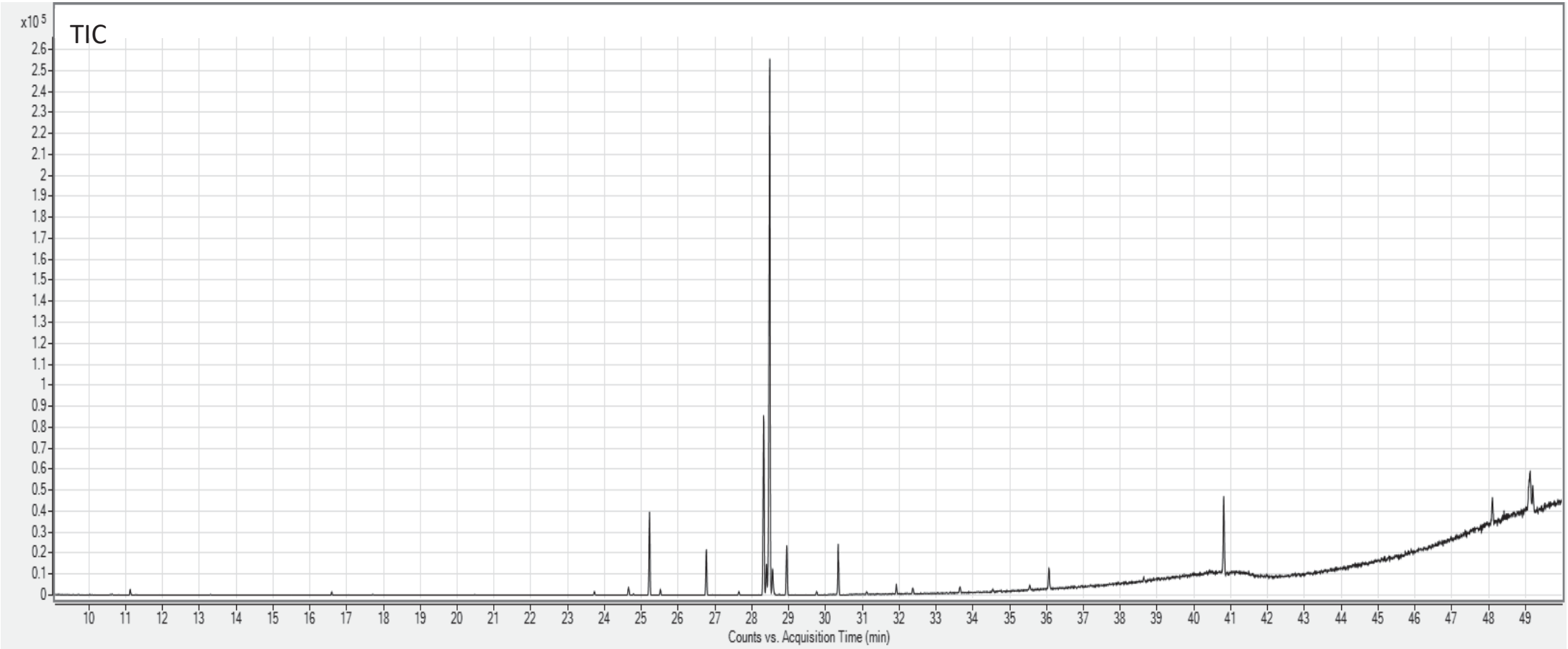


Fig. 258: Partial total ion chromatogram of a blank sample 1 associated with Samples BECS 2303, 2306, 2309.

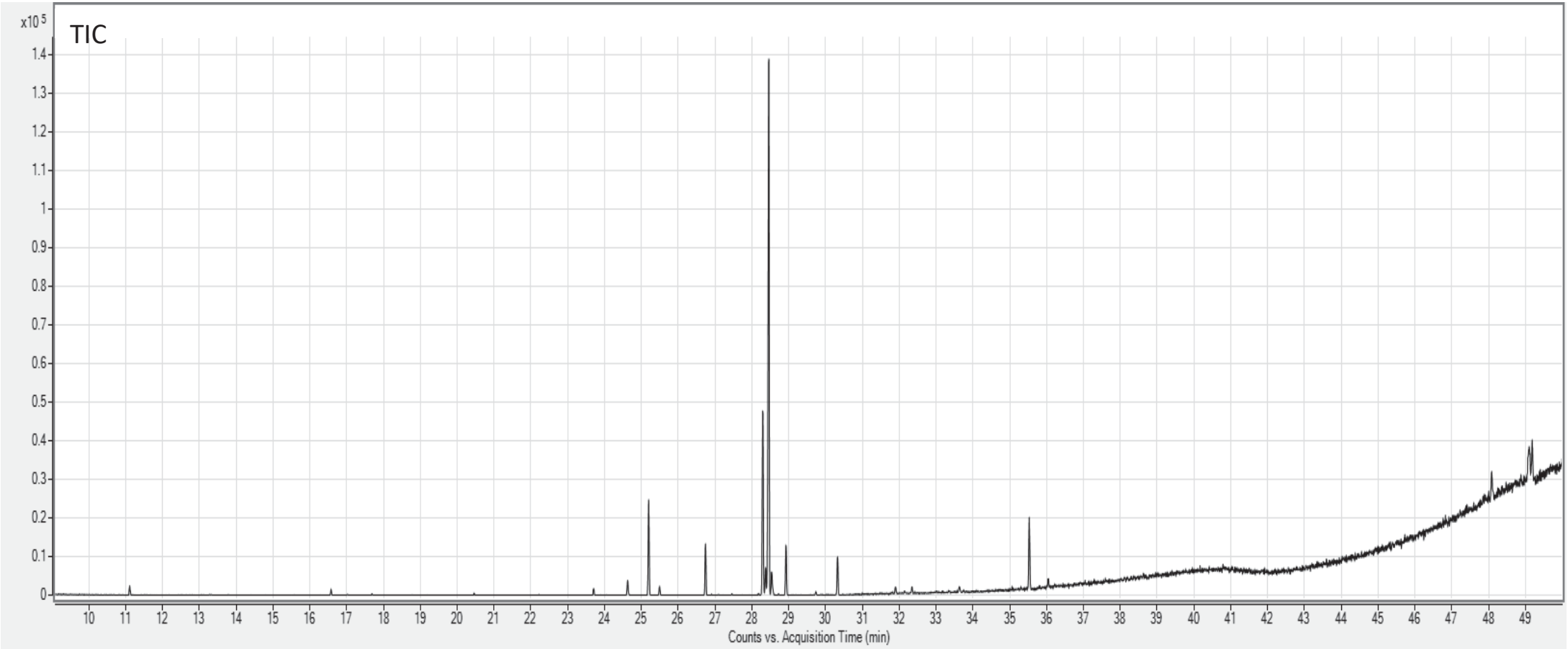


Fig. 259: Partial total ion chromatogram of a blank sample 2 associated with Samples BECS 2303, 2306, 2309.

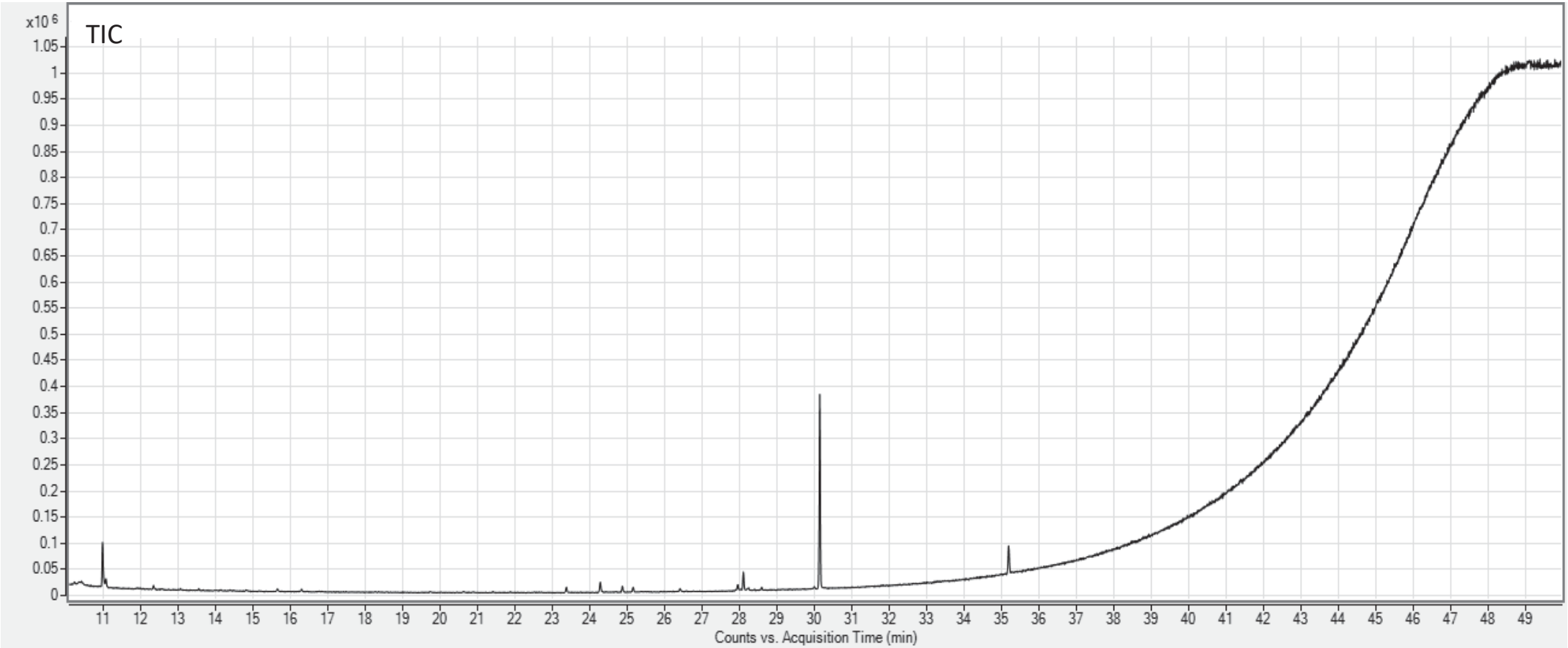


Fig. 260: Partial total ion chromatogram of a blank sample 1 associated with Samples BECS 2313, 2320, 2328, 2332.

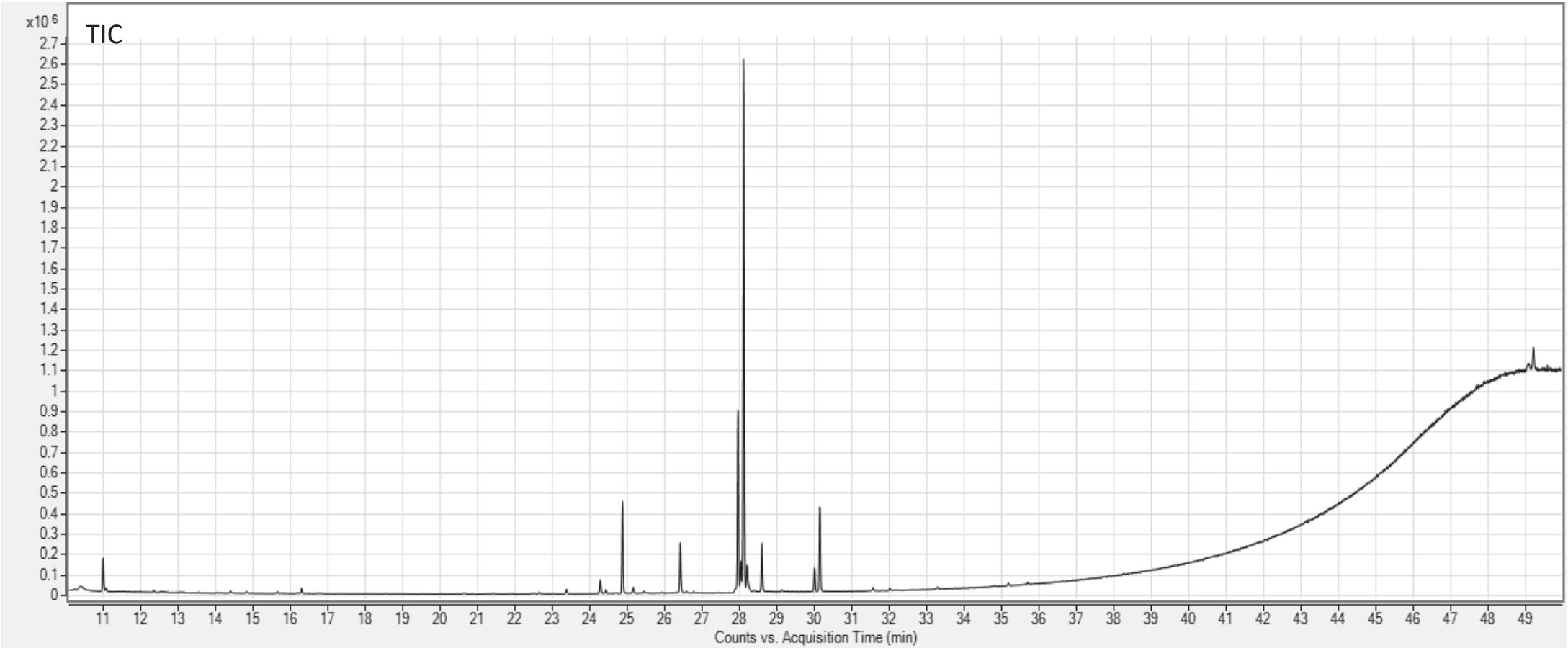


Fig. 261: Partial total ion chromatogram of a blank sample 2 associated with Samples BECS 2313, 2320, 2328, 2332.

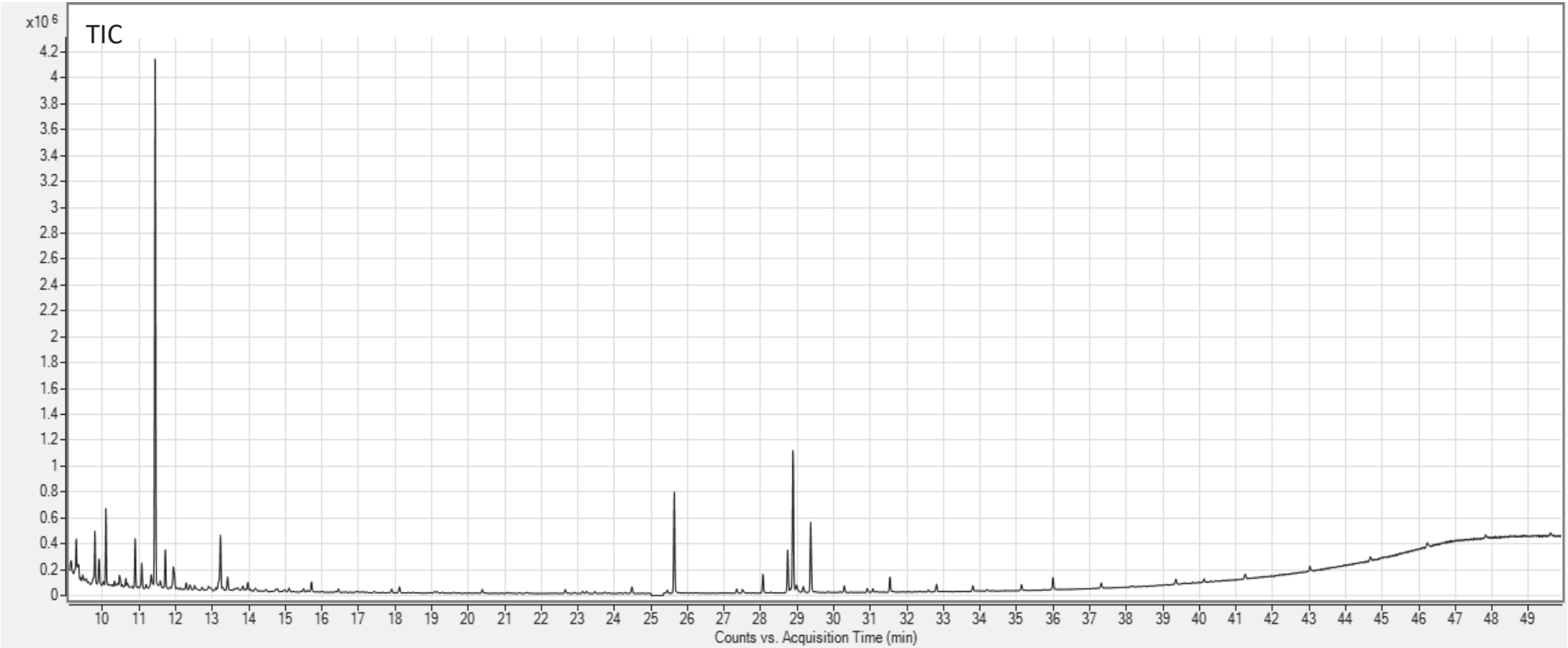


Fig. 262: Partial total ion chromatogram of a blank sample 2 associated with Samples BECS 2317, 2324, 2531, 2534, 2537, 2540, 2599, 2602, 2649, 2652.

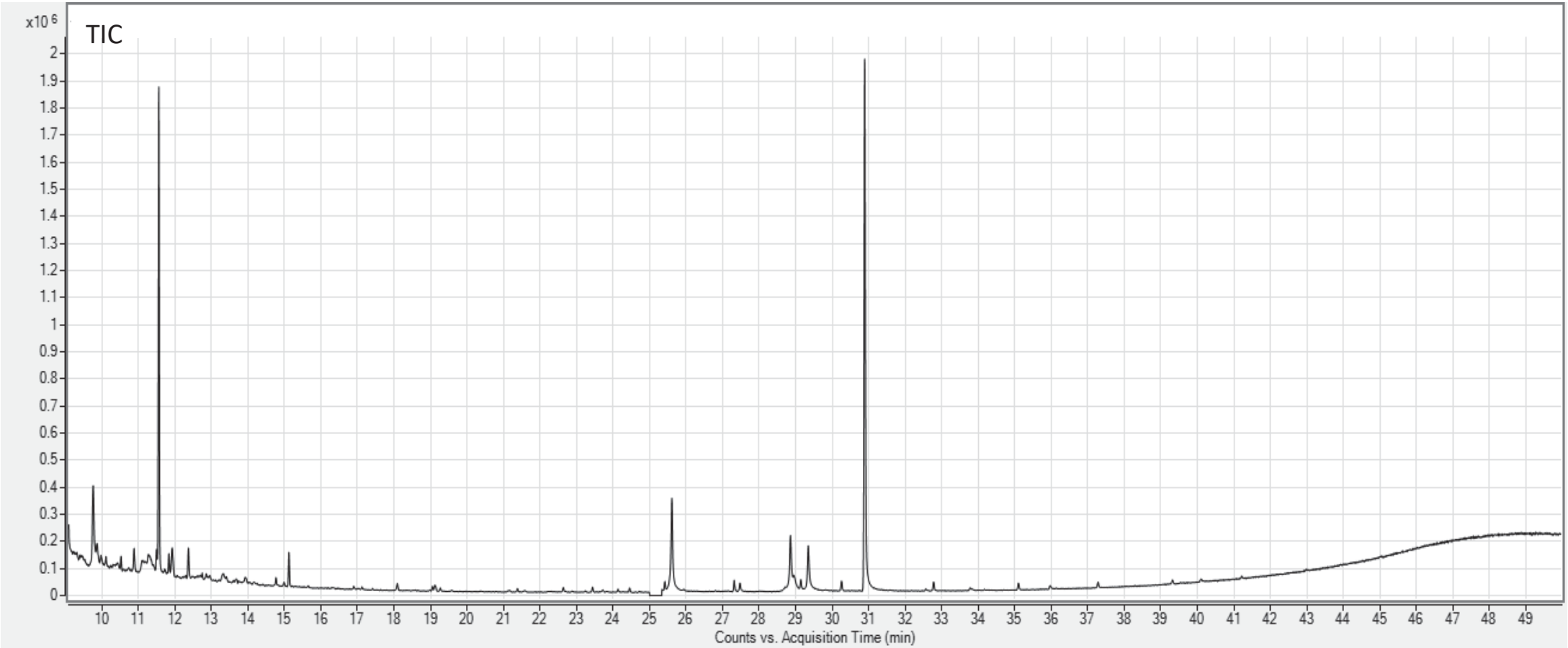


Fig. 263: Partial total ion chromatogram of a blank sample 1 associated with Samples BECS 2591, 2594, 2605, 2608, 2720, 2723, 2728, 2732, 2736, 2739, 2742, 2746, 2749, 2752, 2755, 2758, 2761, 2807, 2810, 2813.

