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Exploring the legacies of steel slag at Glengarnock, North
Ayrshire: A situated interdisciplinary account of an
anthropogenic geomaterial

Jenna Katy Gray Kirk

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

School of Geographical and Earth Sciences
College of Science and Engineering
University of Glasgow

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Abstract

The steelmaking furnace is a place where raw earth materials and human industrial activities meet. Steel slag is an entity that is encouraged to form through the intersection of these influences, as it is employed to withdraw and entrain natural chemical impurities, and hold these contaminants separate from the furnace's nascent end products. Once it has completed this task, slag is dumped at the outer limits of a works landscape. Here—generally out of sight and out of mind—it enters into new relations with its surroundings. Steel slag does not occur naturally in our environment – its existence depends upon human agency. Yet its material origins and post-depositional afterlives are also shaped by environmental processes. Steel slag can thus be conceived of as an anthropogenic geomaterial, holding multi-temporal stories which can be traced by attending to the entangled worlds it encompasses. The potential of these narratives has however received almost no scholarly attention.

This thesis presents an account of the steel slag that forms one of the last remaining physical vestiges of the former Glengarnock Steelworks in North Ayrshire, Scotland. The deposition of this slag into a loch closely neighbouring the works gradually claimed an entirely new anthropogenic landscape from this waterbody, which has in recent years been shaped by a local authority led regeneration project. I develop an interdisciplinary approach—that emerges from the particular juxtaposition of my research context and the three disciplines of geography, archaeology and geology—to explore the past, present and possible futures of this place, positioning its slag as a once largely forgotten, but now newly re-encountered material legacy that simultaneously manifests as a waste product, a post-industrial remnant, and as a novel anthropogenic rock. In so doing, I demonstrate how a personal engagement with this slag's stories can be used to reanimate taken-for-granted histories, rewrite emerging heritage narratives, and re-imagine carbon futures. In this thesis, I am continuously challenged and surprised by Glengarnock's steel slag, yet I also come to care about this neglected industrial waste deposit. I find ultimately that electing to pay attention to a local outcropping of an anthropogenic geomaterial reveals choices, and that exploring what can be done with our material legacies, as well as what might be conferred as a result, can contribute to the task of working through the world shaping implications of humanity's assumption of geological force.

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This thesis is dedicated to the memory of Dr Lorna J. Waite, who, upon our first meeting, instantly extended a warm expression of sisterhood, which has remained a source of profound encouragement. Lorna crafted her own thesis and creative works around the Glengarnock Steelworks. Her children's novel, *Frances and the Blasties*, is composed as an allegory reflecting Lorna's own research journey, and features a steel doorway, through which the titular character must pass to embark on a mission to rewrite her community's history. Later, another character reflects upon the Gaelic tradition of tying red ribbons to trees, to remember those no longer with us. Lorna's work weaves the everyday material world of Glengarnock's industrial past into a figurative exploration of acts of both memory and moving forwards. The steel doorway thus exists in real life, a fellow remnant of the works existing alongside the slag at the centre of this thesis. On my final trip to the former steelworks site, I tied a red ribbon to this structure, to honour Lorna's labour, generosity, memory, and message – her memorandum transmitting tidings of hope and renewal from the shoreline of Slag Hill.

Declaration of Originality
University of Glasgow
College of Science and Engineering

Name: Jenna Kirk

Registration Number: XXXXXXXX

I certify that the thesis presented here for examination for a PhD degree of the University of Glasgow is solely my own work other than where I have clearly indicated that it is the work of others (in which case the extent of any work carried out jointly by me and any other person is clearly identified in it) and that the thesis has not been edited by a third party beyond what is permitted by the University's PGR Code of Practice.

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I declare that the thesis does not include work forming part of a thesis presented successfully for another degree [unless explicitly identified and as noted below].

I declare that this thesis has been produced in accordance with the University of Glasgow's Code of Good Practice in Research.

I acknowledge that if any issues are raised regarding good research practice based on review of the thesis, the examination may be postponed pending the outcome of any investigation of the issues.

Chapter 1: Introduction

1. The view from a train window: reperceiving Glengarnock

For many years, every weekday morning, I would board a train. This train would take me from my home town on the south western coast of Scotland, to university, and latterly work, in my local ‘big city’ of Glasgow. Had I not each day lapsed into that particular state of inattention brought on by the mundanity of routine, I could have appreciated the varied scenery afforded by my daily journey. After my train had left behind carriage window-framed panoramas of the sea, but before it had entered an extensive complex of urban conurbations, it passed through the Garnock Valley – cutting a transect across a landscape of flat pastureland and high skies, which met distant hills at its watershed boundary. For a short distance, the rail line ran alongside the valley’s eponymous River Garnock, but further on a series of lochs came to dominate the view. For me however, the Garnock Valley simply portended the point in my journey when the train’s already weak Wi-Fi provision cut out completely. The village of Glengarnock lay at the heart of this signal-less void, and I celebrated the passage of the few ‘fast trains’ each day which skipped its stop entirely. More often than not however, we would draw into its small station, attended by a ticket office that never seemed to be open. Waiting for a few passengers to board or alight, the one road which ran through the village could be glimpsed, leading to the adjoining town of Kilbirnie. As the train pulled away and proceeded on, the landscape was quickly overtaken by Kilbirnie Loch, the often uniformly grey hue of its waters seemingly offering little to engage the eye, other than an invitation for them to gently glaze over. Such were my impressions of Glengarnock and its surroundings – in essence, this was simply a place that stopped me getting from A to B as quickly as I would like.

It was during another of these train journeys, on my way home from work in the spring of 2019, that I first read about an incipient PhD project. The advertised studentship aimed to work with ‘steel slag’ – a kind of industrial waste which also happened to constitute some of the last material remains of the Glengarnock Steelworks. Intrigued, I made sure to pay attention as the train made its way past Kilbirnie Loch. It was hard to imagine a steelworks there, and I had never heard of one at Glengarnock, despite living my whole life in the area. Later, when I got home, I asked my parents if they had known it.

“Oh yes” my mum replied, “I think it closed sometime in the 1980s maybe – after we arrived here.”

“We got a lot of ex Glengarnock steelworkers taking up jobs at Hunterston” my dad added. By ‘Hunterston’, he was referring to his pre-retirement place of work – a nuclear power station, which lay on the coast about 13 miles drive from the Glengarnock Steelworks site. Before I was born, my parents had moved into Hunterston’s vicinity, as certain members of staff had to live within a particular radius of the station in case of emergencies. North Ayrshire— the county which accommodated both Glengarnock’s metallurgy and Hunterston’s electricity— had remained our family’s home ever since. For a few years, my commute had also looked rather different, as instead of leaving North Ayrshire’s seascapes and valleys behind me on my journeys into Glasgow, I had stayed, finding my own job at Hunterston post-graduation. Each morning, I would make my way down the station’s access road, heading towards the coast. As I drove, the vast cuboid structures of the reactor and turbine hall buildings would gradually come into view on my left – and in my rear view mirror, if I was running late, I might see a bus full of schoolchildren pursuing me as I travelled towards the station’s visitor centre. I worked there as part of a team providing site tours to the public, and through this role I had steadily accumulated many facets of the station’s story. Yet with Hunterston’s decommissioning date looming— and with it, the cessation of tours— my own part in the unfolding of the station’s future was not to be realised. Though I had just discovered the existence of Glengarnock’s Steelworks, I found myself harbouring a sense of empathy towards its former workers. During my tours, I had often described Hunterston as one of the last bastions of industrial activity in North Ayrshire, yet I now knew a little more of what had been lost from this area. I was however taken aback by how quickly the Glengarnock Steelworks had surrendered its foothold in the memories of the generations that emerged after its closure, especially, as I researched further, given its huge presence in the landscape that had once held it.