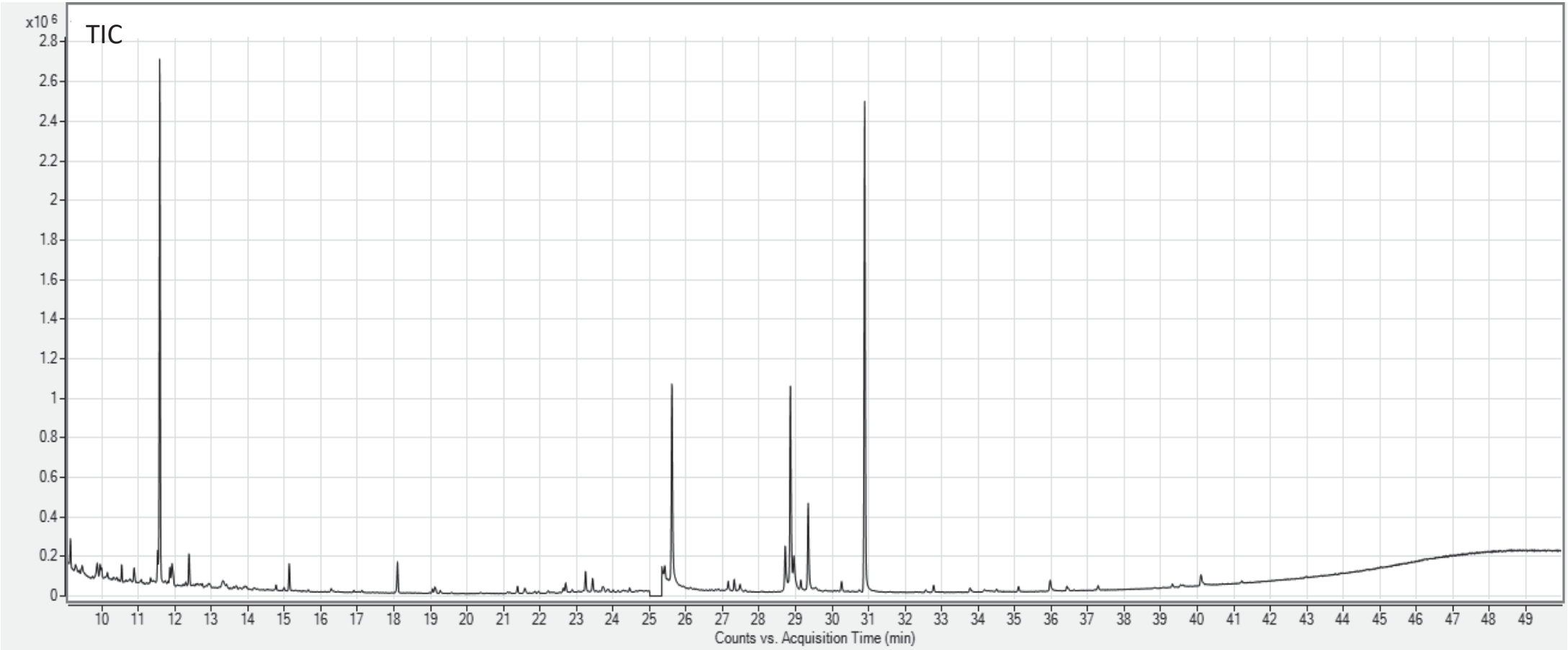


Fig. 264: Partial total ion chromatogram of a blank sample 2 associated with Samples BECS 2591, 2594, 2605, 2608, 2720, 2723, 2728, 2732, 2736, 2739, 2742, 2746, 2749, 2752, 2755, 2758, 2761, 2807, 2810, 2813.

APPENDIX E
Chromatograms reference samples

This appendix contains the chromatograms of reference samples (malted barley, wheat beer, barley beer, nutmeg and dates) analysed and presented in this thesis, as well as control samples (laboratory blanks).

The chromatogram is a two-dimensional plot with the ordinate axis giving average concentration in terms of detector response and the abscissa represents the retention time of each compound represented by a peak.

Major compounds and archaeologically significant compounds found exclusively in the sherd samples have been identified and labelled.

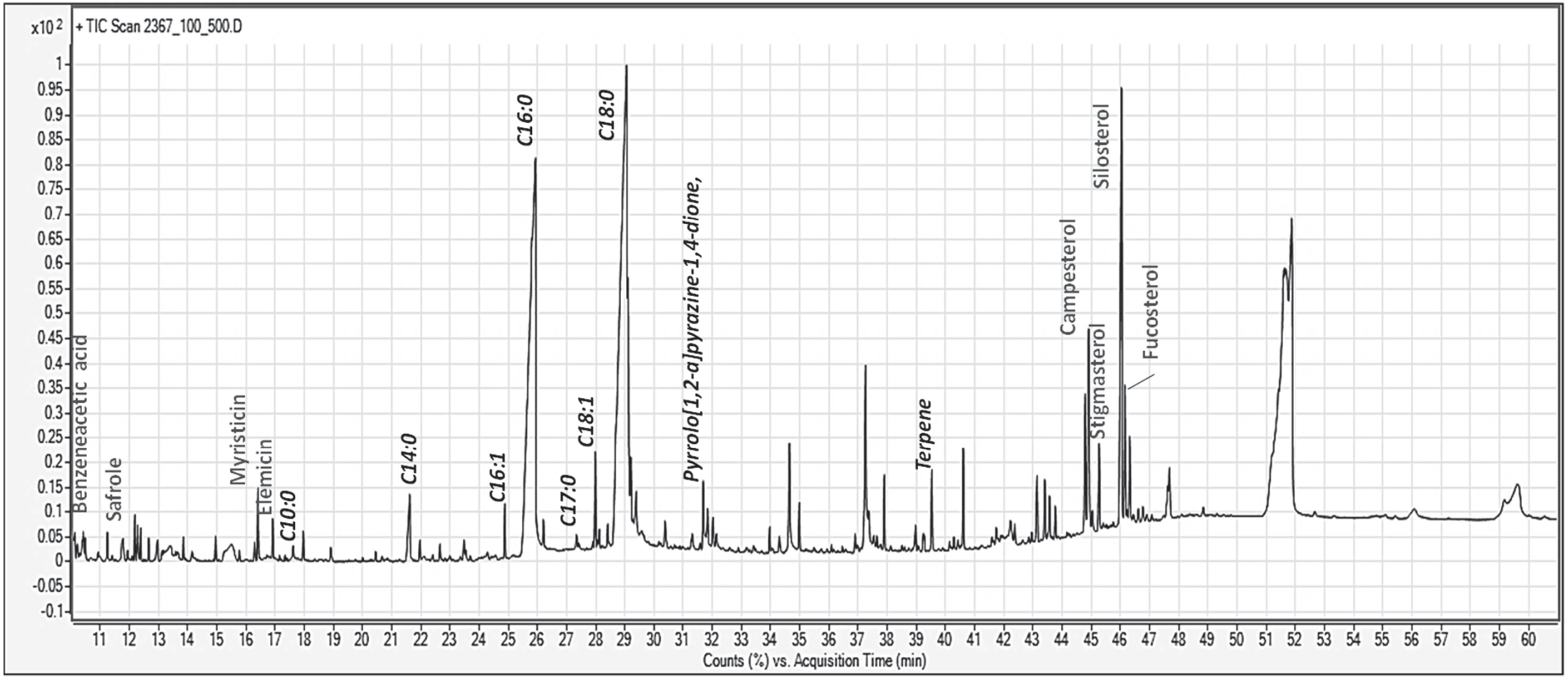


Fig. 265 : Partial total ion chromatogram of a sample of malted barley. Compounds in italic are found in our archaeological samples.

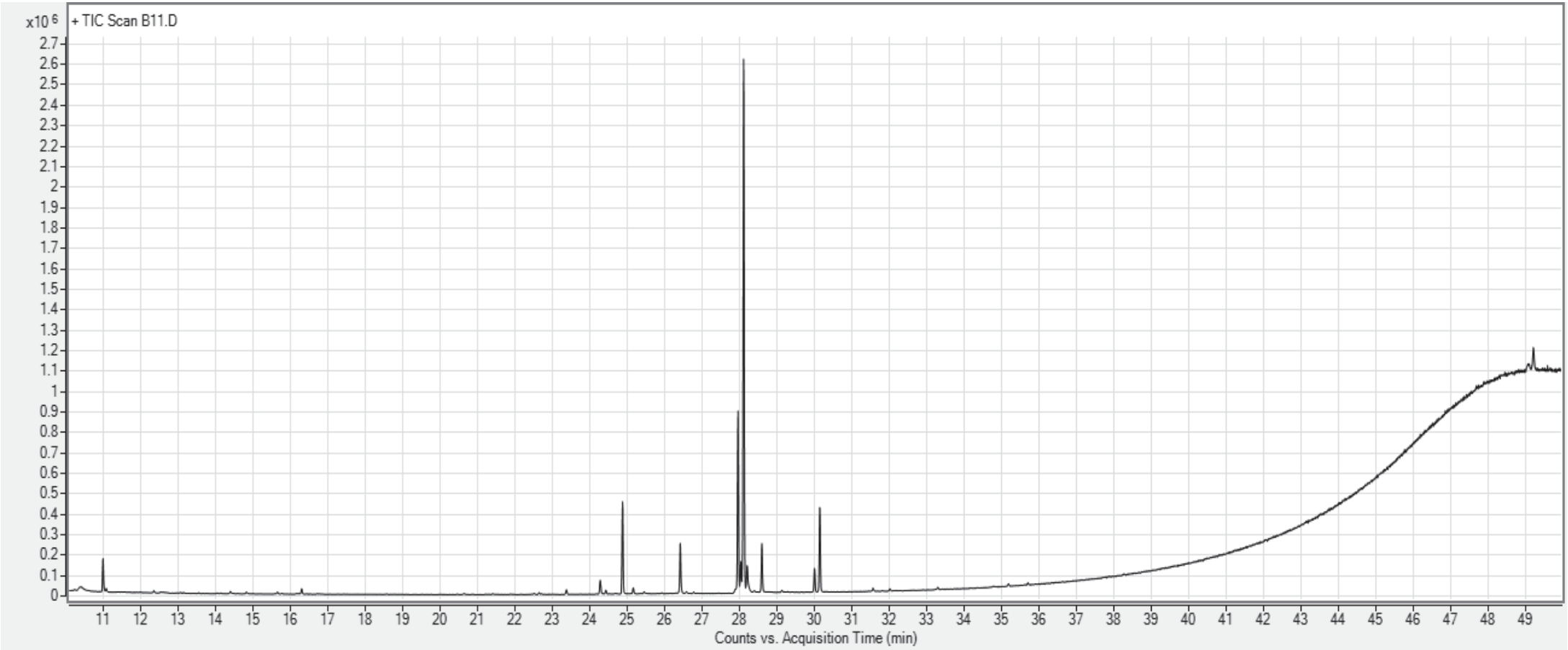


Fig. 266: Partial total ion chromatogram of a blank sample associated with the Sample of malted barley (BECS 2367)

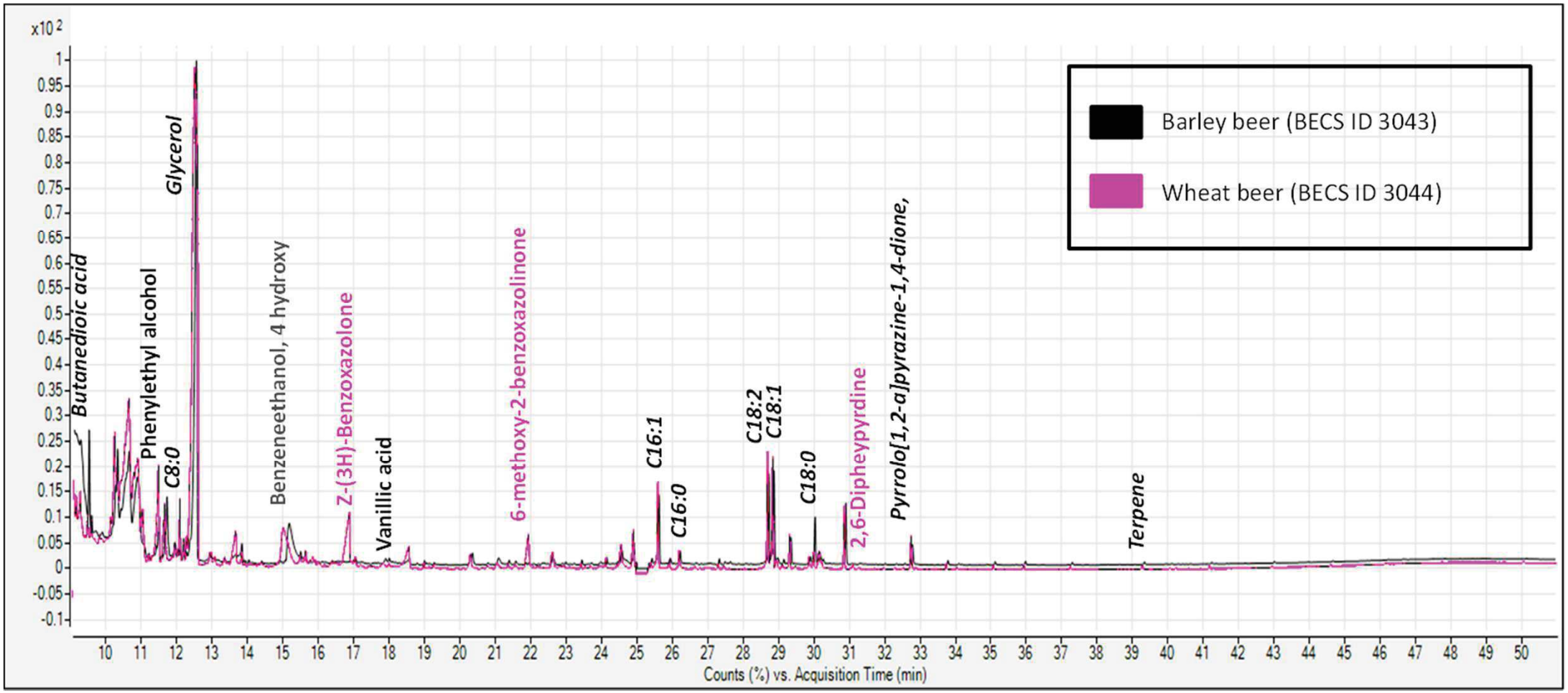


Fig. 267: Combined partial total ion chromatograms of samples of two modern beers (BECS 3043 and 3044): in pink, a sample of wheat beer containing a mixture of wheat malt and barley malt, and in black a sample of barley beer made from barley malt. Compounds in italic are found in our archaeological samples.

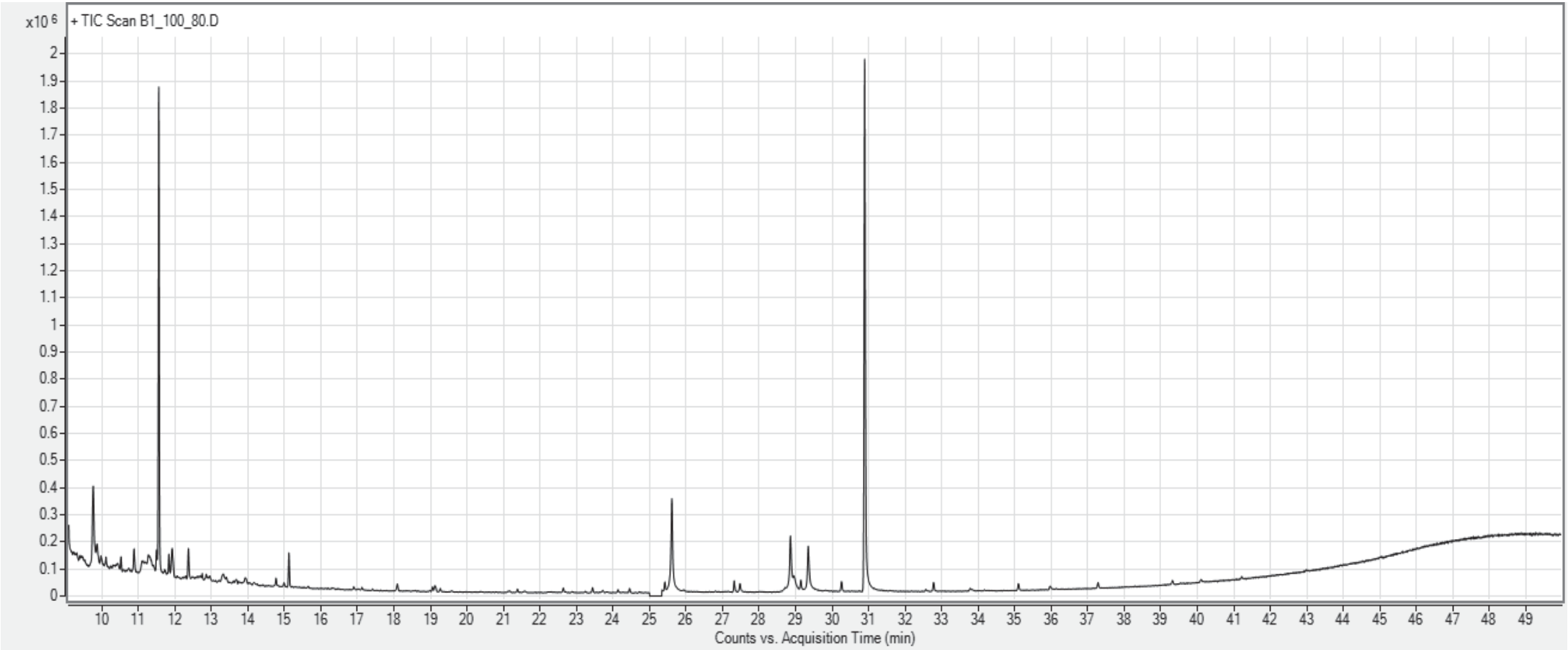


Fig. 268: Partial total ion chromatogram of a blank sample associated with Samples of modern beers BECS 3043, 3044.

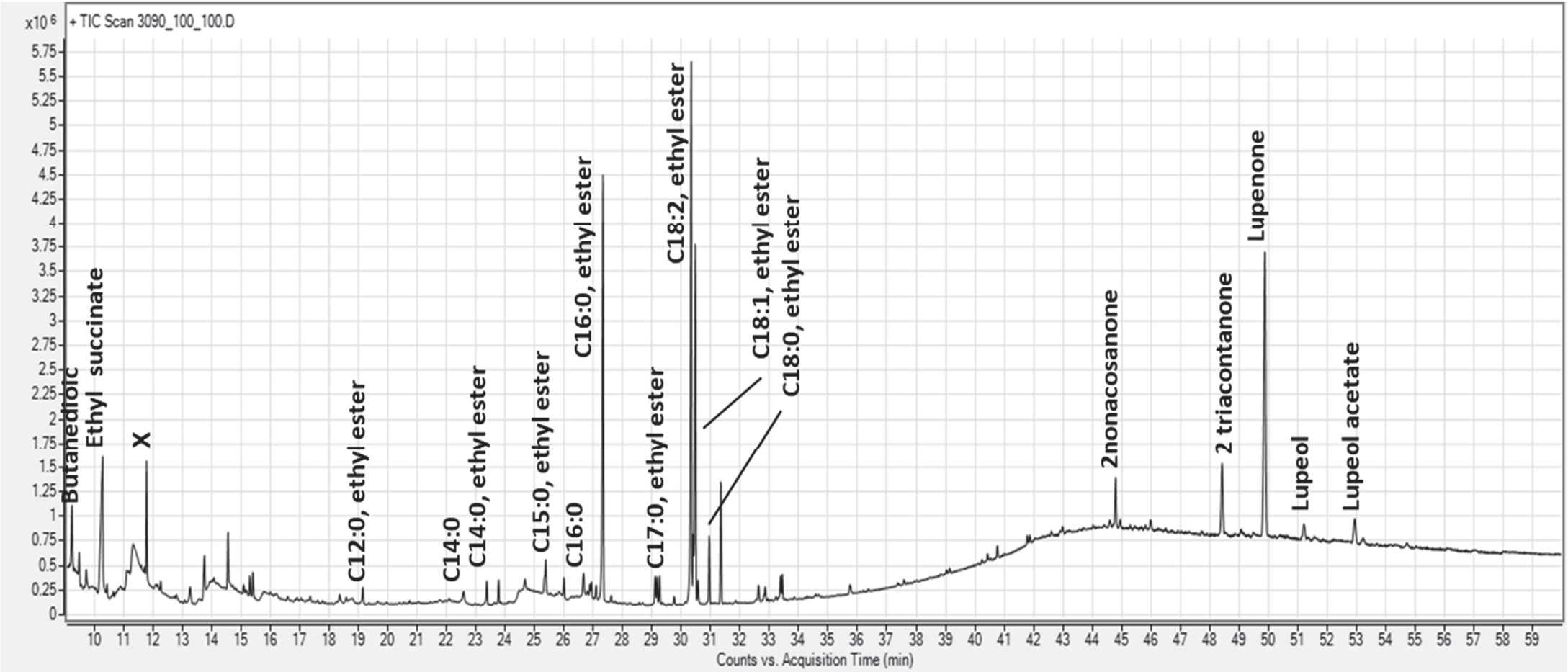


Fig. 269: Partial total ion chromatogram of a sample of dates from Iraq

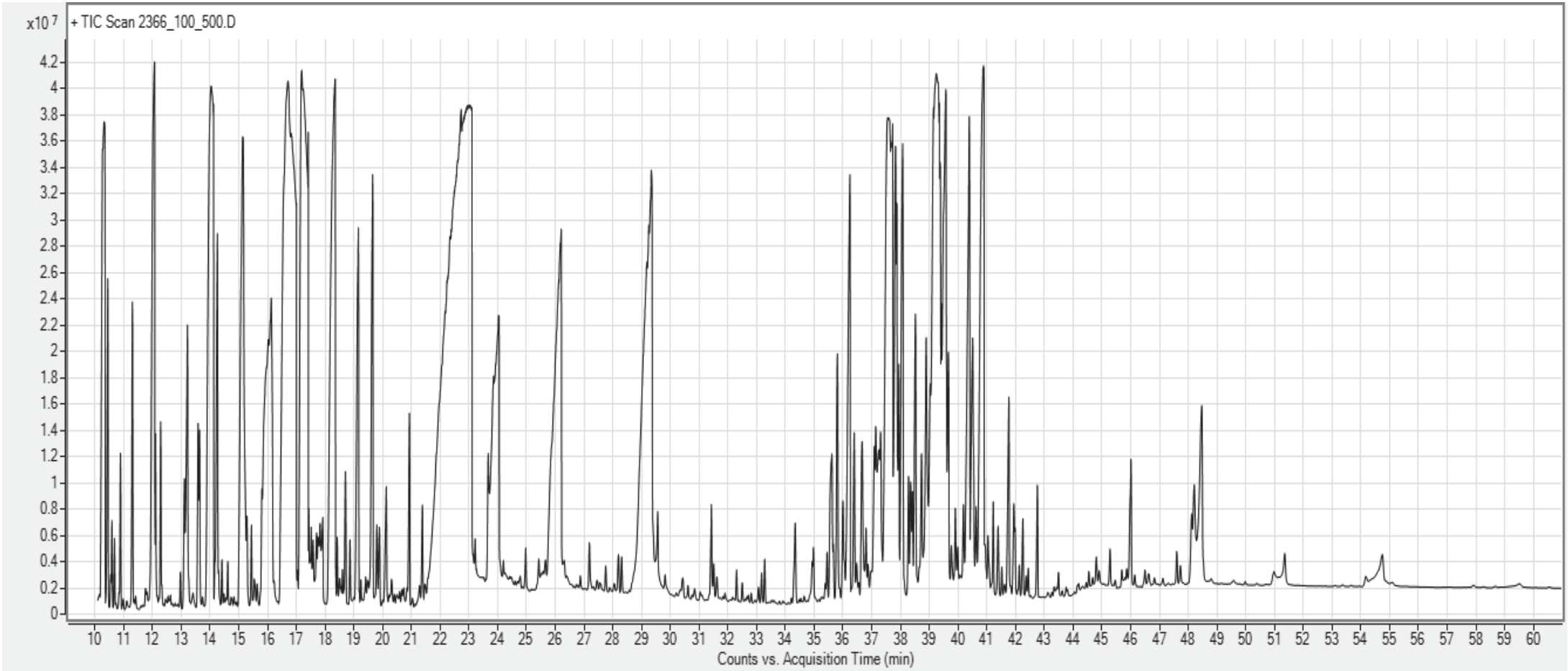


Fig. 270: Partial total ion chromatogram of sample of nutmeg without acid/neutral separation

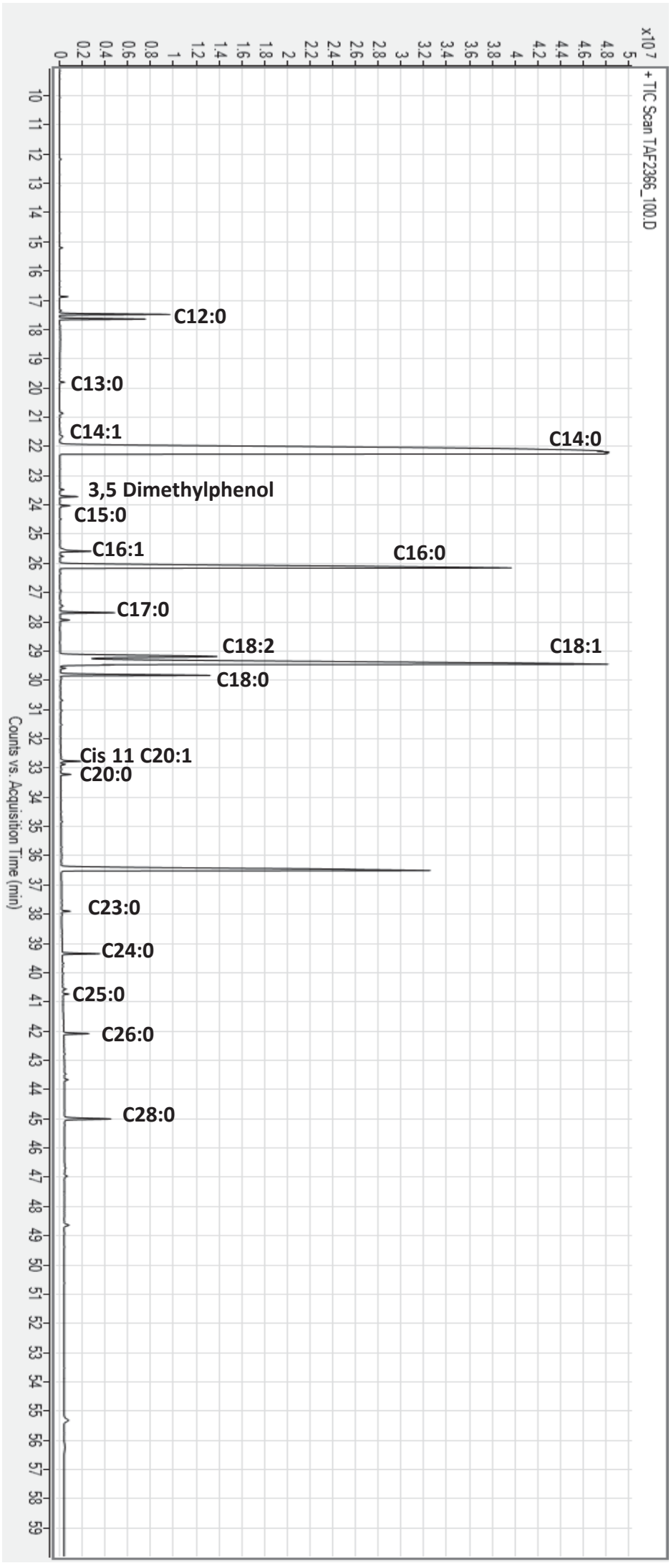


Fig. 271: Partial total ion chromatogram of the TAF of a sample of nutmeg

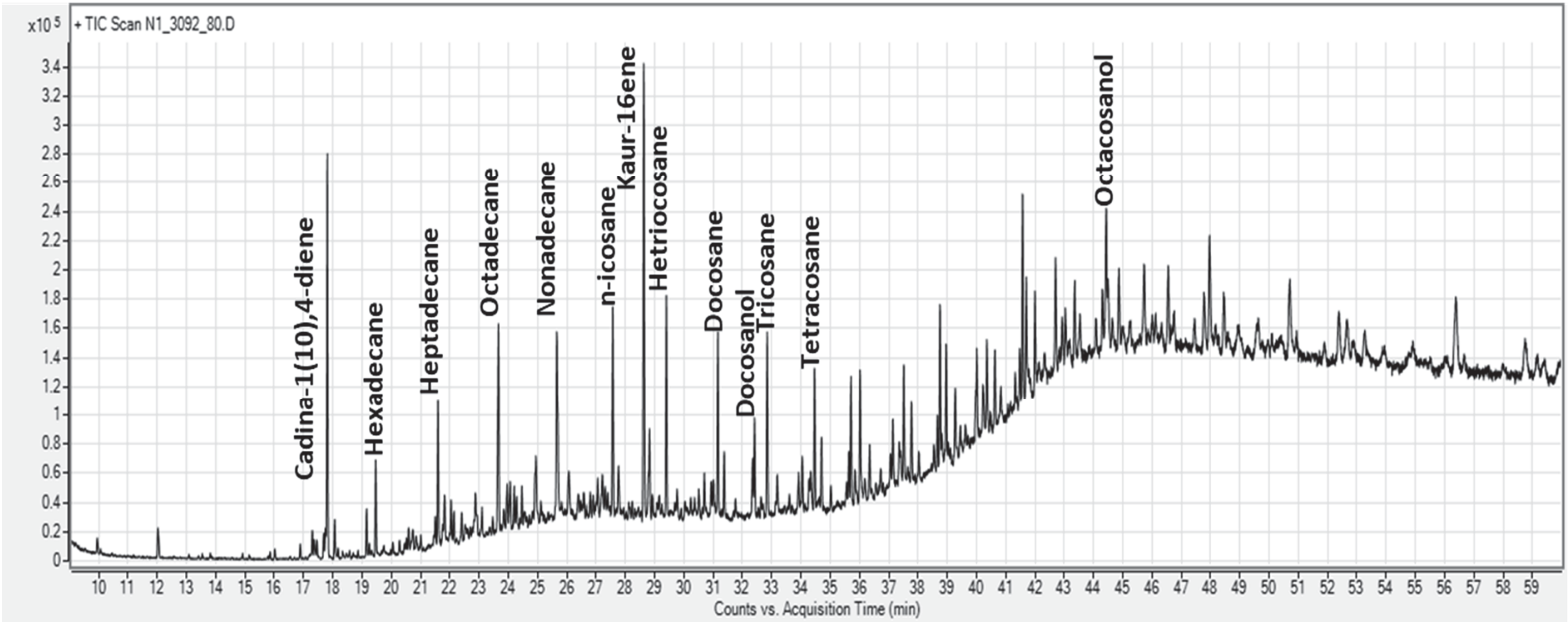


Fig. 272: Partial total ion chromatogram of the N1 fraction of a sample of nutmeg

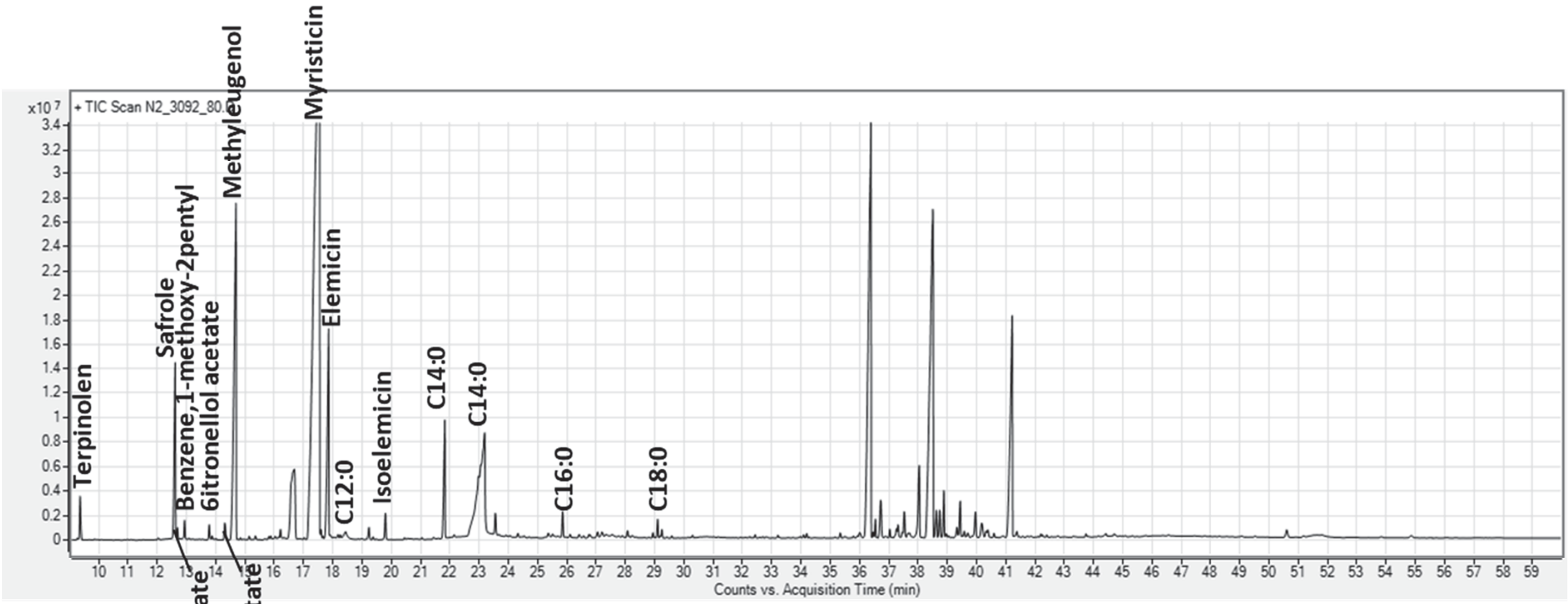


Fig. 273: Partial total ion chromatogram of the N2 fraction of a sample of nutmeg

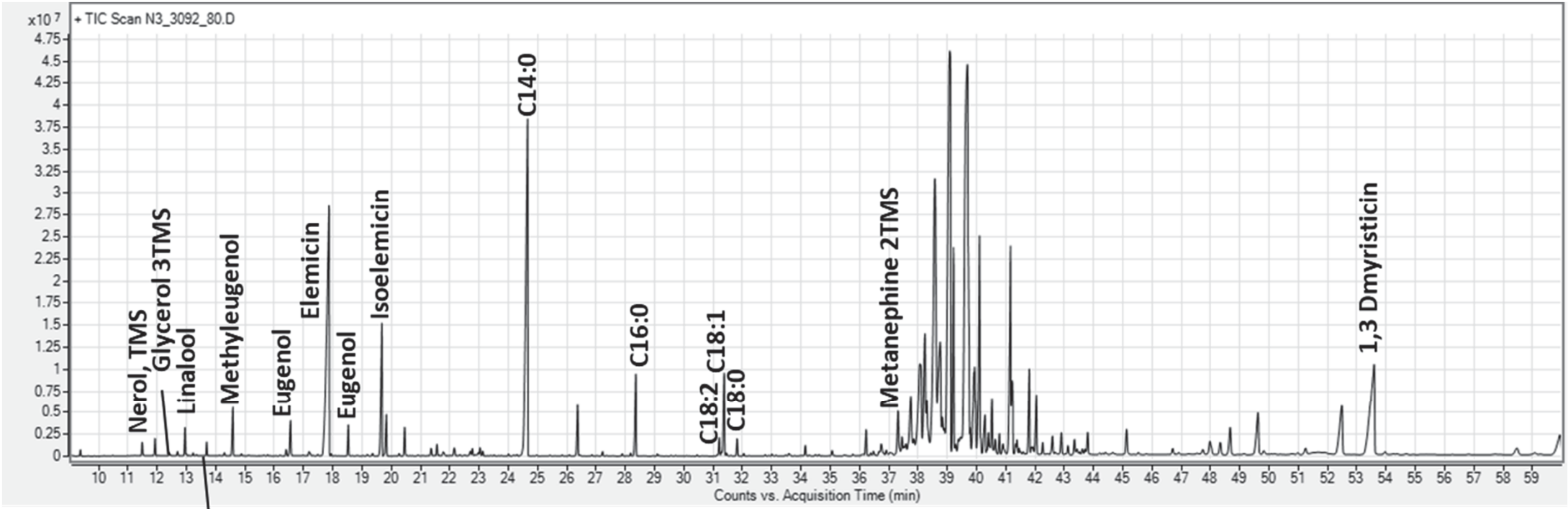


Fig. 274: Partial total ion chromatogram of the N3 fraction of a sample of nutmeg

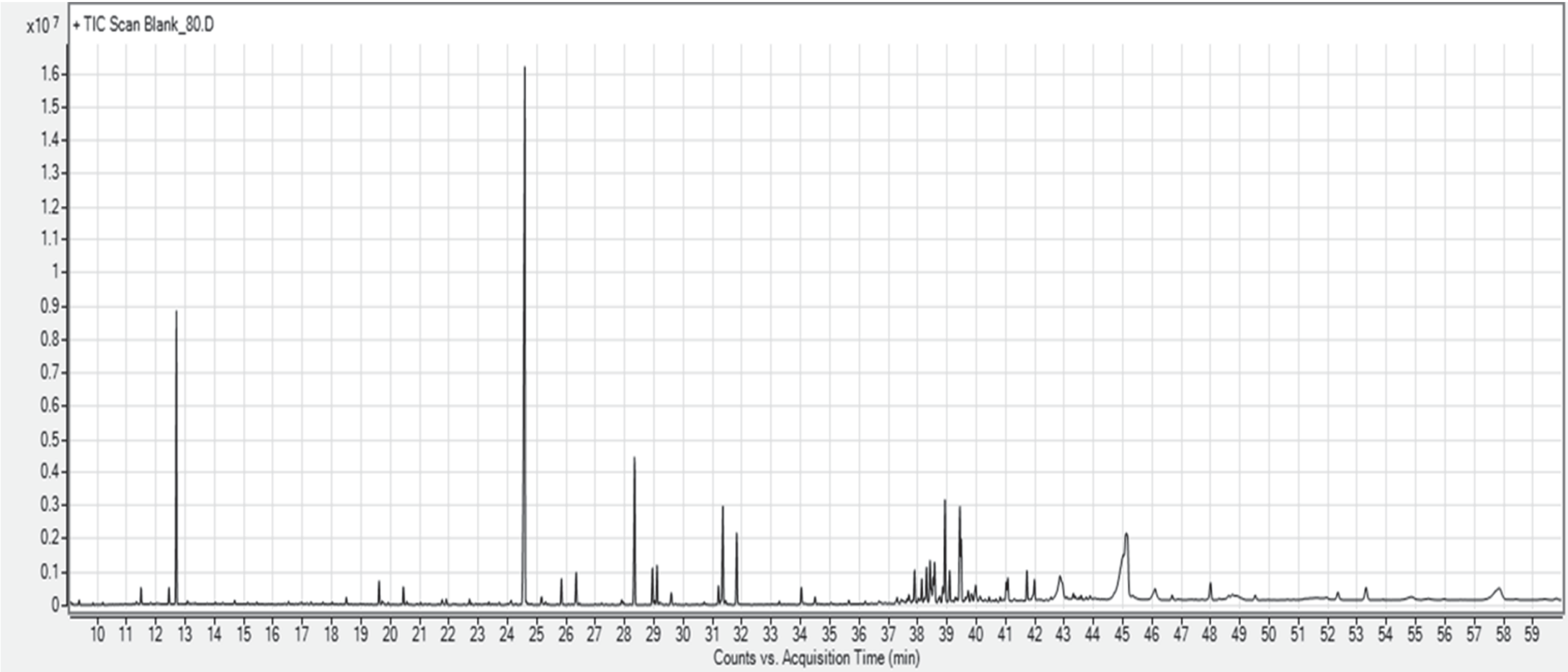


Fig. 275: Partial total ion chromatogram of a blank sample associated with the samples of nutmeg and dates.