If I had been making my way home from Glasgow in 1970, the view of Kilbirnie Loch from the carriage window would have been very different. **Figure 1.1** (overleaf) shows the extent of the Glengarnock Steelworks in this year, less than a decade before its furnaces were blown out for the last time in December 1978 (Charman, 1981). Travelling down the train line that follows the loch’s eastern shore, the work’s dense warren of building and cranes, circumnavigated by its own bunched threads of railway tracks and sidings, may well have been partially hidden from view by the heaps of waste material surrounding it – eyewitness



Figure 1.1- A map showing the extent of the Glegarnock Steelworks in 1970. Accessed using Digimap Ordnance Survey Collection, <https://digimap.edina.ac.uk/>.

accounts which take in the presence of the steelworks from a distance tend to focus on the interplay between that which it threw up or out, and the waterbody in its foreground. One description of the view from the train window recalls the steelworks in the years leading up to its closure as “... a silhouette of chimneys framed against the oval loch” (Waite, 2011a:69). Another, portraying the same view in 1851, just over a decade after metal working at Glegarnock had commenced, evokes the works “... shedding their refulgent light ‘oer glittering wave and crimsoned shore’... when cooped up in the dark, close carriage we were suddenly lighted up by what seemed a loch of molten gold” (Wylie, 1851:14-15, in Waite, 2011a:125). A third testimony details the violent explosions that rang out as the work’s molten waste material was dumped into the loch’s cold waters (Brophy, 2017). This depositional activity also stamped its footprint in the landscape. A comparison of historic map

extracts illustrates that as the Glengarnock works expanded operations through the years, its waste claimed ever more territory from the neighbouring loch¹ (see **figure 1.2** overleaf). In 1858, the Glengarnock Ironworks had been in operation for less than 15 years (Charman, 1981). Yet waste deposits can already be seen bulging into Kilbirnie Loch, eating into its southern waters. By 1916, these early waste incursions look positively tentative in comparison to the conglomerated heap of waste that had entirely reformed the loch's southern shoreline. Metallurgical production had also advanced at Glengarnock, so that its iron manufacturing operations had been joined by a steelworks, which had started operations in 1892 (ibid). In 1916, and in the midst of World War 1, both works were producing materials for the government's Ministry of Munitions, with plans simultaneously drawn up for a brand new 'Scheme B' steelworks plant to augment these efforts (ibid). There is a substantive gap in the map extracts available following this period, but when Glengarnock was next surveyed, in 1958, it is clear that this scheme had come to fruition. The site of the former iron and steel works had been cleared (the old steel furnaces ceasing operations in 1923 and the old iron furnaces following seven years later), and new melting shop and rolling mill buildings (to produce and process steel respectively) had been established at the south-western edge of Kilbirnie Loch (ibid). Seemingly following the path of least resistance, the work's waste had also spread from this point, eventually culminating in a kind of peninsular hill, its deposits spilling down to the south-western loch shore. By the 1990s however—the decade in which I was born—the steelworks had been close to entirely cleared from the landscape that once held it. The map extract from 1990, almost eerily blank, recalls the absent-presence of the 'Glengarnock Steel Works' – the letters forming its name relegated to a corner of the land it once occupied. Accompanied by nascent re-vegetation attempts, they fill just one of the cartographic voids left in its wake. A train passenger, travelling by on their way to or from Glasgow, could perhaps be forgiven for assuming that there was nothing much here, as landforms made of discards naturalised into a new landscape of industrial redundancy.²

¹ Not long after I first encountered this PhD project, I bumped into a family friend, who also happened to be a former Glengarnock steelworker. When I asked him why Kilbirnie Loch was specifically chosen as the place to dump the work's slag waste, he replied (a little sheepishly) "because it was there."

² Although the Glengarnock works waste forms the most substantial material remnant of this industry's presence in the contemporary landscape, there are also a few former works buildings that still stand today. These can be found in the area marked as the 'Lochshore East Industrial Estate' on the 1990 map extract in figure 2.

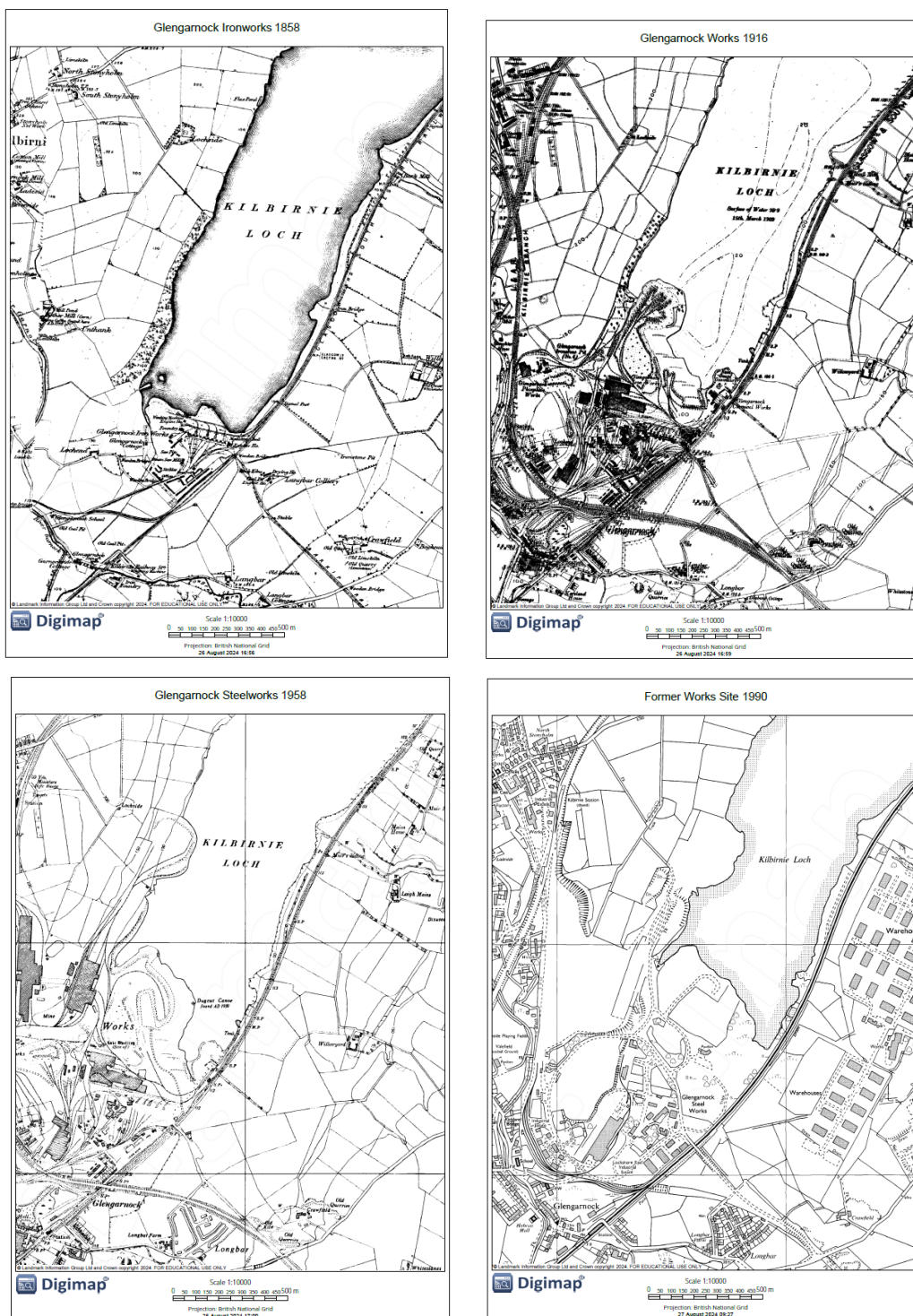


Figure 1.2- Four map extracts, documenting the progressive growth of industrial waste into Kilbirnie Loch. Accessed using Digimap Ordnance Survey Collection, <https://digimap.edina.ac.uk/>.

2. Toxic or glorious? Finding new slag legacies to explore

In October 2020, I visited the former Glengarnock Steelworks site for the first time, with my new PhD supervisors, Professor Simon Naylor, Dr Kenny Brophy, and Dr John MacDonald. Our destination was the peninsular landform of works waste that jutted out into the south western waters of Kilbirnie Loch. Yet what greeted us there was not what I had expected. Having spent about twenty minutes struggling through a boggy expanse of tall grasses, reeds and scrubby trees, we emerged at the loch shoreline. Along it lay a shingly layer of rock. This, it transpired, was steel slag. I looked around, taking in the triptych of surfaces which surrounded us – blue-grey loch waters lapping at a dark crescent of stony ground, closely bounded by the orangey greens of soggy vegetation. It all seemed rather... flat (see **figure 1.3** overleaf). My sense of slight underwhelm can perhaps be attributed to the ways in which industrial waste deposits appear in the popular imagination. George Orwell's description of the industrial landscapes of Northern England in *The Road to Wigan Pier* (1937) is a case in point. He describes an accumulation of slag as:

“... at best a hideous thing, because it is so planless and functionless. It is something just dumped on the earth, like the emptying of a giant's dust-bin. On the outskirts of the mining towns there are frightful landscapes where your horizon is ringed completely round by jagged grey mountains... Even when a slag-heap sinks, as it does ultimately, only an evil brown grass grows on it, and it retains its hummocky surface... like a choppy sea suddenly frozen... Even centuries hence... the sites of ancient slag-heaps will still be distinguishable from an aeroplane” (Orwell, 1937:97-98).

For Orwell, slag deposits evidently exhibit an immediate and striking sense of ugliness. Their uncontrolled excesses ensure that the landscapes which accommodate them can never truly escape their presence, as the petrified monumentality of these industrial behemoths are perpetuated into the far future. Crucially, his depiction also centres around the slag heaps'



Figure 1.3- A photograph taken during our first visit to the Glengarnock slag. Out of shot to the right, the land does gradually slope upwards, but this gentle topography does not resemble the kind of slag heap I had anticipated (photograph courtesy of John MacDonald).

significant elevation above their surroundings. Although there is cartographic and photographic evidence that Glengarnock's slag deposits once formed great mounds here (see **figure 1.4** overleaf), their statuesque permanence came to be reduced. Following the closure of the steelworks, its slag heaps were smoothed over, and for the most part, intentionally covered by vegetation (Carter, 1984). Instead of a slag heap then, the industrial waste that remained visible at Glengarnock had ended up resembling more of a slag beach – a sliver of memory, that could easily remain imperceptible.

Orwell's passage also brings up the matter of industrial waste terminology, and it is worth dedicating some space here to briefly elucidate what slag is, and what it is not. Of course, when thinking about this word, there is the matter of what the Oxford English Dictionary refers to as its 'extended uses.' Etymologically, the definition to which the modern mind may



Photo by Wm. Allen.
 ANCIENT DUG-OUT CANOE RECOVERED
 FROM KILBIRNIE LOCH.

Figure 1.4- A photograph from an article published in the *Transactions of the Glasgow Archaeological Society* in 1933. In the foreground, an ancient vessel is displayed, but this image’s backdrop highlights that vast slag heaps once formed part of this landscape (image taken from Mann, 1933, in Brophy, 2017).

unwillingly jump — denoting a “sexually promiscuous or lewd woman” —originates surprisingly recently. As late as the 1960s, the OED records references to ‘slags’ encompassing both men and women. This meaning derived from 19th and early 20th police or prison slang, whereby a slag was “a person who, or thing which, is the lowest, worst or most objectionable of a group or society”, evolving to describe “a petty criminal; a rough or disreputable person.” The very earliest non-technical use of the term recorded by the OED is from F. Grose’s 1788 *Classical Dictionary of the Vulgar Tongue*. Here, a slag is “a slack mettled fellow, one not ready to resist or affront”— namely, a (male) coward. This earliest of non-technical usages is considerably pre-dated by the first technical usage of the term however, recorded by the OED as appearing in 1552. It is therefore likely that etymological

cross fertilisations occurred between the technical and non-technical utilisations of the word slag, as the inorganic bearer of the epithet was often regarded as valueless and impure (all citations here from OED, 2024a, and OED, 2024b).

Turning to the technical use of this term then, ‘slag’ is defined by the Oxford English Dictionary as “a piece of stony waste material, produced in the smelting or refining of metal, or from other industrial processes” (OED, 2024b). I found that as I learnt more about this material, the self-penned adage ‘not all slag is steel slag’ felt increasingly appropriate. ‘Or from other industrial processes’ opens up a considerable amount of flexibility in the use of this term, and indeed, Orwell’s own descriptions of slag heaps refer to the accumulations of waste resulting from coal extraction, as opposed to those generated by metal working. To avoid confusion, this thesis will therefore adopt the Scottish word ‘bings’ if referring to deposits of non-metallurgical waste. Generally, the slag produced from metal working is ascribed a prefix (e.g. iron slag, steel slag, copper slag) to denote the specific process from which it was discarded. As this thesis centres much of its focus on what has previously been described as a kind of slag peninsula—the area of land which grew into the south western waters of Kilbirnie Loch, made from the steel slag waste generated by the ‘Scheme B’ Glengarnock Steelworks—I will use prefixes when describing other forms of metallurgical waste, but will otherwise henceforth use the terms ‘slag’ and ‘steel slag’ interchangeably.

Steel slag itself meanwhile, can be understood as a kind of ‘recombinant geology.’ This phrase, devised by Paton and DeSilvey (2016) describes the ancillary materials that form as humans craft objects from rock. Taking the art of stonemasonry as their example, the authors depict how, as blocks of granite are sawn, shaped and sluiced with water, a waste ‘sludge’ comes into being, as tiny rocky offcuts and spilled fluid meld to form a grainy liquid. Small rivulets of this sludge can run out of the masons’ workshop, down into the neighbouring granite quarry, and thence become co-fabricated in turn with the outside environment, collecting as an anthropogenic mud at the bottom of this hollowed-out section of earth. In the far future, this deposit might itself be subjected to great temperatures and pressures, and thus make a partial return to its geological origins, at once changed by humanity, yet transcending our particular footprint all the same. Steel slag’s own recombinant geology is one which originates in the amalgamation of many ingredients. First, seams of iron ore are mined and

then refined³ to produce the raw material needed to make steel. To ensure that this steel is as untainted as possible by the ore's initial chemical heterogeneity, these 'impurities' must be removed, by encouraging a slag to form. This is done by heating the refined ore in a furnace until it is molten, and then adding further geological additives (such as limestone or manganese) to react with these impurities, drawing them into a newly forming substance. Floating on top of the increasingly purifying metal, this slag is thus made to extract and keep separate any substances that, through their inclusion in the metal mixture, could weaken the desired steel product. Once it has done its work, the molten slag layer is removed from the furnace, conveyed to where it is to be deposited, and then discarded (this description is informed by Barraclough, 1990; MacFarlane, 1917; and Sharp, 1966). When a steelworks is active, these successive anthropogenic landscape layers often lie open to the elements, and when metallurgical operations come to an end, this strata might become interred under a coating of soil, punctuated by the roots of vegetation. In both scenarios, the steel slag is open to new kinds of recombination with the physical conditions that now retain it.

Back on the slag shoreline at Glengarnock, I was beginning to get my eye in. Now I could see that the 'rocks' on the shoreline were in fact fused together, forming an uneven and uncanny, almost lunar surface. Looking closer again at this expanse, I spotted glimmers of unnaturally iridescent colours, flashing intermittently as small pools of loch water amplified their effect. This liquid-captured luminosity reminded me of oil spills. Orwell's descriptions of industrial waste deposits also carry a definite sense of contamination. His slag heaps appear visually offensive by dint of their sheer unsightliness, and emotionally harmful as they insidiously encircle and press in upon those who labour in their shadow. Yet the sparsity and state of the life that they do support— 'only an evil, brown grass'— suggests that they are also materially poisonous. This toxic legacy was carried through into my own research project, which initially aimed to assess the environmental, social and historical ill-effects of Glengarnock's steel slag, working alongside its local community to co-produce this knowledge. A few months after I had first visited Glengarnock's slag deposits however, I came across an online announcement from North Ayrshire Council, detailing consultation work surrounding the redevelopment of the former steelworks site. A multi-million-pound visitor hub was to be built; pathways encouraging walks around the loch were to be

³ As well as the producing the raw materials for steel manufacture, this process can also be altered to extract purer iron from its ores. These procedures both generate their own 'iron slag.' A more detailed treatment of this topic will be presented in Chapter 4.

constructed; and plans to develop the area as a destination for loch-based water sports were earmarked. Vows were also made to consider the heritage of the site throughout its regeneration, as it became ‘The Lochshore Park.’ I subsequently contacted the council, and learnt that in 2019, independent contractors had been hired to report the results of environmental analyses assessing the potential impact that slag contamination could have on the regeneration proposals. These were generally found to be negligible.⁴ The slag legacy I had sought to follow turned out to have already been investigated, and the landscape I expected to inhabit was set to transform over the course of my research. Venovcevs and Bangstad (2022:2, citing Galeev, 2017) note that in Russian, the word ‘legacy’ finds its root in the word наслед (nasled), meaning “onto or upon a ‘trace.’” Meanwhile, the English etymology of this term shows that it originally emerged in written sources in the 14th century, and denoted the name of a chosen delegate who would act for a high powered individual. It was only around a century later that the notion of a legacy as an object that could be passed down or bequeathed arose (OED, 2024c). My discovery of the Lochshore regeneration project had left me with a fundamental dilemma, related to each of these lexical lineages. What new legacies could I find in steel slag, beyond the toxicity that I had first projected onto this remaining trace of the Glengarnock Steelworks? My difficulties were compounded as I struggled to determine how I might receive representations from an entity that was always intended to be forgotten.