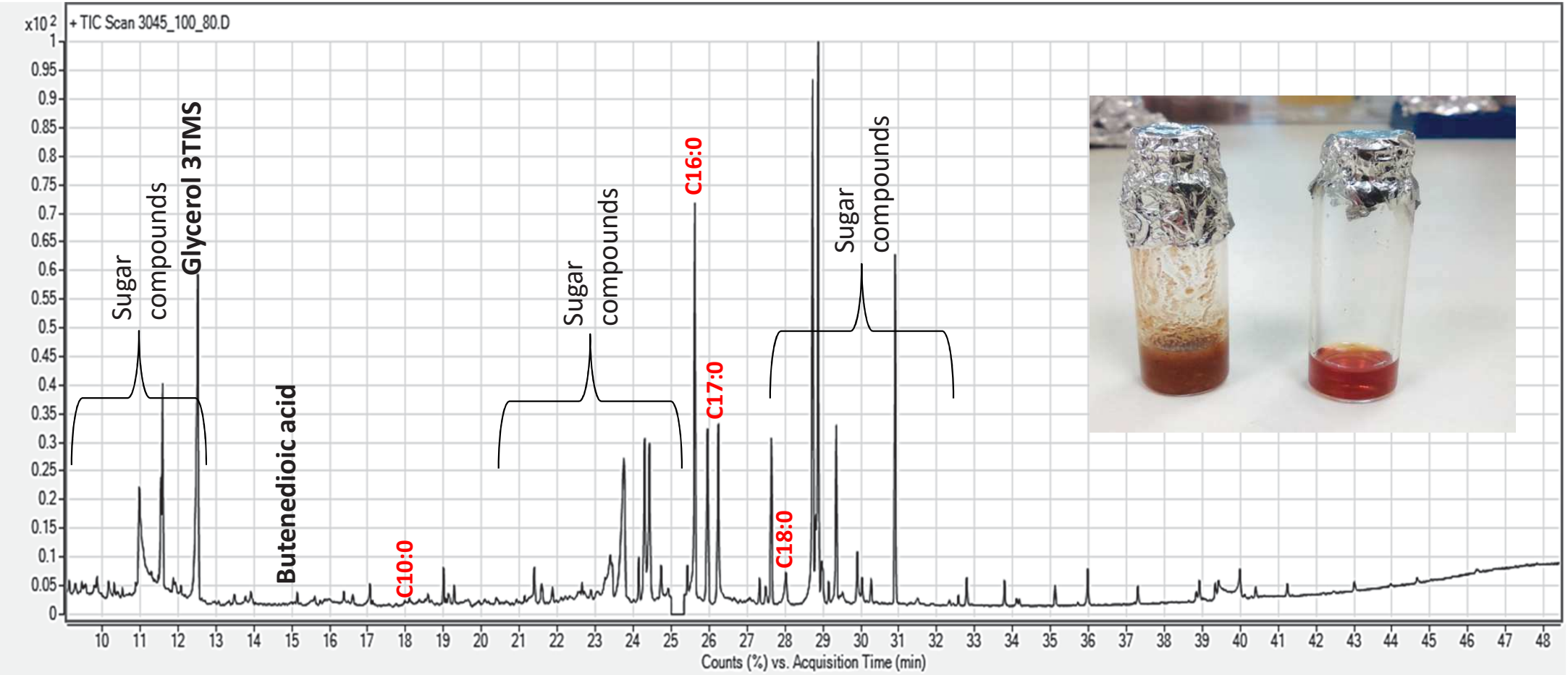


Fig. 276: Partial total ion chromatogram of a sample of beer recreated during the course "Feasting like the Ancients: An Inter-Disciplinary Approach to Early Food and Drink" using ingredients and replicas of ancient vessels

APPENDIX F
Main compounds mass-spectra

This appendix contains the mass spectra of the major archaeologically significant compounds identified in this thesis.

Each mass spectrum of the compounds found in the archaeological samples are compared and matched with compounds mass spectra from the NIST spectral library and reference samples.

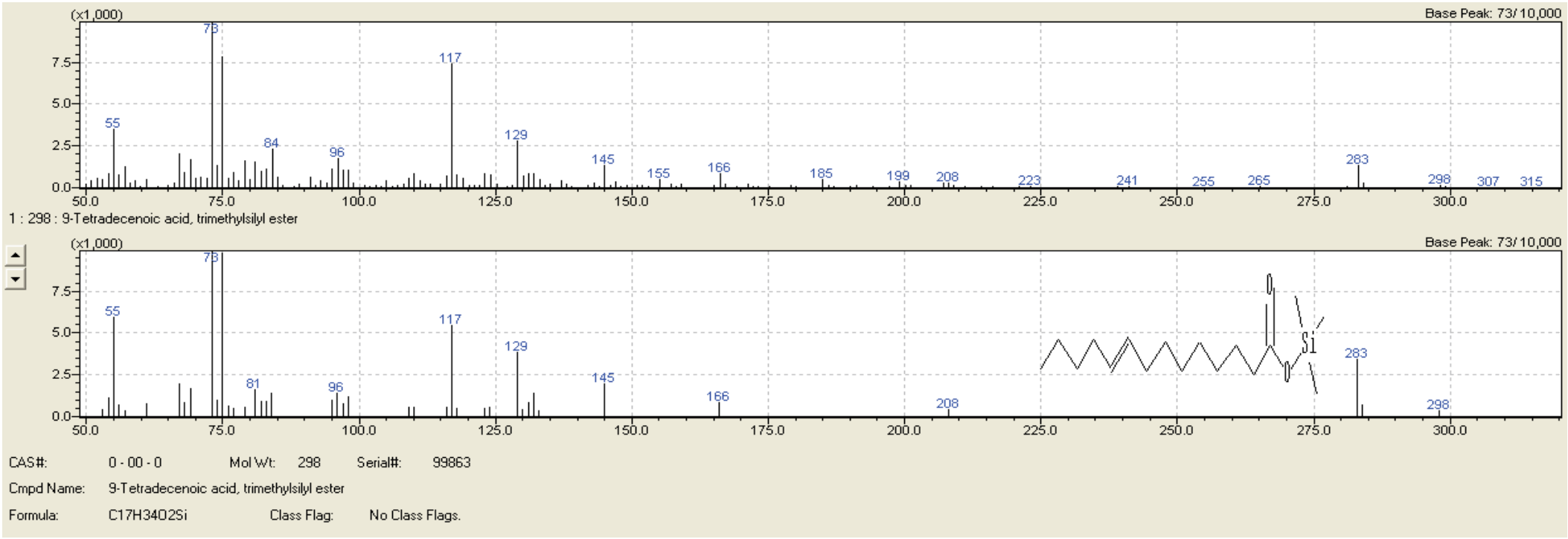


Figure 277: Matching and identification of $C_{14:1}$ fatty acid (myristoleic acid) mass-spectra acquired on GC-MS Shimadzu. Top: Mass-spectrum of the unknown compound found in the archaeological samples. Bottom: Mass-spectrum of $C_{14:1}$ fatty acid (9-tetradecenoic acid, tms) from the NIST spectral library.

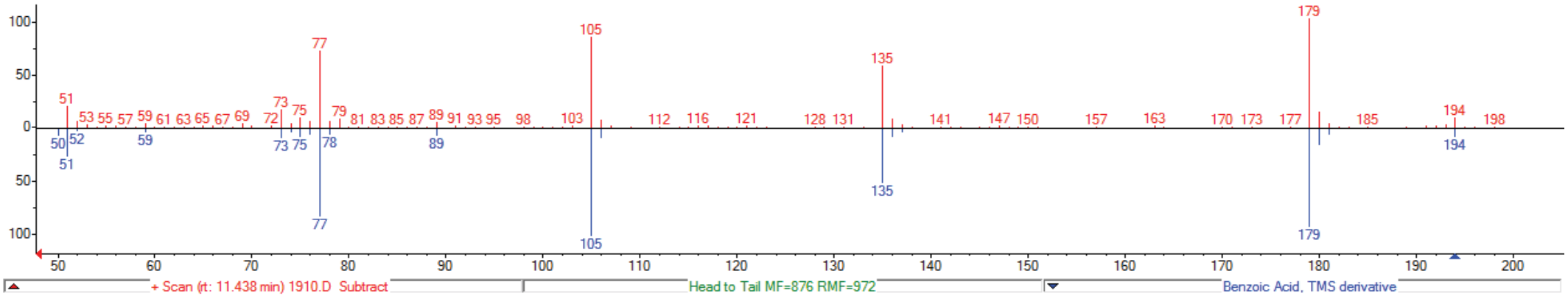


Figure 278: Matching and identification of benzoic acid mass-spectra acquired on GC-MS Agilent. Top in red: Mass-spectrum of the unknown compound found in the archaeological samples. Bottom in blue: Mass-spectrum of benzoic acid from the NIST spectral library.

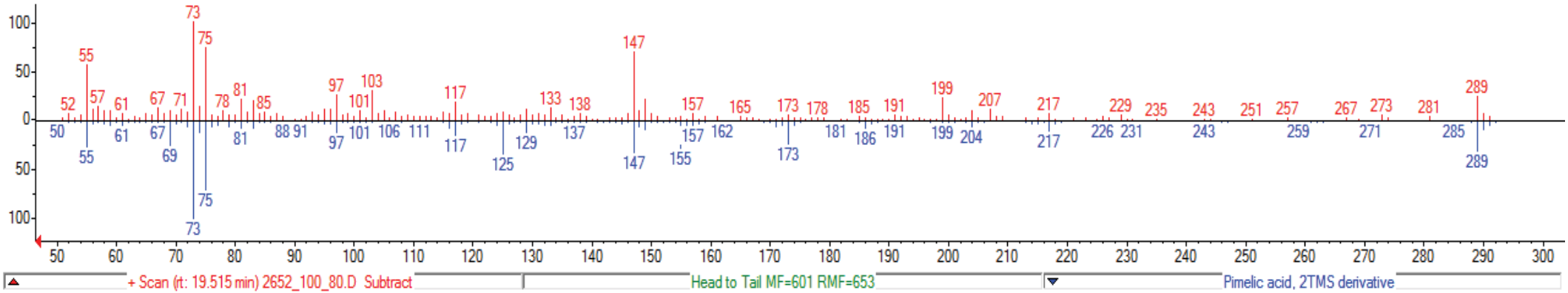


Figure 279: Matching and identification of pimelic acid mass-spectra acquired on GC-MS Agilent. Top in red: Mass-spectrum of the unknown compound found in the archaeological samples. Bottom in blue: Mass-spectrum of pimelic acid from the NIST spectral library.

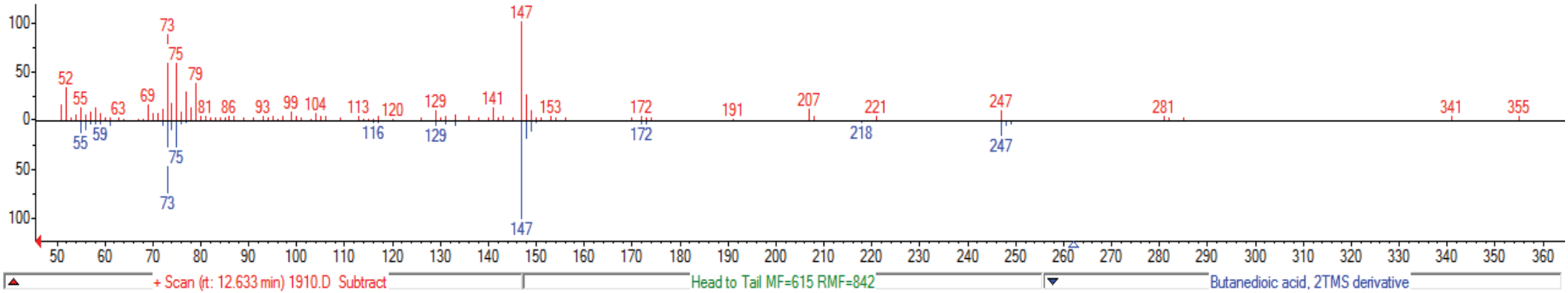


Figure 280: Matching and identification of butanedioic acid mass-spectra acquired on GC-MS Agilent. Top in red: Mass-spectrum of the unknown compound found in the archaeological samples. Bottom in blue: Mass-spectrum of butanedioic acid from the NIST spectral library.

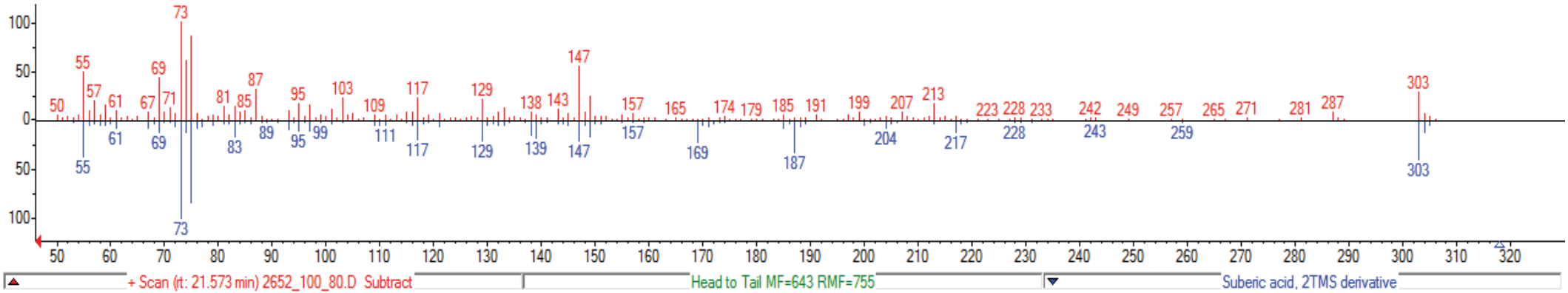


Figure 281: Matching and identification of suberic acid mass-spectra acquired on GC-MS Agilent. Top in red: Mass-spectrum of the unknown compound found in the archaeological samples. Bottom in blue: Mass-spectrum of suberic acid from the NIST spectral library.

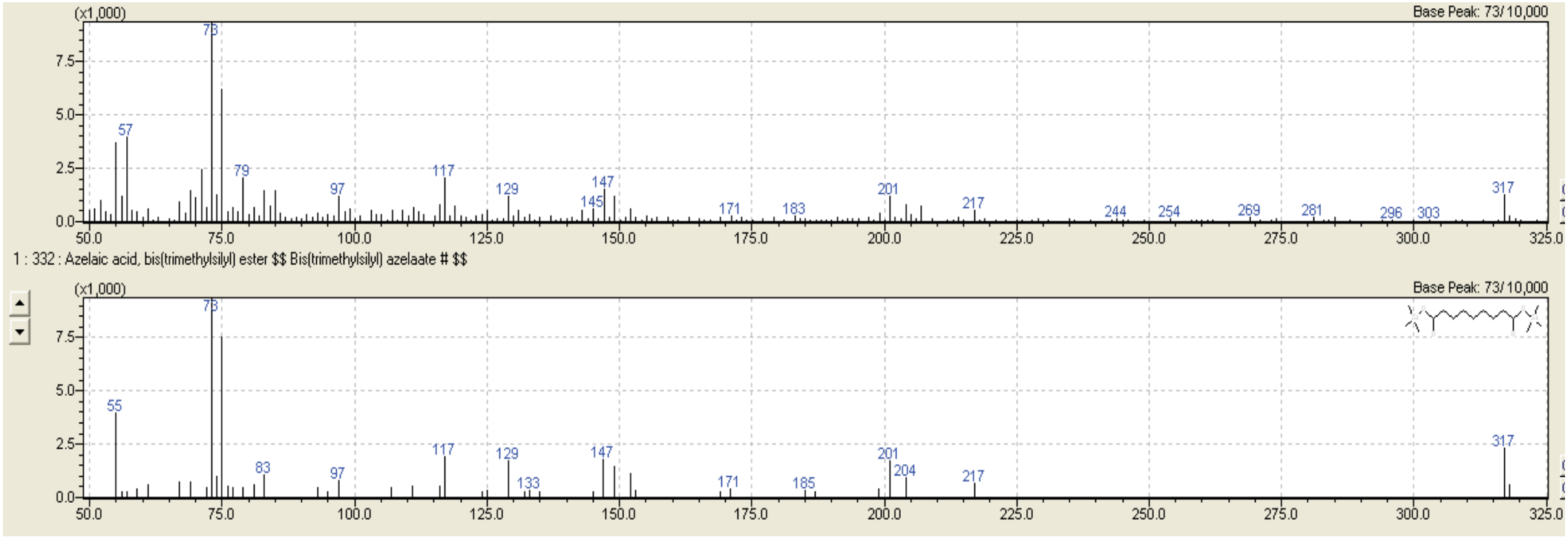


Figure 282: Matching and identification of azelaic acid mass-spectra acquired on GC-MS Shimadzu. Top: Mass-spectrum of the unknown compound found in the archaeological samples. Bottom: Mass-spectrum of azelaic acid from the NIST spectral library.

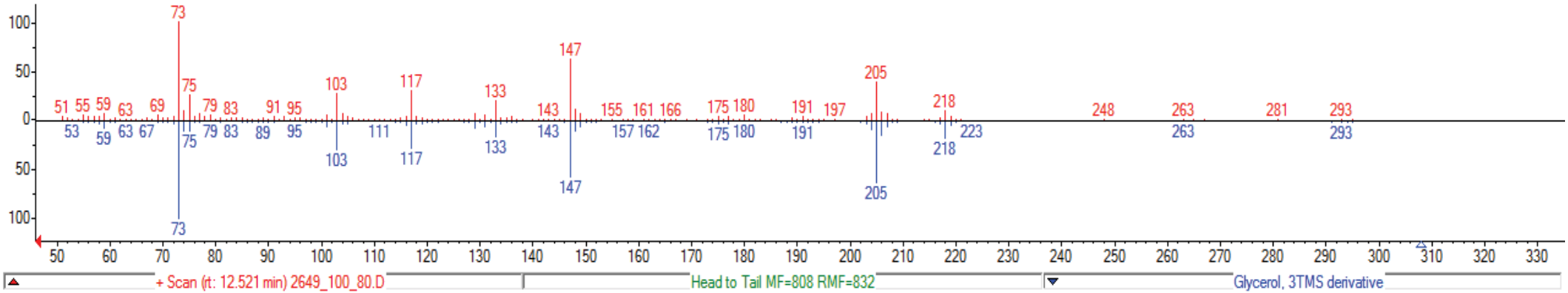


Figure 283: Matching and identification of glycerol, 3TMS mass-spectra acquired on GC-MS Agilent. Top in red: Mass-spectrum of the unknown compound found in the archaeological samples. Bottom in blue: Mass-spectrum of glycerol, 3TMS from the NIST spectral library.