The question of how I might come to know Glengarnock’s slag differently was however quickly accompanied by the pressing matter of how I might go about this in a post-pandemic world. As I started this PhD project in October 2020, a second national lockdown was on the horizon, coming into effect in the December of that year. Restrictions in Glasgow lifted in April 2021, so most of my research was conducted in the long shadow cast by Covid-19. As a human geographer (more specifically, a historical geographer) with experience in archival and oral history research methods, the research spaces I was used to occupying ended up

⁴ I was latterly able to access the Contamination Assessment Report submitted to North Ayrshire Council by contractors RPS Ltd. The report details how potential soil and groundwater contamination was assessed against “screening criteria derived to be protective of human health” which varied depending on the “proposed end use” for different areas of the site. These end uses included ‘commercial’, ‘public open space’ and ‘residential with home grown produce’ categories (RPS, 2019:vi). Soil contamination levels were not found to exceed the criteria for the site end uses proposed by the regeneration project. Excessive levels of some heavy metals were found in samples of shallow groundwater, but these were not found to have impacted the water quality of Kilbirnie Loch. The report recommended that no remediation actions were required, but did suggest continued monitoring be carried out in the future.

remaining inaccessible for far longer than I had anticipated. As I recommenced my fieldwork following the lockdown, most archives and heritage centres were still closed, and most could provide no immediate sense of when they might reopen. Meanwhile, I also had to consider that my PhD project was funded by means of an ESRC studentship on an interdisciplinary strategic steer, and was thus required to demonstrate the utility of an interdisciplinary research approach. My work would therefore entail a search for points of confluence between the disciplines of geography, geology and archaeology. Yet, as I will explore throughout this thesis, adopting an interdisciplinary approach allowed me to inhabit new research spaces as well as those previously familiar to me, and this became central to how I expanded my sense of what Glengarnock's slag could be.

Indeed, as I began to search for scholarly perspectives that would help me move beyond my confined understanding of slag as merely a noxious entity, the voice that emerged most strongly from the literature— by dint of its unique stance— was that of an archaeologist called Michael Given. In his work with ancient Cypriot copper slag, Given recognises the 'curious neglect' that slag has suffered at the hands of his colleagues, as "... like garbage, excrement and uncultivated land, it has all too often been rejected as mere 'waste'" (Given, 2018:161). Despite these prevailing attitudes, he defiantly describes this material as "glorious" (ibid). Given's avowedly singular perspective towards slag was revelatory for me when I first encountered it. As I read his work, and partook in generous, expansive conversations with Michael himself, I learnt that in contrast to my own assumption that slag's fundamental ontology began and ended in its impurity, he asks how we might think otherwise with slag, and then teases out a myriad of potential meanings that might be found in its specific materialities. He describes slag as something that almost demands our attention, through its sensory properties. Its irregular surface— reminiscent of volcanic lava flows— makes it difficult to traverse on foot, forcing us to watch our step and thus engage with it more closely. More than simply opaquely black, slag also holds an intensity of colour that is only revealed as light and our line of sight intersect at the correct angle. I saw this iridescence on the shoreline of Kilbirnie Loch and immediately thought of petrochemical discards, but for Given, this effect demonstrates that slag can repay more than a cursory glance, by revealing initially hidden depths. Its eventual separation from a finished metallurgical product belies how it functions in the furnace, by capturing and holding all that goes into it. In this way, slag is at once relational and contextual – its formation encompasses the coming together of

technological entities, human labour and geological materials. Years later, some of these signatures can be elucidated by archaeologists, who harness slag's capacity to transmit a snapshot of its origins in a particular time and place. This also endows slag with an "intriguing ambivalence" (ibid:162) – depending on how you look at it, it can be of either the natural or human worlds. In truth, it is a mixture of both, existing— to adopt a term coined by my supervisor John MacDonald— as an 'anthropogenic geomaterial.' After its deposition, slag enters equally rich afterlives, also formed by the "dance of agency" between these spheres of influence (ibid:170). "To approach the *slagness* of slag" Given argues, "means following all the transformations that it acts out through its life" (ibid:169). "Being incidental to human design", slag is quickly opened up to the gathering of new meanings and materialities post-deposition, by virtue of our neglect of it (ibid). It can metamorphose through new non-human relations such as weathering, and pick up new associations – Given himself traces how various religious connotations might have been read into the Cypriot copper slag through time. Slag thus crosses temporalities, inviting us to consider how others might have known it in the past. Given also highlights slag's capacity to tell rich, ongoing stories of a place, as it simultaneously composes its very ground, in his own research context forming monumental mounds that dot the Cypriot landscape. His work thus demonstrates that slag has a geography – in the very literal sense of its translation from the Greek *geographia* or 'earth writing' (Gregory, 2009). The tales that can be written about this material also write worlds, encompassing the pasts it has endured; the presents it currently inhabits; and even the futures it might perpetuate into. At the same time, the content of these writings depend upon the particularities of how slag is situated – its narratives renewed depending on where and how it materialises, as well as the contexts through which it is authored. Yet, as Given points out, the potential stories offered up by slag's "... rich continuing biography... [have] almost been entirely neglected in the scholarship" (ibid:169). His work thus issues an invitation, one which I would like to take up in my articulation of the research aims of this thesis.

3. Thesis aims and structure

A clear, overarching question emerged from my initial attempts to explore the legacies of Glengarnock's steel slag, which guided my research focus away from my a priori assumptions to instead ask 'what other stories can this slag tell?' This question is in turn grounded in my three research aims. Each aim maps onto a particular empirical chapter in

this thesis, which are broadly demarcated respectively to explore the pasts, presents and possible futures of this particular anthropogenic geomaterial, whilst simultaneously making room for considerations of how these temporalities might intersect. Each aim and its associated empirical chapter also foreground research methods from one of the three disciplines employed in this thesis. These methods are then variously complemented by the interdisciplinary influence of other perspectives.

The first aim of this thesis is to use archival sources to recover stories of the Glengarnock steel slag's past. I will track the many different physical forms assumed by this slag throughout its history, and examine how these diverse materialities were experienced and imbued with meaning. By seeking out voices from the past, to whom this slag mattered, I will demonstrate how attending to neglected things can reanimate taken-for-granted histories.

The second aim of this thesis is to adapt traditional archaeological field techniques to survey the landscape created by Glengarnock's slag, amidst the regeneration work that brought the Lochshore Park into being. Whilst new forms of heritage interpretation emerged into this place, positioning its slag as an agent of historic landscape change, I will use my field experiences to craft a different kind of narrative. By gradually familiarising myself with a number of specific slag formations, I will show that the Lochshore slag is itself continually being shaped by ongoing processes of transformation.

The third aim of this thesis is to speculatively re-imagine a Lochshore Park future where slag is valued by its local community. To do this, I will investigate a particular property of steel slag – its ability to mineralise and thus capture atmospheric carbon dioxide. I will perform scientific analyses of selected slag samples to determine how the Lochshore Park's physical landscape could be shaped to enhance the efficacy of this process. I will also conduct interviews with local community representatives to extrapolate how slag carbon capture might align with existing aspirations for this place. By putting the outcomes of this work in conversation, I will explore the implications of a resultingly unconventional approach to waste management, whereby both slag and its local community are rendered visible through this endeavour.

As well as tracing the particular stories that Glengarnock's steel slag can tell, I also wish to explore how I can put these specific narratives in conversation with literature pertaining to

the particularities of my research context— including scholarly work that engages with neglected and subsequently re-encountered material legacies. In the pages that follow then, Chapter 2 will review three thematic areas of literature, on the topics of Waste, Post-Industrial Afterlives, and the Anthropocene. I will begin by considering the ways in which waste matter can variously be defined, managed and historicised, before proceeding to examine how post-industrial afterlives might manifest through the interplay between ruination, memory, forgetting and material legacies. I will finally spend time elucidating the nature of the Anthropocene, and assessing how its proposal has been received in the disciplines of geology, geography and archaeology. This chapter will then reflect upon how Anthropocene landscapes and geomaterials could be storied beyond the confines of chronostratigraphy, and will conclude by drawing out particular threads of potential development to be taken forward in this thesis.