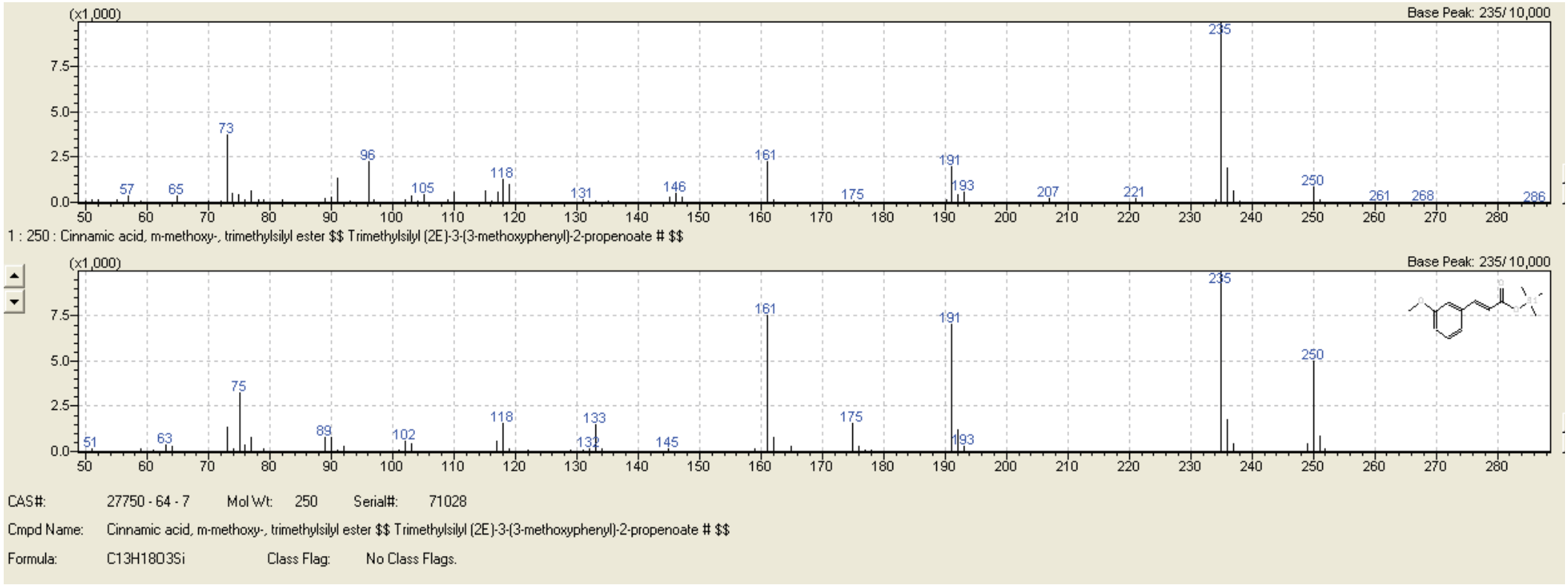


Figure 284: Matching and identification of methoxycinnamic acid mass-spectra acquired on GC-MS Shimadzu. Top: Mass-spectrum of the unknown compound found in the archaeological samples. Bottom: Mass-spectrum of methoxycinnamic acid from the NIST spectral library.

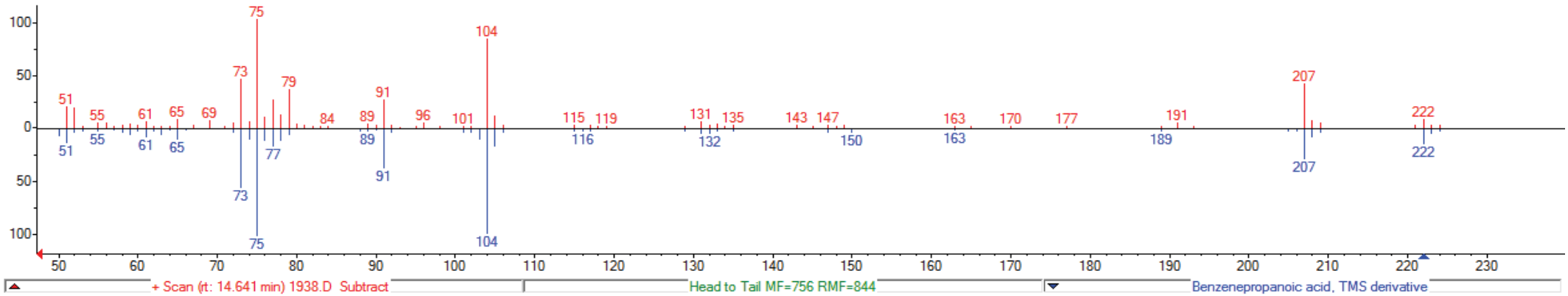


Figure 285: Matching and identification of hydrocinammic acid (benzenepropanoic acid) mass-spectra acquired on GC-MS Agilent. Top in red: Mass-spectrum of the unknown compound found in the archaeological samples. Bottom in blue: Mass-spectrum of hydrocinammic acid from the NIST spectral library.

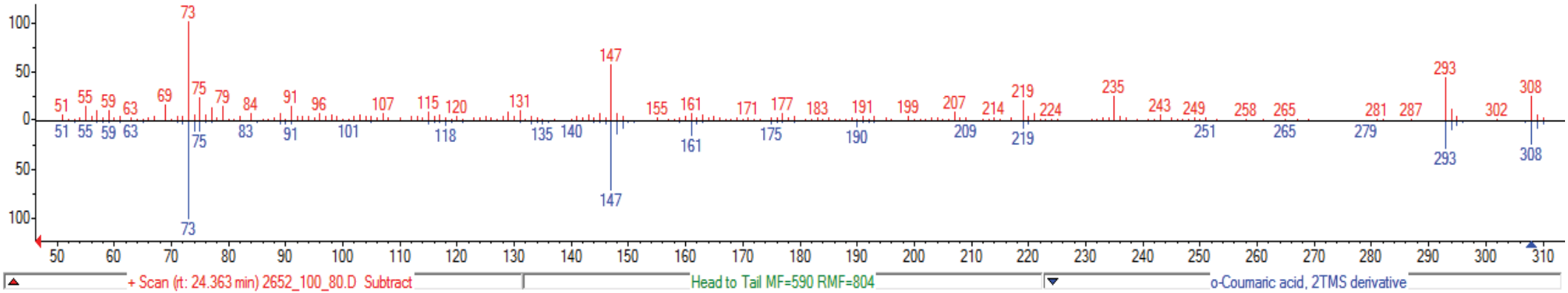


Figure 286: Matching and identification of o-coumaric acid mass-spectra acquired on GC-MS Agilent. Top in red: Mass-spectrum of the unknown compound found in the archaeological samples. Bottom in blue: Mass-spectrum of o-coumaric acid from the NIST spectral library.

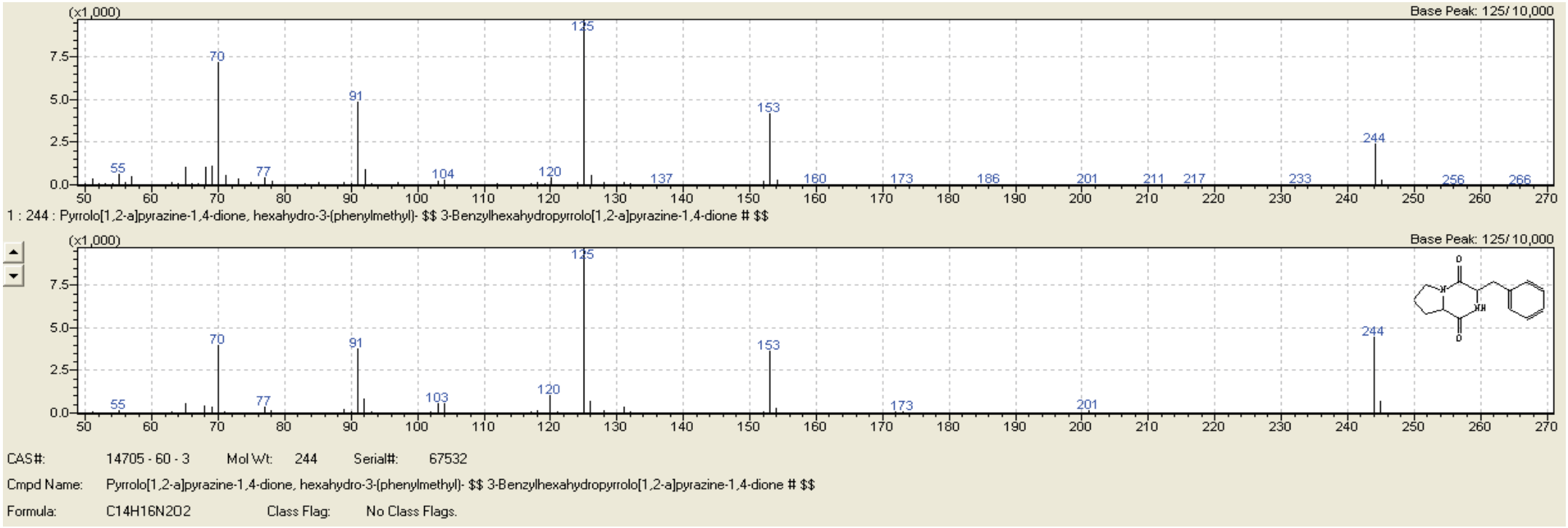


Figure 287: Matching and identification of pyrrolo[1,2-a]pyrazine-1,4-dione, hexahydro-3-(phenylmethyl) mass-spectra acquired on GC-MS Shimadzu. Top: Mass-spectrum of the unknown compound found in the archaeological samples. Bottom: Mass-spectrum of pyrrolo[1,2-a]pyrazine-1,4-dione, hexahydro-3-(phenylmethyl) from the NIST spectral library.

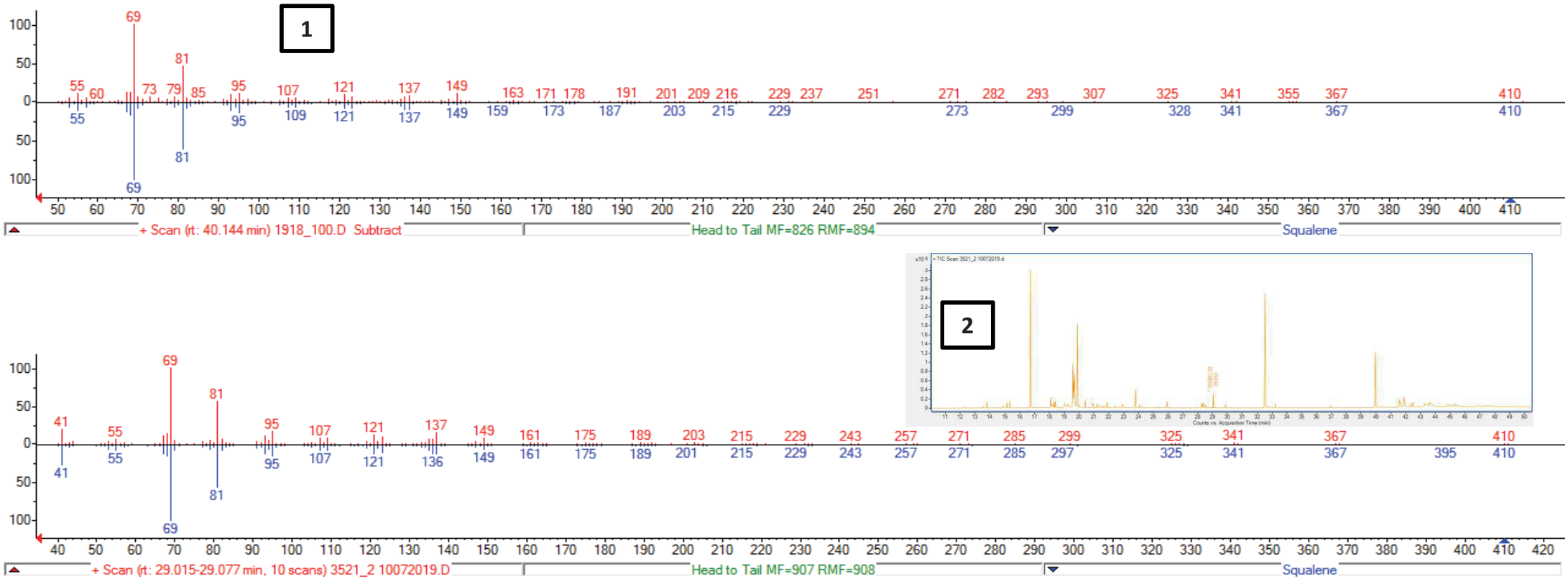


Figure 288: Matching and identification of squalene mass-spectra acquired on GC-MS Agilent. (1) Top in red: Mass-spectrum of the unknown compound found in the archaeological samples. Bottom in blue: Mass-spectrum of o-coumaric acid from the NIST spectral library; (2) The same compound of squalene has been identified in a bacteria type I methanotroph sample analysed by Anca Amariei (University of Glasgow).

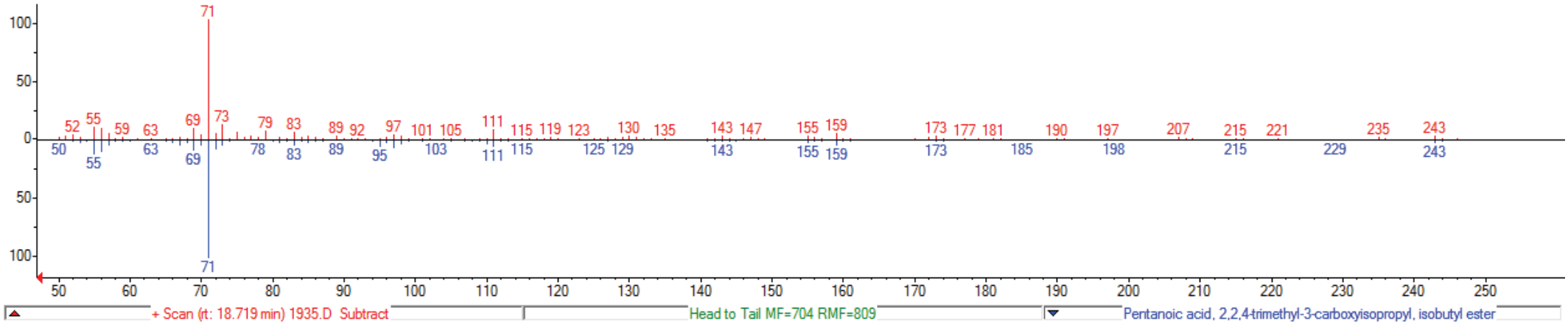


Figure 289: Matching and identification of 1-Isobutyl 4-isopropyl 3-isopropyl-2,2-dimethyl succinate (2,2,4-trimethyl-3-carboxy isopropyl-isobutyl pentanoate) mass-spectra acquired on GC-MS Agilent. Top in red: Mass-spectrum of the unknown compound found in the archaeological samples. Bottom in blue: Mass-spectrum of 1-Isobutyl 4-isopropyl 3-isopropyl-2,2-dimethyl succinate from the NIST spectral library.

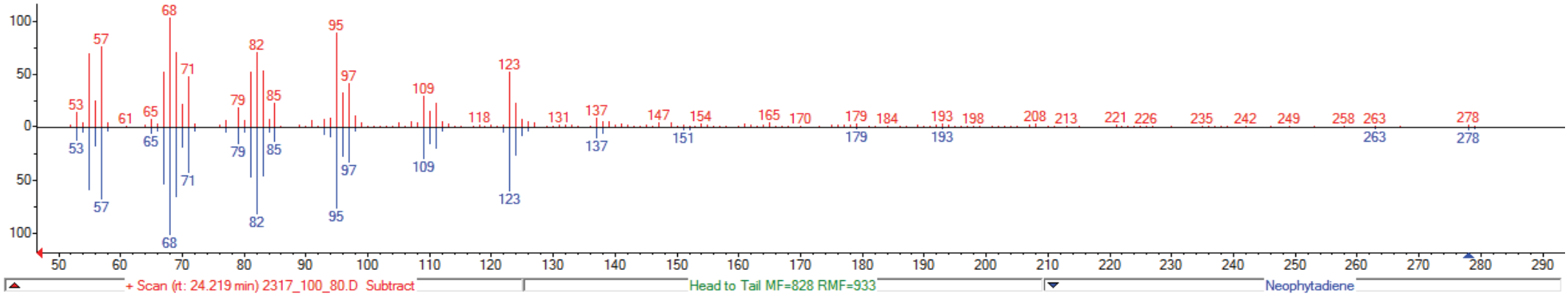


Figure 290: Matching and identification of neophytadiene mass-spectra acquired on GC-MS Agilent. Top in red: Mass-spectrum of the unknown compound found in the archaeological samples. Bottom in blue: Mass-spectrum of neophytadiene from the NIST spectral library.

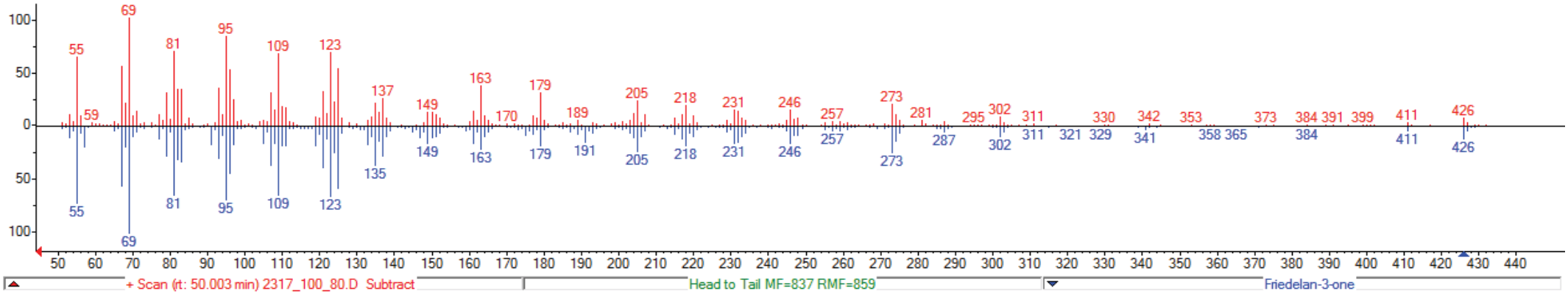


Figure 291: Matching and identification of friedelin mass-spectra acquired on GC-MS Agilent. Top in red: Mass-spectrum of the unknown compound found in the archaeological samples. Bottom in blue: Mass-spectrum of friedelin from the NIST spectral library.