Chapter 3 departs from the format of a traditional methodology, as it does not feature a detailed exploration of the specific research methods used in this thesis. This undertaking will instead be contained in my empirical chapters (chapters 4 through 6), which will each, as previously mentioned, foreground research methods from one of the three disciplines employed in this thesis, whilst examining how these can be complemented by the interdisciplinary influence of other perspectives. The various methods I use in this thesis are more diverse in nature than they might otherwise have been had I adopted a single-discipline approach. As some of these methods may thus also be unfamiliar to the reader, this choice holds the additional benefit of more clearly elucidating their nature, by introducing them closer to their respective results. Chapter 3 will instead then explore the interface between my research methods and the development of my overall research approach with the help of a research timeline visualisation. Following this timeline, I will guide the reader through the formulation of my initial approach to my research, before dwelling with a number of in-field complexities that necessitated a fundamental shift in my thinking. This shift will be further articulated through an exploration of the factors that caused me to drift away from, and then subsequently re-focus upon the slag at the centre of my research project. I will next turn to survey how interdisciplinarity has been experienced by other PhD students working in geography, who have sought to create disciplinary communality through projects which are designed to primarily be undertaken in an individual capacity. Finally, I will refract these perspectives through my own process of ‘becoming interdisciplinary’ to present an account of

my eventual research approach, where I used interdisciplinarity to write my way through problems that arose in the course of my fieldwork.

In the first empirical chapter (Chapter 4), I will examine the understandings of steel slag that I inherited in the context of my education— in a western European nation that had relatively recently experienced deindustrialisation— before outlining a commitment to move beyond this received wisdom, to discover how Glengarnock’s steel slag was known in other times. I will then recount the difficulties I experienced in accessing historical materials in the face of both Covid-19 restrictions and archival destruction, before relating how I used perspectives both from and inspired by historical geography, archaeology and geology to assemble the documentary fragments that remained. I will then craft a story encompassing over one hundred years of history centred around interactions with this waste material, exploring, through the voices that emerge from three very different kinds of archive, how Glengarnock’s slag materialities were inherited, experienced, transformed and passed down in turn.

Chapter 5 will introduce the reader to Glengarnock’s slag landscape, as the former steelworks site was being transformed by the Lochshore regeneration project. I will firstly outline how a visitor to this new park destination might encounter its slag, by relating my encounter with a freshly installed interpretation board. This chapter will then set itself up to explore how an alternative heritage narrative of the Lochshore slag might be constructed, through an up close and personal engagement with this material. I will next survey both how my initial plans to apply archaeological methods in this field came undone, and how putting archaeological and geographical perspectives in conversation offered another way forwards. This chapter will subsequently feature a narrative essay, presenting a multi-temporal account of my walks through the Lochshore slag landscape, sometimes alone, and sometimes accompanied by companions holding different disciplinary perspectives. By spending time surveying four distinct slag features, this chapter will reflect upon the disorientating nature of this landscape, before concluding by considering a particular paradox, formed by the act of coming to care for that which has emerged through neglect.

Chapter 6 will explore a particular and unexpected ‘recombinant geology’ (Paton and DeSilvey, 2016) formed in steel slag’s post-deposition afterlife as this material mineralises atmospheric carbon dioxide (CO₂). I will review literature on this process, identifying a gap

in studies of Glengarnock's own slag mineralisation capacity regarding the differences between its ability to capture CO₂ when it is exposed to the elements, as opposed to when it is buried beneath a layer of soil and vegetation. I will design and carry out a small comparative study that uses Scanning Electron Microscopy, X-Ray Diffraction, and Thermogravimetric Analysis techniques to establish the differences in CO₂ mineralisation between Glengarnock slag samples collected from exposed and buried locations respectively. Simultaneously however, I will review literatures that reveal the importance of place based enquiries to assess local appetites for carbon capture schemes, and will conduct interviews with community representatives that trace their aspirations for the Lochshore regeneration project. Combining these approaches, I will finally speculatively re-imagine and critically evaluate a possible Lochshore future, where the capabilities of slag to mineralise CO₂ are no longer surprising, but actively celebrated.

Chapter 7 will conclude this thesis by first returning to each of my research aims, as I demonstrate how these have been fulfilled in the course of my work. I will next put forward suggestions as to how my research at Glengarnock could be taken forward in the future, before turning to the exchanges made between my research context and the themes of Waste, Post-Industrial Afterlives, and the Anthropocene. I will move on to consider how my work has contributed to the opening up of new research spaces for each of the three disciplines employed in my research, as well as considering my findings with regards to interdisciplinarity. Finally, I will turn back to reflect upon on my responses to the invitation issued by Michael Given in this first thesis chapter, which gave impetus to this exploration of the Glengarnock steel slag's material legacies.

Chapter 2: Literature Review

1. Introduction

When I first embarked upon the task of gathering literature for this review chapter, I initially tried to locate materials that related directly to steel slag. I quickly found however that the majority of sources which resulted from this particular search term derived from writings on materials engineering, which fell outwith even the expanded disciplinary remit of this project.⁵ I therefore had to employ a different approach, instead taking a step back to ask a series of fundamental questions of Glengarnock's slag, namely: *what* is it, *where* is it, and *when* is it? This quickly opened up a series of answers, and associated academic literatures, to explore further. Slag is brought into being in the steel making furnace primarily as a means of discard, acting as a receiver and entrainer of undesired chemical elements. Its short operational life is then superseded by a far longer period of repose, as it is dumped in largely unvalued deposits. Literatures surrounding the theme of 'Waste' thus formed the response to the first of the questions I had put to the Glengarnock slag. The landscape that Glengarnock's steel slag occupies (and indeed, partially constitutes) was, when I first encountered it, shaped by decisions made following the closure of the Glengarnock Steelworks. As my work progressed however, this landscape entered a new, transitional phase. The second area of literature explored in this chapter— encompassing 'Post-Industrial Afterlives'— thus locates the anthropogenic geomaterial at the centre of this thesis in a post-industrial setting, yet also recognises the different, even co-existing trajectories this place might open out into. Finally, I found that the third question I asked of the Glengarnock slag— that of when it is— immediately brought to mind current debates swirling, both within and outwith academia, around humanity's place in deep time, and whether our own industrious, excessive deposits

⁵ Steel slag does feature in a limited manner in some geosciences literature, but as noted later in this introduction, this work will be specifically covered in Chapter 6. In addition, whilst slag does feature in archaeological literatures that encompass the area of archaeometallurgy, *steel* slag is not often included, as its relatively recent occurrence in the archaeological record does not generally intersect with the interests of those studying ancient metal working (see for example Roberts and Thornton, whose 2014 reader, *Archaeometallurgy in Global Perspective: Methods and Syntheses* focusses entirely on early, pre-industrial metallurgy, and Hauptmann, who contributes to this text through a chapter on 'The investigation of archaeometallurgical slag', and specifically distinguishes between 'modern' and 'archaeological' slags therein). In addition, information that can be gained through the application of archaeometallurgical techniques (such as, for example, the particular technological process that produced a slag) can often alternatively be found through archival repositories when it comes to steel slag.

have now heralded a new chrono-stratigraphic addition to the Geological Time Scale— ‘The Anthropocene’— defined by humanity’s assumption of geological force.

I have thus adopted a conceptual approach in this literature review, choosing these three broad themes to assist me in situating steel slag within my own research context. As my work on this research project continued however, a further connection emerged, linking each of these themes to both my research context, and to each other. I realised that a core challenge of my work was the conundrum posed by the task of exploring the legacies of a material that was intended to be forgotten. A key opportunity meanwhile existed for me to explore the conditions within which these legacies might be re-encountered. This chapter will thus review my three thematic areas of literature with these dynamics in mind. The Waste section therefore firstly considers the malleable ways in which discarded matter can be defined, before moving on to examine how this meaning making intersects with instances where waste matter is not forgotten, through waste management practices. The means by which industrial wastes in particular can become re-remembered, and thence encountered as historical entities are then drawn out. In the Post-Industrial Afterlives section, I review work which dwells within the process of ruination, and explore the tensions that can arise when that which has been neglected is re-discovered and re-valued. I then move on to explore how practices of remembering and forgetting themselves are held in tension within the unfolding material futures of post-industrial places. In the final section of this literature review, I examine how each of the disciplines embedded within this thesis— geography, archaeology and geology— have encountered the sudden centring of anthropogenic geomaterials in our collective awareness following the emergence of the Anthropocene. I then engage with cross-cutting disciplinary perspectives that variously demonstrate how anthropogenic geomaterials can also be centred in work that engages with the task of recording and grappling with the implications of the Anthropocene in everyday settings. This chapter will conclude by connecting my research aims to these themes, exploring how my work in subsequent chapters of this thesis can take forward certain concerns and questions that have arisen here.