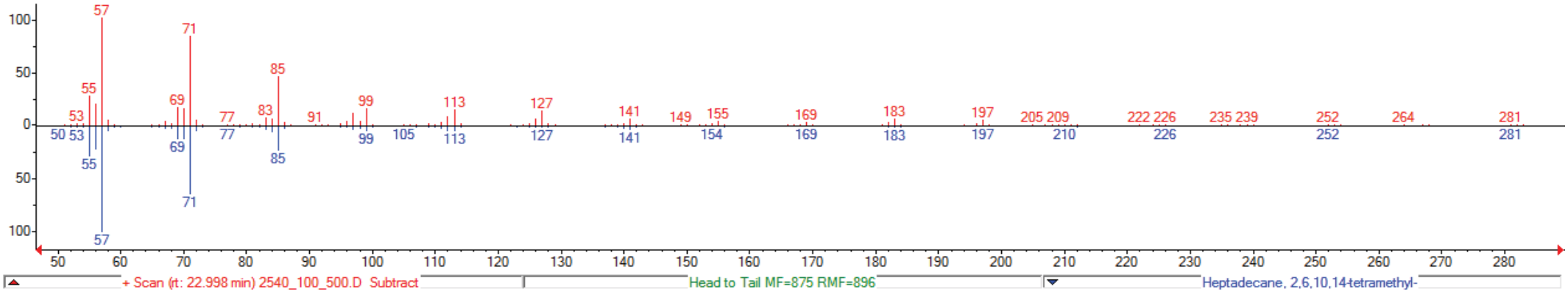


Figure 292: Matching and identification of phytane (2,6,10,14-tetramethylhexadecane) mass-spectra acquired on GC-MS Agilent. Top in red: Mass-spectrum of the unknown compound found in the archaeological samples. Bottom in blue: Mass-spectrum of phytane from the NIST spectral library.

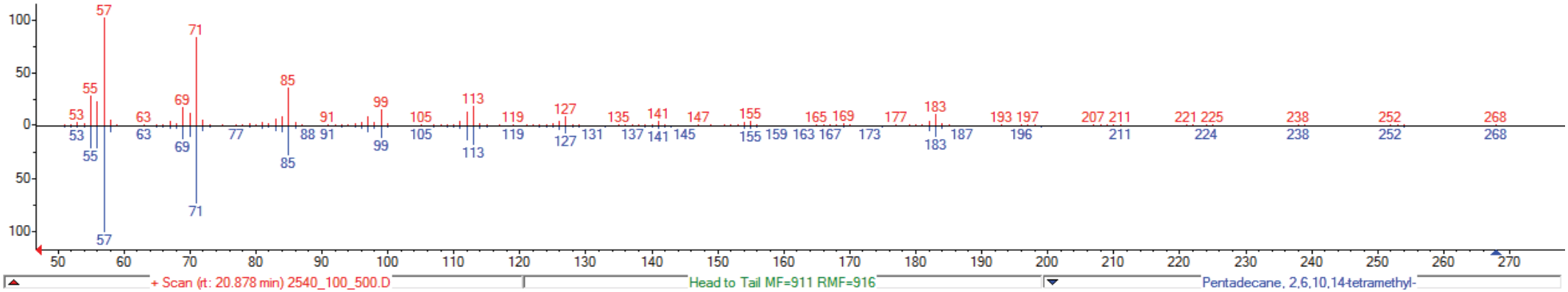


Figure 293: Matching and identification of pristane (2,6,10,14-tetramethylpentadecane) mass-spectra acquired on GC-MS Agilent. Top in red: Mass-spectrum of the unknown compound found in the archaeological samples. Bottom in blue: Mass-spectrum of pristane from the NIST spectral library.

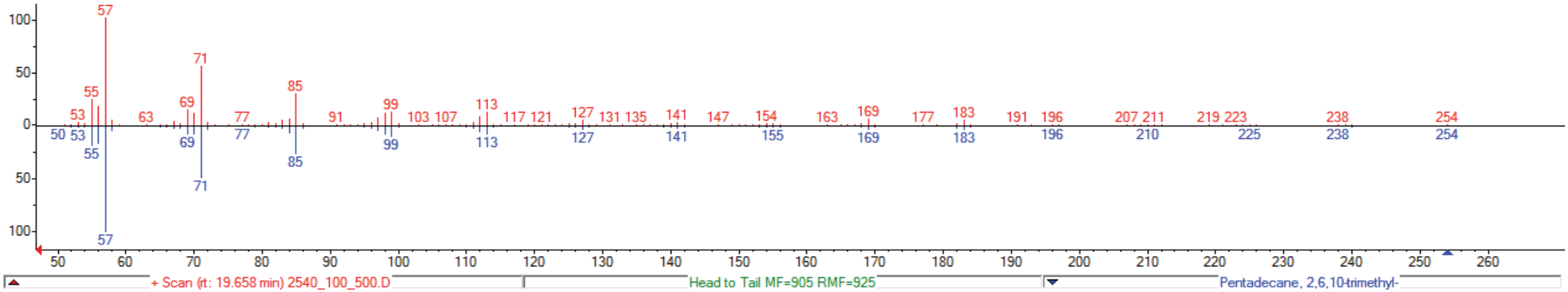


Figure 294: Matching and identification of norpristane (2,6,10-Trimethylpentadecane) mass-spectra acquired on GC-MS Agilent. Top in red: Mass-spectrum of the unknown compound found in the archaeological samples. Bottom in blue: Mass-spectrum of norpristane from the NIST spectral library.

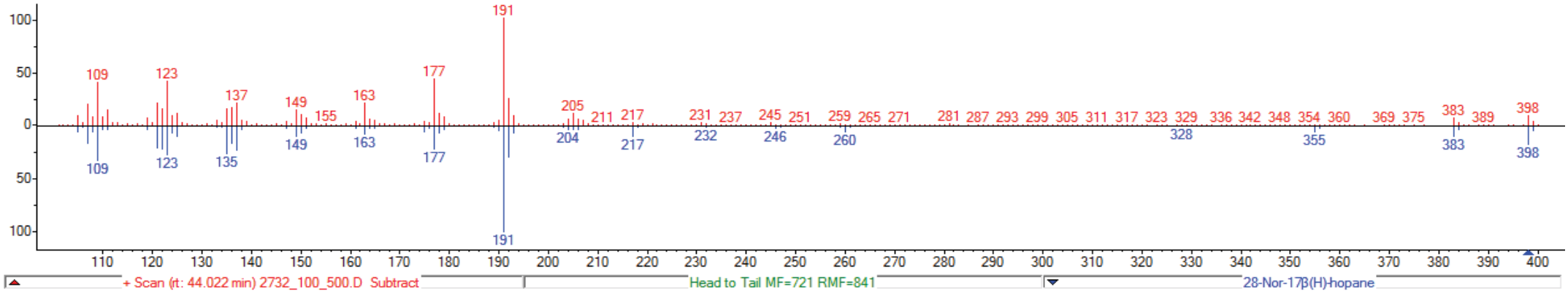


Figure 295: Matching and identification of 28-Nor-17β(H)-hopane mass-spectra acquired on GC-MS Agilent. Top in red: Mass-spectrum of the unknown compound found in the archaeological samples. Bottom in blue: Mass-spectrum of 28-Nor-17β(H)-hopane from the NIST spectral library.

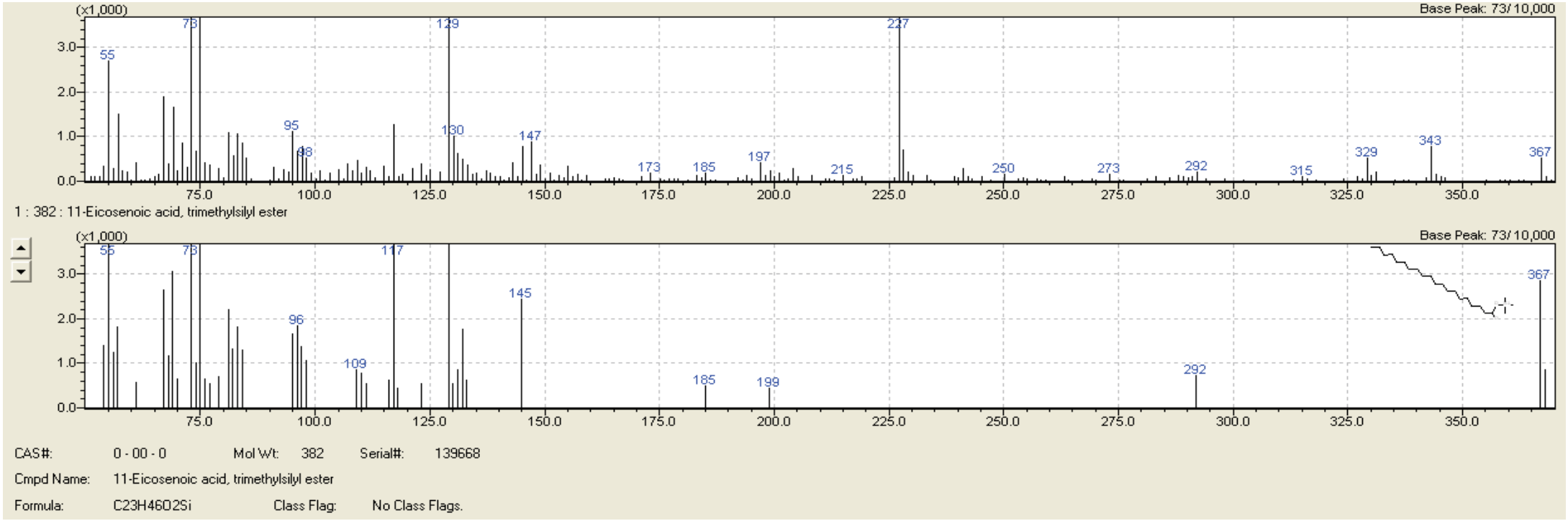


Figure 296: Matching and identification of $C_{20:1}$ fatty acid (11-eicosenoic acid) mass-spectra acquired on GC-MS Shimadzu. Top: Mass-spectrum of the unknown compound found in the archaeological samples. Bottom: Mass-spectrum of $C_{20:1}$ fatty acid from the NIST spectral library.

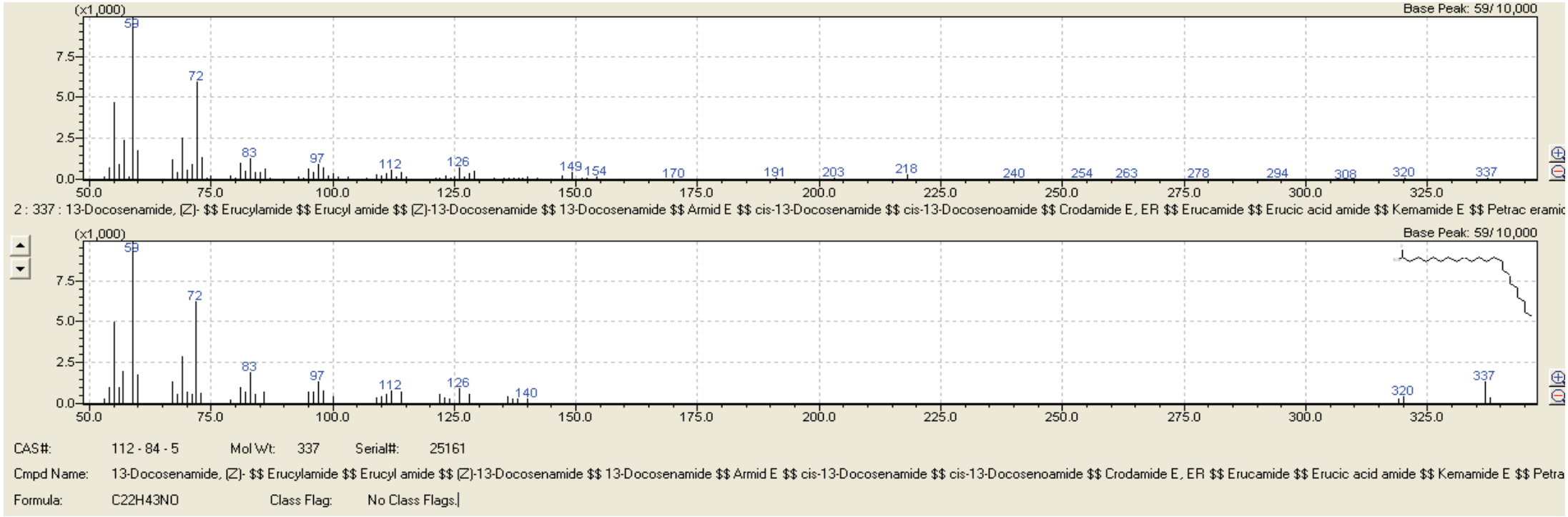


Figure 297: Matching and identification of erucylamide mass-spectra acquired on GC-MS Shimadzu. Top: Mass-spectrum of the unknown compound found in the archaeological samples. Bottom: Mass-spectrum of erucylamide from the NIST spectral library.

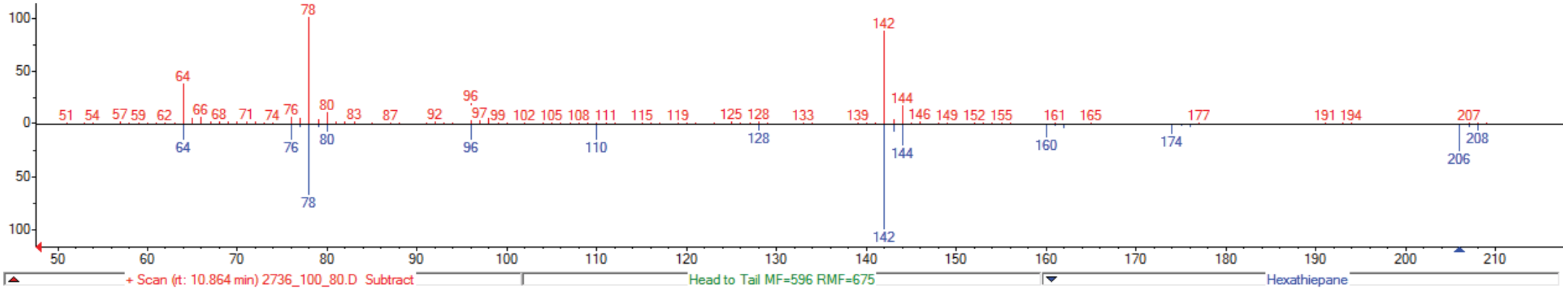


Figure 298: Matching and identification of hexathiepane mass-spectra acquired on GC-MS Agilent. Top in red: Mass-spectrum of the unknown compound found in the archaeological samples. Bottom in blue: Mass-spectrum of hexathiepane from the NIST spectral library.

APPENDIX G
Results tables

This appendix contains a summary of my results presented in the form of two tables.

Table 1 (a-b) presents the existence or absence of fatty acids in each archaeological samples and control samples. Table 2 (a-h) presents the existence or absence of other categories of lipids in each archaeological samples and control samples.

ID	Analysis date	TYPE	DATE	BECS ID	Context	Context 2	Saturated FA	C7:0	C8:0	C9:0	C10:0	C11:0	C12:0	C13:0	C14:0	C15:0	C16:0	C17:0	C18:0	C19:0	C20:0	C22:0	C23:0	C24:0	C25:0	C26:0	C28:0	Monounsaturated FA	C14:1	C16:1	C18:1	C20:1(cis-11)	Diunsaturated FA	C18:2	Oxo FA	10-oxo-C18:0	FA ester	Isopropyl myristate	Trimethylsilyloxy derivatives	2-Trimethylsilyloxyheptanoic	3-Trimethylsilyloxypalmitic
KM158	10/01/2018	B	2017	2540	Y88	Locus 113 Lot 1																																			
KM171	12/04/2018	B	2017	2720	V85	Locus 105 Lot 1	X										XXXX		XXXX									X			XXXX										
KM172	15/04/2018	B	2017	2807	Y89	Locus 6 Lot 1	X										X		XXXX									X			XXXX										
KM176	09/04/2018	B	2017	2599	V85	Locus 164 Lot 4	X										XXXX		XXXX									X			XXXX										
KM187	15/04/2018	B	2017	2755	Y88	Locus 110 Lot 1	X										XXXX		XXXX									X			XXXX										
KM19	10/10/2017	B	2016	1772	Y88	Locus 3 Lot 9	X								XXX		XXX		XXX									X			X										
KM1	10/10/2017	FB	2016	1760	Y88	Locus 2 Lot 4	X										XX		XX		X							X			X										
KM178	12/04/2018	C	2017	2736	K136D	Locus 4 Lot 2	X				X		X	XXX	X	X	XXXX	X	XXXX				X	XXXX				X			XXXX										
KM135	12/04/2018	FC	2017	2749	Y89	Locus 5 Lot 4	X										X		XXXX					XXXX				X			XXXX										
KM140	12/04/2018	FC	2017	2317	Y89	Locus 5 Lot 2	X								XX	X	XXXX		XXXX									X			XXXX										
KM150	28/03/2018	FC	2017	2303	Y89	Locus 5 Lot 2	X						X		X		X		X		XXX							X			XXXX										
KM154	12/04/2018	FC	2017	2739	V85	Locus 164 Lot 3	X									X	XXXX		XXXX									X			XXXX										
KM170	15/04/2018	FC	2017	2810	Y89	Locus 6 Lot 1	X										XXXX		XXXX									X			XXXX										
KM175	12/04/2018	FC	2017	2728	Y88	Locus 108 Lot 1	X										XXXX		XXXX									X			XXXX										
KM191	15/04/2018	FC	2017	2732	Y89	Locus 5 Lot 6																																			
KM196	15/04/2018	FC	2017	2746	Y89	Locus 5 Lot 6																																			
KM20	10/10/2017	FC	2016	1774	Y88	Locus 3 Lot 8	X				XXXX		XXXX		XXXX	XXXX	XXXX	XX	XXXX	X	XX	XX		X		X		X	X	X	X	X						X	X
KM22	10/10/2017	FC	2016	1922	L80D	Locus 2 Lot 1	X			X					X	X	XXXX	X	XXXX		XX			X		X		X		X	X									
KM281	15.04.18	FC	2017	2761	Y89	Locus 6 Lot 1	X										XXXX		XXXX									X			XXXX										
KM34	10/10/2017	FC	2016	1766	Y88	Locus 17 Lot 22	X				XXX		X	X	XXX	X	XXXX	X	XXXX		X	X		X				X	X	X	X	X	X	X						
KM38	10/10/2017	FC	2016	1769	Y88	Locus 21 Lot 34	X				XXX		XX	X	XXX	X	XXXX	X	XXXX		X	X		X				X	X	X	X	X	X	X						
KM42	10/10/2017	FC	2016	2215	Y88	Locus 1 Lot 1	X		X	X					X	X	XXXX	X	XXXX		X		X	X				X		X	X									
KM51	10/10/2017	FC	2016	2015	Y88	Locus 20 Lot 35	X										XXXX		XXXX																						
KM155	15/04/2018	FC HN	2017	2605	V85	Locus 164 Lot 3	X										XXXX		XXXX									X			XXXX										
KM190	12/04/2018	FC HN	2017	2723	V85	Locus 164 Lot 5	X							XXX			XXXX		XXXX									X			XXXX										
KM193	15/04/2018	FC HN	2017	2608	V85	Locus 164 Lot 4																																			
KM29	10/10/2017	FC HN	2016	1781	Y88	Locus 15 Lot 23	X				XXN/A		XXXN/A	X	XXXN/A	XXXN/A	XXXN/A	XXXN/A	XXXN/A		XN/A	XN/A		XN/A		XN/A		X	XN/A	XN/A	XN/A	X	X	XN/A						
KM156	12/04/2018	J	2017	2742	Y89	Locus 5 Lot 6	X										XXXX		XXXX									X			XXXX										
KM165	09/04/2018	J	2017	2602	V85	Locus 164 Lot 5	X									XXXX	XXXX		XXXX		X	X	X	X				X			XXXX		X	XXXX						
KM179	09/04/2018	J	2017	2649	Y88	Locus 114 Lot 1	X				XX		XXX		XXX		XXXX		XXXX									X			XXXX										
KM2	10/10/2017	J	2016	1750	Y88	Locus 2 Lot 4	X					XX	XXXX		X	X	XXXX	X	XXXX			X		X		X		X		X	X									
KM200	15/04/2018	J	2017	2813	Y88	Locus 110 Lot 1	X										XXXX		XXXX									X			XXXX										
KM203	15/04/2018	J	2017	2758	V85	Locus 117 Lot 2	X	X	X	X					XXXX		XXXX	X	XXXX									X			XXXX										
KM115	28/03/2018	JAR	2017	2320	Y88	Locus 104 Lot 1	X										XXXX		XXXX									X			XXXX										

Table 1a: Summary of the major fatty acids found in the reference samples of malted barley, modern barley beer, modern wheat beer, nutmeg and dates as well as in the 59 vessel samples (X - Drilled samples) with comparison with control samples: **X -** Inner surface sample, **X** - Outer surface sample and **X** – Soil sample.