This literature review of course forms an integral part of an interdisciplinary thesis, and so I also had to bear in mind how I would approach writing from the perspective of a human geographer, looking for points of confluence and conversation with archaeological and geological perspectives. It is worth specifying that I draw here predominantly from literature within the sub-field of contemporary archaeology, which deals with the remains of the recent

rather than ancient past, and that my reading of geological literatures is complemented by more broadly geoscientific perspectives, which work within more recent timescales. The three themes selected— Waste, Post-Industrial Afterlives and The Anthropocene— to some extent hold resonance, and thus encourage exchanges within and between the three disciplinary areas employed in this thesis. In the first two sections of this literature review— those on Waste and Post-Industrial Afterlives— I have however chosen not to sub-divide my writing on the basis of disciplinary area. This is because geological engagement with the theme of Waste generally encompasses perspectives working closely in tandem with engineering, which would draw my review beyond the disciplinary scope of this thesis. Meanwhile, geological perspectives surrounding Post-Industrial landscapes are dominated by work on contamination management and remediation, which, as detailed in Chapter 1, were not matters I could take forward in my own research context. I have therefore instead generated sub-sections around particular ideas that emerge within these themes. This choice of structure means that the first two sections of this chapter predominantly feature work from human geography and contemporary archaeology (as well as other social science and humanities disciplines). As a result, the literature in these sections that pertains to science often comes from the perspectives of social scientists and humanities scholars writing upon scientific ideas and practices, rather than from those working within the sciences themselves, although room is also made for scientific voices who engage with these themes to envision how their work might alter broader practice in their area. By contrast, in the final section of the literature review, the work under examination is initially sub-divided into disciplinary (geology, human geography and archaeology) categorisations, before opening out into more overarching explorations of how the Anthropocene can be read through ‘small stories’ of landscape histories, the ‘storied matter’ that constitutes our planetary imprints, and through Anthropocene geosciences beyond chronostratigraphy. This alternative structure is adopted here to better elucidate the cross-cutting nature of the Anthropocene. Although originating within geological circles, the Anthropocene has migrated to other disciplinary settings too, and so by initially specifically reviewing how each of the disciplinary areas employed in this thesis have received the Anthropocene, I was able to engage with the voices that emerged at the edges of each, advocating for interdisciplinary responses to the implications of this proposed epoch.

Finally, it is also worth noting in this introductory section that the thematic nature of this chapter’s structure has also given rise to decisions regarding what to necessarily exclude from

its remit. This literature review will therefore not cover work which is better placed within the context of relevant empirical chapters. For instance, the limited literature that exists concerning the Glengarnock Steelworks is employed in Chapter 4 as archival empirical material in its own right, and I dedicate some space in Chapter 5 to discuss how heritage futures might be practiced through post-industrial waste deposits in more depth. Meanwhile, a review of scholarly work on the process of CO₂ mineralisation is included in Chapter 6 to better elucidate for the reader of this thesis the science employed therein.

2. *Waste*

2.1 *Defining Waste*

The task of defining the term ‘waste’ suffers, Sonza and Brunclíková (2017:2) suggest, from “the troubled relationship between omnipresence and clarity.” That is, although “waste is so ubiquitous... and intuitively obvious that its definition seems to be an easy task” they contend that instead “the opposite is true” (ibid). Indeed, the pervasiveness of waste matter belies the ways in which meanings ascribed to the term are not fixed, but have been subject to active management through time, put to work in creating, maintaining, or challenging systems. Writing in the British historical context, environmental historian Tim Cooper traces how the original etymology of the term ‘waste’— derived from the Latin ‘vastum’ and denoting areas of uncultivated land— was subject to contestation in the 17th and 18th centuries. Although undeveloped, wastes were nevertheless used by a wide variety of people under common rights of usage. Moves to ‘improve’ such land to increase its productivity (under private ownership) changed the meaning of the word ‘waste’, introducing connotations of uselessness and related justifications for “the necessity of progress”, inciting a fundamental shift in the moral geographies of the term (Cooper, 2009:252). Cockayne (2020:271-272) traces how, by the 19th century, this sense of morality had manifested in negative appraisals of the wasting practices of previous generations. These judgements were however intricately tied to Victorian self-conceptions – casting themselves as superior producers of rational knowledge, the 19th century “... male literati... marvelled at how science permitted reuses that their forebears had never so much as imagined.” Although therefore emerging as a potential enemy to “productivity and progress” (ibid) in the early 19th century, industrious reuse of waste materials was recognised as a valuable aider and abetter of these objectives –

until accelerating industrialisation vastly increased waste abundances, and diminished abilities to deal with the sheer quantities produced (although c.f. Herment and Le Roux, 2017, who argue these issues were not confined to the 1800s, instead originating a century earlier). The meaning of ‘waste’ thus evolved again, growing into a “systemic problem” to be addressed by those invested in the perpetuation of the systems that created this issue (ibid:254). Waste became something to distance oneself from through disposal practices – a conceptualisation which largely persists today, but which took on another tenor in the 1960s, when broader emerging environmental concerns enrolled waste in a wider sense of a sustainability crisis. For Cooper then, to think of waste as merely the physical traces of processes such as industrialisation or capitalism is to miss how waste itself became constitutive of how such systems were understood, challenged, defended, redeemed, or indeed discarded (see also Gille, 2007). It is worth noting in addition however that others (including Cockayne, 2020; Gregson and Forman, 2021) have pointed out that a societal-level narrative of the kind presented by Cooper can be complicated by exploring how waste is perceived at different scales.

Although the work reviewed above pays attention mainly to how those outside of academic contexts variously defined waste, Alexander and O’Hare (2023) record similarly differentiated practices of meaning making when tracing scholarly genealogies of the term in the humanities and social sciences. They pinpoint Mary Douglas’s (1966) *Purity and Danger* as the herald of three particular waves of work on waste, the first finding its genesis in Douglas herself, and specifically her notion of ‘dirt’ as ‘matter out of place.’ For Douglas, dirt is a symbolic label, applied in order to exert social control – thus, anything that is identified as ‘dirty’ is seen to be disorderly, requiring removal from places designated as ‘clean.’ Douglas’s work on dirt therefore takes shape through binary distinctions (dirty/clean; permitted/excluded) and analytical impetus from examining how communities apply these ordering systems to others, and to themselves. Despite the fact that Douglas’s dirt is “almost ritually invoked in waste scholarship” however, Alexander and O’Hare point out that her work does not specifically deal with waste per se. Cooper (2010:1116) concurs, noting “dirt’s need to remain uncomfortably close to the human body” and the ways in which this negates broader conceptualisations of waste matter. Douglas’s relational and constructivist perspectives on dirt still hold influence in waste scholarship today, as waste is commonly held to symbolically connote that which is designated as unwanted (Reno, 2014). However, a turn away from ‘dirt’, and a refocusing on flows of discarded materials, generated a second

wave of waste scholarship, centring on consumption practices, and in particular, our own ‘rubbish’ (Alexander and O’Hare, 2020).