ID	Analysis date	TYPE	DATE	BECS ID	Context	Context 2	Saturated FA	C7:0	C8:0	C9:0	C10:0	C11:0	C12:0	C13:0	C14:0	C15:0	C16:0	C17:0	C18:0	C19:0	C20:0	C22:0	C23:0	C24:0	C25:0	C26:0	C28:0	Monounsaturated FA	C14:1	C16:1	C18:1	C20:1(cis-11)	Diunsaturated FA	C18:2	Oxo FA	10-oxo-C18:0	FA ester	Isopropyl myristate	Trimethylsililoxy derivatives	2-Trimethylsililoxyheptanoic	3-Trimethylsilyloxypalmitic
KM129	09/04/2018	JAR	2017	2324	V85	Locus 157 Lot 1	X										XXXX		XXXX		X	X		X		X		X		X	X										
KM149	28/03/2018	JAR	2017	2332	V85	Locus 103 Lot 1	X										XXXX		XXXX									X			XXXX										
KM130	28/03/2018	JAR	2017	2313	Y88	Locus 108 Lot 1	X										XXXX		XXXX									X			XXXX										
KM121	15/04/2018	KG	2017	2594	V85	Locus 164 Lot 3	X										XXXX		XXXX									X			XXXX										
KM132	03/11/2017	KG	2017	2309	Y88	Locus 108 Lot 1	X								X		XXXX	X	XXXX									X			XXXX										
KM147	09/04/2018	KG	2017	2306	Y89	Locus 5 Lot 2	X						X		X		XXXX	X	XXXX									X			XXXX										
KM148	10/01/2018	KG	2017	2328	Y89	Locus 4 Lot 3	X									X	XXXX		XXXX		X							X			XXXX	X	X	XXXX							
KM17	10/10/2017	KG	2016	1777	Y88	Locus 3 Lot 10	X				XXXX				XXXX	XX	XXXX	XX	XXXX		X	XX						X	X	X	X	X	X	X							
KM18	10/10/2017	KG	2016	1918	Y88	Locus 14 Lot 19	X		XXXN/A	XXXN/A					XXXN/A	XXXN/A	XXXN/A	XN/A	XXXN/A	XN/A	XN/A	XN/A		XN/A	XN/A	XN/A		X		XN/A	XN/A	XN/A									
KM180	09/04/2018	KG	2017	2531	V85	Locus 117 Lot 2	X										XXXX		XXXX									X			XXXX										
KM181	09/04/2018	KG	2017	2537	Y89	Locus 3 Lot 2	X			XXXX	X		X			X	XXXX		XXXX									X			XXXX										
KM182	15/04/2018	KG	2017	2591	V85	Locus 164 Lot 1	X										XXXX		XXXX									X			XXXX										
KM186	09/04/2018	KG	2017	2534	V85	Locus 159 Lot 1	X										XXXX		XXXX									X			XXXX										
KM201	09/04/2018	KG	2017	2652	Y88	Locus 113 Lot 1	X				X		X	X	X	XXXX	XXXX	X	XXXX		XX	XXXX																	X		X
KM30	10/10/2017	KG	2016	2218	Y88	Locus 1 Lot 1																																				
KM41	10/10/2017	KG	2016	2223	Y88	Locus 1 Lot 1	X			X					X	X	XXXX		XXXX									X			X						X	X			
KM48	10/10/2017	KG	2016	2018	Y88	Locus 20 Lot 35	X										XXXX		XXXX																						
KM49	10/10/2017	KG	2016	1747	Y88	Locus 20 Lot 35	X				X		XXXX		XXXX	XXXX	XXXX	XX	XXXX		X	XX		X		X		X		X	X										
KM54	10/10/2017	KG	2016	1935	Y88	Locus 35 Lot 113	X		XXXX	XXXX	XXXX		XXXX		XXXX	XXXX	XXXX	XX	XXXX		X	XXXX		X				X		X	X										
KM55	10/10/2017	KG	2016	1757	Y88	Locus 20 Lot 35	X				XXXX		XXXX		XX	XX	XXXX	XX	XXXX		X	XX						X		X	X										
KM56	10/10/2017	KG	2016	1756	Y88	Locus 20 Lot 35	X				XXXX		XXXX		XX	XXXX	XXXX	XX	XXXX		X	XX		X		X		X		X	X										
KM66	10/10/2017	KG	2016	1915	Y88	Locus 36 Lot 41	X		X	X			XXX		XXX		XXXX	XX	XXXX		X	XXXX		XX		XX	XX	X		X	X			X	X					
KM70	10/10/2017	KG	2016	1938	Y88	Locus 40 Lot 46	X								XXX		XXXX		XXXX		X	XXX		X				X		X	X										
KM11	10/10/2017	N	2016	1910	Y88	Locus 3 Lot 10	X			X					X		XXXX		XXXX									X		X	X										
KM280	12/04/2018	N	2017	2752	Y89	Locus 6 Lot 1	X										XXXX		XXXX																						
MALTED BARLEY				2367			X				X				X		X		X									X		X	X										
WHEAT BEER				3043			X		X								X		X		X							X		X	X		X	X						
BARLEY BEER				3044			X		X								X		X									X		X	X		X	X						
NUTMEG				2366			X						X	X	X	X	X		X		X		X	X	X	X	X	X	X	X	X	X	X							
DATES				3090			X								X		X		X																						

Table 1b: Summary of the major fatty acids found in the reference samples of malted barley, modern barley beer, modern wheat beer, nutmeg and dates as well as in the 59 vessel samples (X - Drilled samples) with comparison with control samples: **X -** Inner surface sample, **X** - Outer surface sample and **X** – Soil sample.

ID	Analysis date	TYPE	DATE	BECS ID	Context	Context 2	**Carboxylics**	Benzoic	Pimelic	Suberic	Butanedioic	Azelaic	Fumaric	**Terpene**	Squalene	Neophytadiene	**Aldehydes**	Octadecenal	4-phenoxybenzaldehyde	**Amides**	Erucylamide	Octadecanamide	**Phenolics**	Hydrocinnamic	Methoxycinnamic	O-coumaric	**Wax esters**	Oleyl palmitoleate	Oleyl oleate	Dodecyl oleate	Octadecyl palmitate	**Propanoic acid, 2-methyl-, 1-(1,1-dimethylethyl)-2-methyl-1,3-propanediyl ester**	**Phosphoric**	**Acetic acid, phenoxy-, trimethyl ester**	**1-Isobutyl 4-isopropyl 3-isopropyl-2,2-dimethyl succinate**	**Pyrrolo[1,2-a]pyrazine-1,4-dione**
KM158	10/01/2018	B	2017	2540	Y88	Locus 113 Lot 1																														
KM171	12/04/2018	B	2017	2720	V85	Locus 105 Lot 1																														
KM172	15/04/2018	B	2017	2807	Y89	Locus 6 Lot 1																														
KM176	09/04/2018	B	2017	2599	V85	Locus 164 Lot 4																														
KM187	15/04/2018	B	2017	2755	Y88	Locus 110 Lot 1																														
KM19	10/10/2017	B	2016	1772	Y88	Locus 3 Lot 9																														
KM1	10/10/2017	FB	2016	1760	Y88	Locus 2 Lot 4																					X			X	X					
KM178	12/04/2018	C	2017	2736	K136D	Locus 4 Lot 2	X	X																												
KM135	12/04/2018	FC	2017	2749	Y89	Locus 5 Lot 4	X	X																												
KM140	12/04/2018	FC	2017	2317	Y89	Locus 5 Lot 2								X		X																				
KM150	28/03/2018	FC	2017	2303	Y89	Locus 5 Lot 2																														
KM154	12/04/2018	FC	2017	2739	V85	Locus 164 Lot 3																														
KM170	15/04/2018	FC	2017	2810	Y89	Locus 6 Lot 1																														
KM175	12/04/2018	FC	2017	2728	Y88	Locus 108 Lot 1																														
KM191	15/04/2018	FC	2017	2732	Y89	Locus 5 Lot 6																														
KM196	15/04/2018	FC	2017	2746	Y89	Locus 5 Lot 6																														
KM20	10/10/2017	FC	2016	1774	Y88	Locus 3 Lot 8	X		X	X	X	XXX	X	X	X								X		XX		X	X	X						
KM22	10/10/2017	FC	2016	1922	L80C	Locus 2 Lot 1	X	X						X	X																					
KM281	15/04/2018	FC	2017	2761	Y89	Locus 6 Lot 1																														
KM34	10/10/2017	FC	2016	1766	Y88	Locus 17 Lot 22	X	XX				X		X	X		X	XXX					X		X							XXX		X		
KM38	10/10/2017	FC	2016	1769	Y88	Locus 21 Lot 34	X					X		X	X		X	XX		X	X		X		X							XXX				
KM42	10/10/2017	FC	2016	2215	Y88	Locus 1 Lot 1																														
KM51	10/10/2017	FC	2016	2015	Y88	Locus 20 Lot 35																														
KM155	15/04/2018	FC HN	2017	2605	V85	Locus 164 Lot 3																														
KM190	12/04/2018	FC HN	2017	2723	V85	Locus 164 Lot 5																														
KM193	15/04/2018	FC HN	2017	2608	V85	Locus 164 Lot 4																														
KM29	10/10/2017	FC HN	2016	1781	Y88	Locus 15 Lot 23								X	XN/A		X	XN/A		X	XN/A			X		XN/A						XXX				
KM156	12/04/2018	J	2017	2742	Y89	Locus 5 Lot 6																														
KM165	09/04/2018	J	2017	2602	V85	Locus 164 Lot 5																														
KM179	09/04/2018	J	2017	2649	Y88	Locus 114 Lot 1	X					XX																								
KM2	10/10/2017	J	2016	1750	Y88	Locus 2 Lot 4	X			X		XX		X	X									X		X							XXX		XXX		X
KM200	15/04/2018	J	2017	2813	Y88	Locus 110 Lot 1																														
KM203	15/04/2018	J	2017	2758	V85	Locus 117 Lot 2																														
KM115	28/03/2018	JAR	2017	2320	Y88	Locus 104 Lot 1																														

Table 2a: Summary of the other major compounds found in the reference samples of malted barley, modern barley beer, modern wheat beer, nutmeg and dates as well as in the 59 vessel samples (X - Drilled samples) with comparison with control samples: **X** - Inner surface sample, **X** - Outer surface sample and **X** – Soil sample.

ID	Analysis date	TYPE	DATE	BECS ID	Context	Context 2	Carboxylics	Benzoic	Pimelic	Suberic	Butanedioic	Azelaic	Fumaric	Terpene	Squalene	Neophytadiene	Aldehydes	Octadecenal	4-phenoxybenzaldehyde	Amides	Erucylamide	Octadecanamide	Phenolics	Hydrocinnamic	Methoxycinnamic	O-coumaric	Wax esters	Oleyl palmitoleate	Oleyl oleate	Dodecyl oleate	Octadecyl palmitate	Propanoic acid, 2-methyl-, 1-(1,1-dimethylethyl)-2-methyl-1,3-propanediyl ester	Phosphoric	Acetic acid, phenoxy-,trimethyl ester	1-isobutyl 4-isopropyl 3-isopropyl-2,2-dimethyl succinate	Pyrrolo[1,2-a]pyrazine-1,4-dione
KM129	09/04/2018	JAR	2017	2324	V85	Locus 157 Lot 1																													
KM149	28/03/2018	JAR	2017	2332	V85	Locus 103 Lot 1																													
KM130	28/03/2018	JAR	2017	2313	Y88	Locus 108 Lot 1																													
KM121	15/04/2018	KG	2017	2594	V85	Locus 164 Lot 3																													
KM132	03/11/2017	KG	2017	2309	Y88	Locus 108 Lot 1														X		X													
KM147	09/04/2018	KG	2017	2306	Y89	Locus 5 Lot 2	X				X																								
KM148	10/01/2018	KG	2017	2328	Y89	Locus 4 Lot 3														X		X													
KM17	10/10/2017	KG	2016	1777	Y88	Locus 3 Lot 10								X	X		X	X					X		X							XXXX				
KM18	10/10/2017	KG	2016	1918	Y88	Locus 14 Lot 19	X					XN/A		X	XN/A																				
KM180	09/04/2018	KG	2017	2531	V85	Locus 117 Lot 2								X	X				XXXX																
KM181	09/04/2018	KG	2017	2537	Y89	Locus 3 Lot 2								X	X					X	XXX														X
KM182	15/04/2018	KG	2017	2591	V85	Locus 164 Lot 1																													
KM186	09/04/2018	KG	2017	2534	V85	Locus 159 Lot 1																													
KM201	09/04/2018	KG	2017	2652	Y88	Locus 113 Lot 1	X		X	X													X			X									
KM30	10/10/2017	KG	2016	2218	Y88	Locus 1 Lot 1																													
KM41	10/10/2017	KG	2016	2223	Y88	Locus 1 Lot 1	X	X																											
KM48	10/10/2017	KG	2016	2018	Y88	Locus 20 Lot 35																													
KM49	10/10/2017	KG	2016	1747	Y88	Locus 20 Lot 35								X	X		X	X		X	X		X		X							XXXX				
KM54	10/10/2017	KG	2016	1935	Y88	Locus 35 Lot 113								X	X		X	X		X	X													X	
KM55	10/10/2017	KG	2016	1757	Y88	Locus 20 Lot 35								X	X								X		X							XXXX				
KM56	10/10/2017	KG	2016	1756	Y88	Locus 20 Lot 35																	X		XX							XXXX				
KM66	10/10/2017	KG	2016	1915	Y88	Locus 40 Lot 46	X	XXX						X	X																				
KM70	10/10/2017	KG	2016	1938	Y88	Locus 36 Lot 41								X	X								X	XX											
KM11	10/10/2017	N	2016	1910	Y88	Locus 3 Lot 10	X	XX			X			X	X								X	X									XXXX		X	
KM280	12/04/2018	N	2017	2752	Y89	Locus 6 Lot 1																													
MALTED BARLEY				2367										X	X																				X
WHEAT BEER				3044			X				X			X	X																	X			X
BARLEY BEER				3043			X				X			X	X																				X
NUTMEG				2366																															
DATES				3090			X				X																								

Table 2b: Summary of the other major compounds found in the reference samples of malted barley, modern barley beer, modern wheat beer, nutmeg and dates as well as in the 59 vessel samples (X - Drilled samples) with comparison with control samples: **X** - Inner surface sample, **X** - Outer surface sample and **X** – Soil sample.

ID	Analysis date	TYPE	DATE	BECS ID	Context	Context 2	Straight-chain alcohols	C10:0	C12:0	C16:0	C17:0	C18:0	C20:0	C22:0	C26:0	C28:0	C30:0	Diols	1,2-octadecanediol	1-3-butanediol, 2TMS	Ketones	2 nonacosanone	Nonacosan-15-one	2 triacontanone	16-hentriacontanone	Even-numbered Alkanes	Odd-numbered Alkanes	C13	C14	C15	C16	C17	C18	C19	C20	C21	C22	C23	C24	C25	C26	C27	C28	C29	C30	C31	C32	C33	C34	C35
KM158	10/01/2018	B	2017	2540	Y88	Locus 113 Lot 1																				x	x		x	x	x	x	x	x	x	x	xxxx	x	x	x	x	x	x	x	xx				
KM171	12/04/2018	B	2017	2720	V85	Locus 105 Lot 1																																												
KM172	15/04/2018	B	2017	2807	Y89	Locus 6 Lot 1																				x									xxxx														
KM176	09/04/2018	B	2017	2599	V85	Locus 164 Lot 4	x					xxxx	xxxx																																					
KM187	15/04/2018	B	2017	2755	Y88	Locus 110 Lot 1																																												
KM19	10/10/2017	B	2016	1772	Y88	Locus 3 Lot 9															x		x		x		x															xxxx		xxxx		xxxx				
KM1	10/10/2017	FB	2016	1760	Y88	Locus 2 Lot 4																																											
KM178	12/04/2018	C	2017	2736	K136D	Locus 4 Lot 2																					x												xx		xx		xx		xx		xx		xx		
KM135	12/04/2018	FC	2017	2749	Y89	Locus 5 Lot 4																				x	x					xxxx			xxxx			xx		xx				xx				
KM140	12/04/2018	FC	2017	2317	Y89	Locus 5 Lot 2																					x						xxxx		xxx					xx		xx		xx				
KM150	28/03/2018	FC	2017	2303	Y89	Locus 5 Lot 2	x						xxxx														x												xx		xxxx		x		xx				
KM154	12/04/2018	FC	2017	2739	V85	Locus 164 Lot 3																																											
KM170	15/04/2018	FC	2017	2810	Y89	Locus 6 Lot 1																																											
KM175	12/04/2018	FC	2017	2728	Y88	Locus 108 Lot 1																																											
KM191	15/04/2018	FC	2017	2732	Y89	Locus 5 Lot 6																				x	x			x	x	x	x	x	xxxx	x	xxxx	x	xxxx	x	x	x	xxxx	x	xxxx	xxxx				
KM196	15/04/2018	FC	2017	2746	Y89	Locus 5 Lot 6																				x	x	x	x	x	xxxx	xxxx	xxxx	xxx	xxxx	xxxx	xxxx	xxxx	xxxx	xxxx	xxxx	xxxx	xxxx	xxxx	xxxx	x	xxxx	x	x	x	x
KM20	10/10/2017	FC	2016	1774	Y88	Locus 3 Lot 8																					x																		xxxx					
KM22	10/10/2017	FC	2016	1922	L80C	Locus 2 Lot 1	x		x																		x														xxxx		xxxx		xxxx		xxxx				
KM281	15/04/2018	FC	2017	2761	Y89	Locus 6 Lot 1																				x	x						xxxx	xxxx	xxxx			xxxx		xx		xx								
KM34	10/10/2017	FC	2016	1766	Y88	Locus 17 Lot 22																					x																					xxxx				
KM38	10/10/2017	FC	2016	1769	Y88	Locus 21 Lot 34																					x																		xx		xx				
KM42	10/10/2017	FC	2016	2215	Y88	Locus 1 Lot 1																																												
KM51	10/10/2017	FC	2016	2015	Y88	Locus 20 Lot 35																				x	x				xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxxx	xx	xxxx				
KM155	15/04/2018	FC HN	2017	2605	V85	Locus 164 Lot 3																																											
KM190	12/04/2018	FC HN	2017	2723	V85	Locus 164 Lot 5					xxx																x					xxx																	
KM193	15/04/2018	FC HN	2017	2608	V85	Locus 164 Lot 4																				x	x	x		x	x	xxxx	xxxx	x	x	x	xxxx	x	x	x	x	x							
KM29	10/10/2017	FC HN	2016	1781	Y88	Locus 15 Lot 23																					x																		xxxn/a		xxxn/a				
KM156	12/04/2018	J	2017	2742	Y89	Locus 5 Lot 6																																												
KM165	09/04/2018	J	2017	2602	V85	Locus 164 Lot 5	x								xxxx												x												xx		xx		xx		xx				
KM179	09/04/2018	J	2017	2649	Y88	Locus 114 Lot 1	x						xxx																																				
KM2	10/10/2017	J	2016	1750	Y88	Locus 2 Lot 4																				x	x				xx													xxxx		xxxx				

Table 2c: Summary of the other major compounds found in the reference samples of malted barley, modern barley beer, modern wheat beer, nutmeg and dates as well as in the 59 vessel samples (X - Drilled samples) with comparison with control samples: **X** - Inner surface sample, **X** - Outer surface sample and **X** – Soil sample.

ID	Analysis date	TYPE	DATE	BECS ID	Context	Context 2	**Straight-chain alcohols**	C10:0	C12:0	C16:0	C17:0	C18:0	C20:0	C22:0	C26:0	C28:0	C30:0	**Diols**	1,2-octadecanediol	1-3-butanediol, 2TMS	**Ketones**	2 nonacosanone	Nonacosan-15-one	2 triacontanone	16-hentriacontanone	**Even-numbered Alkanes**	**Odd-numbered Alkanes**	C13	C14	C15	C16	C17	C18	C19	C20	C21	C22	C23	C24	C25	C26	C27	C28	C29	C30	C31	C32	C33	C34	C35
KM200	15/04/2018	J	2017	2813	Y88	Locus 110 Lot 1																																											
KM203	15/04/2018	J	2017	2758	V85	Locus 117 Lot 2																				X					X	XXXX																	
KM115	28/03/2018	JAR	2017	2320	Y88	Locus 104 Lot 1																																											
KM129	09/04/2018	JAR	2017	2324	V85	Locus 157 Lot 1																				X									XXXX														
KM149	28/03/2018	JAR	2017	2332	V85	Locus 103 Lot 1	X			XXX																X																						XXX	
KM130	28/03/2018	JAR	2017	2313	Y88	Locus 108 Lot 1	X			XXXX																																							
KM121	15/04/2018	KG	2017	2594	V85	Locus 164 Lot 3																																											
KM132	03/11/2017	KG	2017	2309	Y88	Locus 108 Lot 1																																										
KM147	09/04/2018	KG	2017	2306	Y89	Locus 5 Lot 2	X						XXX					X		X																												
KM148	10/01/2018	KG	2017	2328	Y89	Locus 4 Lot 3																				X									XXXX													
KM17	10/10/2017	KG	2016	1777	Y88	Locus 3 Lot 10																					X																				XXXX			
KM18	10/10/2017	KG	2016	1918	Y88	Locus 14 Lot 19																																											
KM180	09/04/2018	KG	2017	2531	V85	Locus 117 Lot 2							XXXX																																				
KM181	09/04/2018	KG	2017	2537	Y89	Locus 3 Lot 2	X					X	X																																				
KM182	15/04/2018	KG	2017	2591	V85	Locus 164 Lot 1																																											
KM186	09/04/2018	KG	2017	2534	V85	Locus 159 Lot 1	X						XXX															X												XX			XXXX		XXXX		XXXX			
KM201	09/04/2018	KG	2017	2652	Y88	Locus 113 Lot 1	X						XXXX					X	XXXX									X											XXXX										
KM30	10/10/2017	KG	2016	2218	Y88	Locus 1 Lot 1																																											
KM41	10/10/2017	KG	2016	2223	Y88	Locus 1 Lot 1																																											
KM48	10/10/2017	KG	2016	2018	Y88	Locus 20 Lot 35																																											
KM49	10/10/2017	KG	2016	1747	Y88	Locus 20 Lot 35																				X	X				XX	XX						XX	XX	XX		XXX		XXX		XXX			
KM54	10/10/2017	KG	2016	1935	Y88	Locus 35 Lot 113	X	X				X	X	X	X	X	X										X											XXX		XXX		XXXX		XXXX		XXXX			
KM55	10/10/2017	KG	2016	1757	Y88	Locus 20 Lot 35																					X											XXX											
KM56	10/10/2017	KG	2016	1756	Y88	Locus 20 Lot 35																					X													XXX				XXXX		XXXX			
KM66	10/10/2017	KG	2016	1915	Y88	Locus 40 Lot 46																																											
KM70	10/10/2017	KG	2016	1938	Y88	Locus 36 Lot 41																					X											XXX			XXX		XXXX						
KM11	10/10/2017	N	2016	1910	Y88	Locus 3 Lot 10																					X																			XX			
KM280	12/04/2018	N	2017	2752	Y89	Locus 6 Lot 1																					X																			XX		XX		XX	
MALTED BARLEY				2367																																												
WHEAT BEER				3044																																												
BARLEY BEER				3043																																												
NUTMEG				2366			X							X		X											X	X				X	X	X	X	X	X	X	X	X	X	X	X	X	X	X				
DATES				3090																		X	X		X																								

Table 2d: Summary of the other major compounds found in the reference samples of malted barley, modern barley beer, modern wheat beer, nutmeg and dates as well as in the 59 vessel samples (X - Drilled samples) with comparison with control samples: **X** - Inner surface sample, **X** - Outer surface sample and **X** – Soil sample.

ID	Analysis date	TYPE	DATE	BECS ID	Context	Context 2	MAG	DAG	Glycerol, 3TMS	Sulfure compounds	Hexathiepane	Cyclic octaatomic sulfur (COS)	Alkenes	Hexadecene -cetene	Octadecene	Nonadecene	Docosene	Octocrylene	Steroids	Stigmastan-3,5 diene	Butylamine-2TMS	Formamide N-N-dibutyl	Aceturic acid	PAH	2,6-Diisopropylnaphthalene	2-(2butoxyethoxy)acetic acid	Glycerol monostearate	Benzophenone	Triterpenoids	Friedelin	Isoprenoid hydrocarbons	Farnesane	Nor-pristane	Pristane	Phytane	Hopanes	17.alfa.,21ß,28,30-Bisnorhopane	28-Nor-17B(H)-hopane
KM158	10/01/2018	B	2017	2540	Y88	Locus 113 Lot 1																							X	X	X		X	X	X	X		X
KM171	12/04/2018	B	2017	2720	V85	Locus 105 Lot 1																																
KM172	15/04/2018	B	2017	2807	Y89	Locus 6 Lot 1							X			XXXX																						
KM176	09/04/2018	B	2017	2599	V85	Locus 164 Lot 4																					XXX	XX										
KM187	15/04/2018	B	2017	2755	Y88	Locus 110 Lot 1																																
KM19	10/10/2017	B	2016	1772	Y88	Locus 3 Lot 9	XXX	X																														
KM1	10/10/2017	FB	2016	1760	Y88	Locus 2 Lot 4	XXX	X																														
KM178	12/04/2018	C	2017	2736	K136D	Locus 4 Lot 2				X	X	XXXX	X	X				XX																				
KM135	12/04/2018	FC	2017	2749	Y89	Locus 5 Lot 4				X		XXXX						XXXX																				
KM140	12/04/2018	FC	2017	2317	Y89	Locus 5 Lot 2							X		XXXX															X	X							
KM150	28/03/2018	FC	2017	2303	Y89	Locus 5 Lot 2							X			XXXX			X	X																		
KM154	12/04/2018	FC	2017	2739	V85	Locus 164 Lot 3																				X												
KM170	15/04/2018	FC	2017	2810	Y89	Locus 6 Lot 1																																
KM175	12/04/2018	FC	2017	2728	Y88	Locus 108 Lot 1																																
KM191	15/04/2018	FC	2017	2732	Y89	Locus 5 Lot 6																									X		X	X	X	X	X	X
KM196	15/04/2018	FC	2017	2746	Y89	Locus 5 Lot 6																									X		XXX	XXX	XXX	X	X	X
KM20	10/10/2017	FC	2016	1774	Y88	Locus 3 Lot 8	XXX																															
KM22	10/10/2017	FC	2016	1922	L80C	Locus 2 Lot 1																																
KM281	15/04/2018	FC	2017	2761	Y89	Locus 6 Lot 1												X																				
KM34	10/10/2017	FC	2016	1766	Y88	Locus 17 Lot 22	XXX																															
KM38	10/10/2017	FC	2016	1769	Y88	Locus 21 Lot 34	XXX			X		XXXX																										
KM42	10/10/2017	FC	2016	2215	Y88	Locus 1 Lot 1																																
KM51	10/10/2017	FC	2016	2015	Y88	Locus 20 Lot 35																									X		X	X	X			
KM155	15/04/2018	FC HN	2017	2605	V85	Locus 164 Lot 3																																
KM190	12/04/2018	FC HN	2017	2723	V85	Locus 164 Lot 5							X		XXX						X	X																
KM193	15/04/2018	FC HN	2017	2608	V85	Locus 164 Lot 4																									X	X	X	X	X	X		X
KM29	10/10/2017	FC HN	2016	1781	Y88	Locus 15 Lot 23	XXX																															
KM156	12/04/2018	J	2017	2742	Y89	Locus 5 Lot 6												X																				
KM165	09/04/2018	J	2017	2602	V85	Locus 164 Lot 5																																
KM179	09/04/2018	J	2017	2649	Y88	Locus 114 Lot 1			XXX												X		X				XXX										
KM2	10/10/2017	J	2016	1750	Y88	Locus 2 Lot 4	XXX	XXX																														

Table 2e: Summary of the other major compounds found in the reference samples of malted barley, modern barley beer, modern wheat beer, nutmeg and dates as well as in the 59 vessel samples (X - Drilled samples) with comparison with control samples: **X** - Inner surface sample, **X** - Outer surface sample and **X** – Soil sample.

ID	Analysis date	TYPE	DATE	BECS ID	Context	Context 2	MAG	DAG	Glycerol, 3TMS	Sulfure compounds	Hexathiepane	Cyclic octaatomic sulfur (COS)	Alkenes	Hexadecene -cetene	Octadecene	Nonadecene	Docosene	Octocrylene	Steroids	Stigmastan-3,5 diene	Butylamine-2TMS	Formamide N-N-dibutyl	Aceturic acid	PAH	2,6-Diisopropylnaphthalene	2-(2butoxyethoxy)acetic acid	Glycerol monostearate	Benzophenone	Triterpenoids	Friedelin	Isoprenoid hydrocarbons	Farnesane	Nor-pristane	Pristane	Phytane	Hopanes	17.alfa.,21ß-28,30-Bisnorhopane	28-Nor-17B(H)-hopane
KM200	15/04/2018	J	2017	2813	Y88	Locus 110 Lot 1																																
KM203	15/04/2018	J	2017	2758	V85	Locus 117 Lot 2			XXX																														
KM115	28/03/2018	JAR	2017	2320	Y88	Locus 104 Lot 1							X				XXXX																					
KM129	09/04/2018	JAR	2017	2324	V85	Locus 157 Lot 1																																
KM149	28/03/2018	JAR	2017	2332	V85	Locus 103 Lot 1							X				XXXX																					
KM130	28/03/2018	JAR	2017	2313	Y88	Locus 108 Lot 1							X				XXXX																					
KM121	15/04/2018	KG	2017	2594	V85	Locus 164 Lot 3																																
KM132	03/11/2017	KG	2017	2309	Y88	Locus 108 Lot 1							X				XXXX																					
KM147	09/04/2018	KG	2017	2306	Y89	Locus 5 Lot 2	XXX						X				XXXX											XXX										
KM148	10/01/2018	KG	2017	2328	Y89	Locus 4 Lot 3																																
KM17	10/10/2017	KG	2016	1777	Y88	Locus 3 Lot 10	XXX																															
KM18	10/10/2017	KG	2016	1918	Y88	Locus 14 Lot 19																																
KM180	09/04/2018	KG	2017	2531	V85	Locus 117 Lot 2	XXX						X		XXXX											X	XXX										
KM181	09/04/2018	KG	2017	2537	Y89	Locus 3 Lot 2			X				X	X													XXX										
KM182	15/04/2018	KG	2017	2591	V85	Locus 164 Lot 1																																
KM186	09/04/2018	KG	2017	2534	V85	Locus 159 Lot 1																					XXX										
KM201	09/04/2018	KG	2017	2652	Y88	Locus 113 Lot 1			XXX																		XXX										
KM30	10/10/2017	KG	2016	2218	Y88	Locus 1 Lot 1																																
KM41	10/10/2017	KG	2016	2223	Y88	Locus 1 Lot 1																																
KM48	10/10/2017	KG	2016	2018	Y88	Locus 20 Lot 35																																
KM49	10/10/2017	KG	2016	1747	Y88	Locus 20 Lot 35	XXX																															
KM54	10/10/2017	KG	2016	1935	Y88	Locus 35 Lot 113			X																													
KM55	10/10/2017	KG	2016	1757	Y88	Locus 20 Lot 35	XXX			X		XXXX																										
KM56	10/10/2017	KG	2016	1756	Y88	Locus 20 Lot 35	XXX			X		XXXX																										
KM66	10/10/2017	KG	2016	1915	Y88	Locus 40 Lot 46																																
KM70	10/10/2017	KG	2016	1938	Y88	Locus 36 Lot 41	XXX		X																													
KM11	10/10/2017	N	2016	1910	Y88	Locus 3 Lot 10	XXX																															
KM280	12/04/2018	N	2017	2752	Y89	Locus 6 Lot 1																		X	X												
MALTED BARLEY				2367					X										X	X																	
WHEAT BEER				3044					X																												
BARLEY BEER				3043					X																												
NUTMEG				2366																																	
DATES				3090					X																												

Table 2f: Summary of the other major compounds found in the reference samples of malted barley, modern barley beer, modern wheat beer, nutmeg and dates as well as in the 59 vessel samples (X - Drilled samples) with comparison with control samples: **X** - Inner surface sample, **X** - Outer surface sample and **X** – Soil sample.

ID	Analysis date	TYPE	DATE	BECS ID	Context	Context 2	Steranes	Stigmastane	Stérols	Cholesterol	Stigmasterol	5-Amino-2-cyanobenzotrifluoride
KM158	10/01/2018	B	2017	2540	Y88	Locus 113 Lot 1	X	X				
KM171	12/04/2018	B	2017	2720	V85	Locus 105 Lot 1						
KM172	15/04/2018	B	2017	2807	Y89	Locus 6 Lot 1						XX
KM176	09/04/2018	B	2017	2599	V85	Locus 164 Lot 4						
KM187	15/04/2018	B	2017	2755	Y88	Locus 110 Lot 1						
KM19	10/10/2017	B	2016	1772	Y88	Locus 3 Lot 9						
KM1	10/10/2017	FB	2016	1760	Y88	Locus 2 Lot 4						
KM178	12/04/2018	C	2017	2736	K136D	Locus 4 Lot 2						
KM135	12/04/2018	FC	2017	2749	Y89	Locus 5 Lot 4						
KM140	12/04/2018	FC	2017	2317	Y89	Locus 5 Lot 2						
KM150	28/03/2018	FC	2017	2303	Y89	Locus 5 Lot 2						
KM154	12/04/2018	FC	2017	2739	V85	Locus 164 Lot 3						X
KM170	15/04/2018	FC	2017	2810	Y89	Locus 6 Lot 1						
KM175	12/04/2018	FC	2017	2728	Y88	Locus 108 Lot 1						
KM191	15/04/2018	FC	2017	2732	Y89	Locus 5 Lot 6	X	X				
KM196	15/04/2018	FC	2017	2746	Y89	Locus 5 Lot 6	X	X				
KM20	10/10/2017	FC	2016	1774	Y88	Locus 3 Lot 8						
KM22	10/10/2017	FC	2016	1922	L80C	Locus 2 Lot 1						
KM281	15/04/2018	FC	2017	2761	Y89	Locus 6 Lot 1						
KM34	10/10/2017	FC	2016	1766	Y88	Locus 17 Lot 22						
KM38	10/10/2017	FC	2016	1769	Y88	Locus 21 Lot 34						
KM42	10/10/2017	FC	2016	2215	Y88	Locus 1 Lot 1						
KM51	10/10/2017	FC	2016	2015	Y88	Locus 20 Lot 35						
KM155	15/04/2018	FC HN	2017	2605	V85	Locus 164 Lot 3						
KM190	12/04/2018	FC HN	2017	2723	V85	Locus 164 Lot 5						
KM193	15/04/2018	FC HN	2017	2608	V85	Locus 164 Lot 4	X	X				
KM29	10/10/2017	FC HN	2016	1781	Y88	Locus 15 Lot 23						
KM156	12/04/2018	J	2017	2742	Y89	Locus 5 Lot 6						
KM165	09/04/2018	J	2017	2602	V85	Locus 164 Lot 5						
KM179	09/04/2018	J	2017	2649	Y88	Locus 114 Lot 1						
KM2	10/10/2017	J	2016	1750	Y88	Locus 2 Lot 4						

Table 2g: Summary of the other major compounds found in the reference samples of malted barley, modern barley beer, modern wheat beer, nutmeg and dates as well as in the 59 vessel samples (X - Drilled samples) with comparison with control samples: **X** - Inner surface sample, **X** - Outer surface sample and **X** – Soil sample.

ID	Analysis date	TYPE	DATE	BECS ID	Context	Context 2	Steranes	Stigmastane	Stérols	Cholesterol	Stigmasterol	5-Amino-2-cyanobenzotrifluoride
KM200	15/04/2018	J	2017	2813	Y88	Locus 110 Lot 1						
KM203	15/04/2018	J	2017	2758	V85	Locus 117 Lot 2						
KM115	28/03/2018	JAR	2017	2320	Y88	Locus 104 Lot 1						
KM129	09/04/2018	JAR	2017	2324	V85	Locus 157 Lot 1						
KM149	28/03/2018	JAR	2017	2332	V85	Locus 103 Lot 1						
KM130	28/03/2018	JAR	2017	2313	Y88	Locus 108 Lot 1						
KM121	15/04/2018	KG	2017	2594	V85	Locus 164 Lot 3						
KM132	03/11/2017	KG	2017	2309	Y88	Locus 108 Lot 1						
KM147	09/04/2018	KG	2017	2306	Y89	Locus 5 Lot 2						
KM148	10/01/2018	KG	2017	2328	Y89	Locus 4 Lot 3						
KM17	10/10/2017	KG	2016	1777	Y88	Locus 3 Lot 10			X		XXXX	
KM18	10/10/2017	KG	2016	1918	Y88	Locus 14 Lot 19						
KM180	09/04/2018	KG	2017	2531	V85	Locus 117 Lot 2			X	XX		
KM181	09/04/2018	KG	2017	2537	Y89	Locus 3 Lot 2						
KM182	15/04/2018	KG	2017	2591	V85	Locus 164 Lot 1						
KM186	09/04/2018	KG	2017	2534	V85	Locus 159 Lot 1						
KM201	09/04/2018	KG	2017	2652	Y88	Locus 113 Lot 1						
KM30	10/10/2017	KG	2016	2218	Y88	Locus 1 Lot 1						
KM41	10/10/2017	KG	2016	2223	Y88	Locus 1 Lot 1						
KM48	10/10/2017	KG	2016	2018	Y88	Locus 20 Lot 35						
KM49	10/10/2017	KG	2016	1747	Y88	Locus 20 Lot 35						
KM54	10/10/2017	KG	2016	1935	Y88	Locus 35 Lot 113						
KM55	10/10/2017	KG	2016	1757	Y88	Locus 20 Lot 35						
KM56	10/10/2017	KG	2016	1756	Y88	Locus 20 Lot 35						
KM66	10/10/2017	KG	2016	1915	Y88	Locus 40 Lot 46						
KM70	10/10/2017	KG	2016	1938	Y88	Locus 36 Lot 41						
KM11	10/10/2017	N	2016	1910	Y88	Locus 3 Lot 10						
KM280	12/04/2018	N	2017	2752	Y89	Locus 6 Lot 1						
MALTED BARLEY				2367								
WHEAT BEER				3044								
BARLEY BEER				3043								
NUTMEG				2366								
DATES				3090								

Table 2h: Summary of the other major compounds found in the reference samples of malted barley, modern barley beer, modern wheat beer, nutmeg and dates as well as in the 59 vessel samples (X - Drilled samples) with comparison with control samples: **X** - Inner surface sample, **X** - Outer surface sample and **X** – Soil sample.