Alexander and O’Hare cite archaeologist William Rathje’s Garbage Project as a typical example of how waste scholarship broadened and the primary analytical lens used to conceptualise waste matter was adjusted. The Garbage Project also represented a key development in how archaeologists themselves defined waste. Rathje’s work— which treated late 20th and early 21st century bins and landfills in Tucson, Arizona as sites of archaeological enquiry— was foundational in promoting archaeological studies of contemporary materials. The essential insight of the Garbage Project was “... if archaeologists can learn important information about extinct societies from ancient garbage, then archaeologists can learn important information about our own society from fresh garbage” (Rathje, 1996:744). As Michael Schiffer (2015:180)— close collaborator of Rathje on the Garbage Project— recounts, such perspectives were not necessarily initially welcomed by the wider discipline, as “prehistorians were scandalized.” Whilst archaeology’s relationship to waste is “closely associated with the study of things that were left behind” (Sonsa and Brunclíková, 2017:1) emphasis had traditionally been placed upon the discipline’s etymological status as ‘the science of ancient things’ (Graves-Brown et al, 2013). For Rathje, Schiffer and colleague J. Jefferson Reid, the kind of archaeology practised through the Garbage Project therefore represented an essential break with this disciplinary inheritance – indeed, it was whilst “grappling with the ways to frame the Garbage Project so that it might become more palatable to archaeologists” that they realised “if archaeology as traditionally defined did not encompass the Garbage Project (or any modern material culture study) then the discipline would have to be redefined” (Schiffer, *ibid*). For the Garbage Project practitioners, the redefinition of waste as a modern archaeological artefact thus entailed a radical shift in disciplinary identity and praxis, as sites of disposal could offer insights into the behaviour of their own contemporaries. In their characterisation of the second wave of waste scholarship, Alexander and O’Hare (2020:6) highlight “the role of states and political economic hegemonies” and their impact upon “the micro practices that these encourage or confront in individuals” as matters of key concern. The Garbage Project itself became enrolled in these dynamics, its data fuelling broader moral concerns surrounding the consumption practices of American citizens, as well as political efforts to address these (Rathje, 2011, Reno, 2013). However, whilst the Garbage Project signified a break in the temporalities of the materials that archaeologists studied, Sonsa and Brunclíková (2017) argue that it represented continuity

with how waste was understood ontologically by the discipline – as something which ‘becomes’ only when it no longer performs its intended function. Viney (2014) characterises this understanding of waste through the notion of ‘use-time’, whereby an orderly temporal narrative trajectory, with a beginning (acquisition), middle (use) and end (discard) is ascribed to an object. Yet more recently, and inspired by developments in disciplines such as human geography, archaeologists have begun to question these taken-for-granted definitions of waste, opening up to the possibility of multiple, or even indeterminate definitions of the term (Sonsa and Brunclíková, 2017).

In her 2012 review of geographical contributions to waste scholarship, Sarah Moore stresses this multifariousness of waste meanings. She notes that waste studies have grown to become “a substantive field in the social sciences” (Moore, 2012:780) and that this development has evolved in relation to various “new geographies of waste” (ibid). Unprecedented abundances of waste production, and the progressively global reach of its trade and management have led to a sense of a “modern waste crisis” (Cooper, 2009:249) and thus to what Moore recognises as the context within which geographers have increasingly been influenced to use waste as a lens to investigate and interrogate its intersection with current environmental anxieties. Such work renders waste as a holder of many identities, such as “hazard, object of management, commodity, resource, archive, filth, fetish, risk, disorder, matter out of place, governable object, abject and actant” (Moore, 2012:781). This extensive list demonstrates “the irreducible plurality of discards *and* their studies” (Alexander and O’Hare, 2020:11), yet Moore encourages us to celebrate these gaps between waste conceptualisations, as they demonstrate the capacities of waste matter both to rely upon cultural inscription to be defined as such, whilst simultaneously holding the ability to slip between and therefore exceed any one of these definitions (see also Kirsch, 2013). Davies (2012:191) expands upon this insight, emphasising that at the point of discard, waste matter does not “cease to exist” but instead begins processes of “relocation and rematerialisation.” These procedures occur at different scales “from the molecular to the international over different time periods and with varying amounts of human intervention and environmental impact” (ibid). It is thus how waste ‘unbecomes’— how it, despite our best efforts to forget about it, does not disappear but instead transforms— that holds the capacity to surprise us (see also Gregson et al, 2010). Viney’s (2014:9) notion of ‘waste-time’ (denoting the afterlife of objects after their use-time has ended) complements this point, describing how once an object is designated as ‘waste’, it is released from “... the obligation to, and expectation of, a functional future.” In contrast to

the orderly narrative trajectory of use-time, waste objects linger on, their stories unfolding self-sufficiently, and their relationship to the future therefore not so clearly legible to us – not least because we ourselves generally do not pay them much attention following their disposal. Alexander and O’Hare’s final and most recent wave of waste scholarship— where waste is recognised as holding its own agency, and thus as possessing the potential to be in active relation with humans and non-humans— influences these opened-out definitions of waste, where the ambiguity involved in encountering an object which causes us to question what it “is, what... it might have been and what it yet might be” is embraced (Viney, 2014:11).

Human geographers and archaeologists studying contemporary material culture find common ground in these forward looking, open-ended definitions of waste, as the former follow where waste goes and what happens to it (Davies, 2012) whilst the latter interpret modern waste artefacts within the contemporary waste record. Both combine an appreciation of how waste items “persist” with an openness to what they may become as a result of “the human capacity to alienate its own creations” – including the possibility that they could “move beyond our comprehension” (Native and Lucas, 2020:857).

2.2 Managing Waste

Mazzolini (2013:31) reflects “it would seem that for decades, waste studies has revolved around matters of definition – what the definition is, but also who gets to write it in response to waste.” Alexander and O’Hare (2020:10) concur, commenting “humans make waste claims that are often primarily discursive”, but emphasise that this meaning making work goes “... on to have drastic material impacts on the human and non-human world.” The task of managing waste— forming the confluence of how we understand waste and what we therefore do about it— thus emerges as a potential point of tension between different standpoints. An exchange, between sociologists Myra Hird and Zsuzsa Gille, illustrates this point well.

In a paper entitled ‘Knowing Waste: Towards an Inhuman Epistemology’ (2012) Hird considers how definitions of waste that stress its indeterminacy undermine waste management systems. Here, the phrase ‘waste management’ comes to denote a particular set of practices and comprehensions of waste— predominantly from engineering and policy perspectives— which situate the responsibilities of dealing with waste as “firmly within the realms of humans acting upon the world” and waste itself as therefore passively subject to the

primacy of human agency (Gregson et al, 2010:1026). Working in the context of municipal landfills, Hird (2012:465) concludes that the “heterogenous, unique mix of each landfill” and the varied interactions that these assemblages have with their surrounding environments, will always render waste management efforts in these settings a failure. The relationship between knowledge and control, central to the implementation of waste management systems, is, she argues, negated by the fact that humans are just one of many forces within landfill settings – and not necessarily the most agentive. In failing to be determinate, waste matter therefore “fails to be contained, fails to be predictable, fails to be calculable, fails to be a technological problem (that can be eliminated)” (ibid). A few months after Hird’s paper was published, Gille (2013) penned a response. In her discussion of Hird’s arguments, she identifies a key distinction: whilst many understandings of the indeterminacy of waste focus upon how easily it can slip between socially ascribed dichotomies (such as valuable/worthless) Hird’s emphasis on waste’s ontology paints it as something that, by its very nature, cannot be fully comprehended. Gille contends Hird’s equation of ‘knowledge’ with ‘determination’ however, implies that there is only one way to ‘know’ waste. She instead encourages a greater appreciation of waste’s epistemologies, warning that we should not neglect the different ways in which waste can be understood or experienced, as this would conceal already-existing inequities in how such modes of knowledge are applied. Gille argues that if we focus our attentions on how waste cannot be known, then we risk undermining long-standing efforts to advocate for the knowledges of those most vulnerable to waste proximities, which have been customarily marginalised in its management.

The contrasts in Hird and Gille’s perspectives are rooted in the issue of how waste is defined, and whose voices we potentially exclude when we fail to build them into our meaning making. Some of the tensions expressed reflect broader dilemmas facing waste studies that are “... caught in a bind between too much and too little focus on the human” (Mazzolini, 2013:31). The task of finding the appropriate balance between potentially diverging approaches in this respect can become all the more strained when applied to the question of what is to be done about waste. However, Hird and Gille appear to be united in their criticisms of waste management systems, characterising them as technocratic, (overly) deterministic, hegemonic, and dominated by scientific perspectives. Indeed, when discussing her support for different waste epistemologies, Gille (2013:2) writes “... there are many other modes of knowing that take place outside laboratories”, implying that the means of knowing waste that emerge from within these spaces should be exceeded. Following Gille’s response

to her original paper, Hird submitted a reply in turn (Hird, 2013a) which acknowledged and largely accepted Gille's analysis. However, Hird built upon the points raised to advance a case for diverse scientific epistemologies, making room for scientists themselves to know and therefore manage waste differently. Drawing from feminist science and technology studies perspectives, and in particular the recognition of scientific uncertainty, Hird highlights the potentials to be found in gathering "practical information about the uncertainties of established and emerging waste management technologies", opening out approaches to waste management that encompass both our abilities and inabilities to know waste; generate explorations as to why this is so; and therefore "open dialogue and decision making to a much broader constituency" (ibid:30). Fundamentally, Hird argues, to cultivate this sense of responsibility to both the known *and* unknown, we must counter our compulsion to tidy away and forget about waste (Hird, 2013b; see also van Wyck, 2013). One way to achieve this therefore is to consider those "whose job it is to remember waste" (Olden, 2016:716), including individuals enrolled in waste management systems, such as managers, scientists and waste workers. As spaces of potential waste forgetting— including landfills, but also sites as varied as abandoned urban neighbourhoods, carbon sinks, and the Great Pacific Garbage Patch (Gabrys, 2009; Thill, 2015)— occupy an ever-growing footprint, the need for these conversations become increasingly important. Writing in the context of an industrial waste site (more specifically, amongst the tailings of a Chilean copper mine) Sebastian Ureta (2016a:1534) acknowledges that waste management programmes do generally view waste as a problem to be solved, often by means of attempting to contain, and deny contact with it. Yet he argues that focussing upon waste management contexts can also reveal that "there is much more happening" than initially meets the eye, observing, "as one starts paying close attention to the practices enacted in and around waste, one realises that many of them do not even remotely comply with the tenets of waste management programmes, rather they emerge and develop in ways completely unexpected by them" (ibid). This recognition can be placed within a broader context of work, which uses ethnographic encounters within sites of wasting to explore the lived experiences that variously unfold there (Reno, 2015). As Ureta points out, this work routinely extends, or even transcends, arguments which consider waste management solely as something to be argued for or against.

Joshua Reno's work offers a distinctive perspective within broader ethnographies of waste management, as it is written from both an archaeological and an auto-ethnographic perspective. Working at a landfill company he calls 'Four Corners', Reno captures how,

whilst working against a backdrop of efforts to contain and conceal a continuous flow of discards, more nuanced waste management practices simultaneously emerged. One particular example stands out from his account. Reno and two young colleagues came across a number of discarded photographs, which captured their female subject pictured in a compromising manner. Reno's colleagues "excitedly began to collect the photographs and gather them under a large rock", saving them for later (Reno, 2013:268). Two older colleagues subsequently discovered the stash, and when Reno recounted how they came to be there, these workers "promptly uttered their disapproval" and sent the photographs to be buried in the landfill (ibid). As an archaeologist, Reno reflects upon the often-uncomfortable closeness between the original (pre-discard) and archaeological (post recovery) contexts of these waste items, as well as the various ethical dilemmas, assertions of power and forms of social consciousness their management gave rise to in the waste workers, including himself. When viewed through the dynamics surrounding particular discarded objects, the waste management practices at the 'Four Corners' landfill site emerge from Reno's account as broadly characterised by a "... commitment to honouring the wishes" of unknown others (ibid:269). As this sense of responsibility was often performed through actions traditionally, and often critically, associated with waste management systems, such as concealment, new layers of meaning can be found in these practices, as we consider both the "specific capacities and affordances [that] characterise waste materials, their management, and their meaning" and "who manages wastes and what... they become together, in specific entanglements of labour, power and possibility" (Reno, 2015:558). Reno's account reveals that, as Liboiron and Lewpawsky (2022) observe, any form of waste management therefore produces 'goods', 'bads' and assumptions about what is good and bad. For this reason, they suggest that when considering waste management systems, it is useful to reflect upon these valuations, how they came to be, and how some perspectives become prioritised over others. What is also paramount however, and as this literature demonstrates, is that we 'stick with' the matter of waste. Some views of waste management suggest that "to frame the issues involved as... being about waste, is to remain trapped by increasingly anachronistic understandings" as the influence of sustainability and circular economy discourses urge an adjustment of focus to "find ways to stop material becoming waste" in the first place (Watson, 2019:230). When it comes to the already abundant volume of existing waste materials however, the cultivation of "... attentiveness and responsibility to the other forms of life and human-non-human labour that are inextricably linked to our discards" (Lau, 2023:1603) means that recognising the 'waste' in 'waste management' remains crucial.

2.3 Historicising Waste

Much of the waste matter discussed in waste scholarship concerns domestic discards from household disposal (Liboiron, 2013; Reno, 2015; Ureta, 2016a). Indeed, this trend has been broadly reflected in this literature review thus far. However, I now wish to turn to a particular strand of literature which concerns the legacies of wastes formerly produced by industries which have themselves been rendered redundant through processes of deindustrialisation. Gavin Bridge (2004) surveys the ways in which academic literatures have developed around this matter of legacy industrial wastes, and that waste's relationship to its surrounding environments, following the demise of the parent industry. Bridge's review focusses upon mine wastes produced by extractive industrial activities. He identifies a "significant broadening over time" (ibid:205) in how questions around mine wastes and the environment have been posed by scholars, as technological and policy responses to initial losses of industry have been succeeded by political ecology and environmental justice perspectives on the consequences of deindustrialisation. More recent work has also considered the ongoing "cultural power" (ibid:241) of post-industrial imaginaries, as wider concerns surrounding the effects of global economic and environmental change are projected onto settings where deindustrialisation has swiftly effected social and environmental transformations. Rhatigan (2020:37) notes the work of cultural and historical geographers has been particularly influential in these explorations of how industrial landscapes "... continue to be valued and imbued with complex meanings and significance" following the often-terminal decline of their "primary economic *raison d'être*." Accompanying turns towards the material in historical and cultural geography (Slatter, 2019) have also focussed attention in particular on how "... the materiality of places shapes practices of commemoration and memorialisation" (Rhatigan 2020:38). The industrial wastes that often characterise the materiality of post-industrial spaces have thus come to be recognised as subject to particular contestations, as conflicting suggestions regarding their management come to represent competing visions of landscape futures – and how best to enrol landscape pasts within them.

Particular legacies of industrial wastes can emerge as key nexus points, around which questions of the most appropriate forms of remembrance are posed. Writing in the context of the Wyoming Valley, a former mining landscape in Pennsylvania, Goin and Raymond (2001:42) trace the debates which circulated around the afterlives of what are known as 'culm

banks' – spoil heaps formed of mine waste. For some valley inhabitants, the culm banks stood as monuments to the works of local ancestors. For others, the constant presence of the spoil heaps led to them becoming regarded as part of the 'natural' character of the local environment. For both groups, the proposal of a government-funded non-profit organisation to environmentally remediate the area "impinged in unexpected ways on the community's historic sense of place." Following the commencement of the remediation work, those for whom the culm banks had naturalised into an accepted and expected topography found "their vernacular, green and black landscape of scrub bush and aspens... bulldozed and replaced by an alien looking, grassy hillside that turned bright yellow in August." For these residents, "the ways in which this 'restored' landscape constituted an improvement was not immediately clear" (ibid:43). For those concerned with preserving the legacies of the area's former industry, the remediation work was seen to accelerate "... the process of erasure of the mining past that produced the landscape of... culm banks" (ibid).

In the face of these contestations, Goin and Raymond reflect that whilst there are undoubted benefits to industrial waste remediation, there are "hidden costs" too (ibid). Quivik (2007) argues that industrial wastes are generally undervalued for the historical information they can convey, as even scholars working in his own sub-disciplinary area of industrial archaeology tend to view such materials fairly one dimensionally – as a means of gaining insights into the technological processes which produced them. Considering the debates surrounding the preservation or remediation of industrial wastes, he therefore suggests exploring how these materials were always enrolled in wider conversations around environmental impacts. Such narratives would allow contemporary remediation efforts to be connected with different kinds of industrial history. Other scholars take different views. Writing on similar tensions in the Copper Basin, Tennessee, M.L. Quinn (1992:115) asks "should *all* degraded landscapes be restored?" (my emphasis), concluding that restoration should not be the only, or assumed, course of action for waste materials, or the places they sit in. By contrast, anthropologist Melissa Baird (2022:5) describes how residents of the Copper Country, Michigan, viewed the mine tailings waste in their midst as "sentient and personified, and more importantly, menacing", due to the toxic effects they observed the waste having upon their environment. In contrast to those who view legacy industrial wastes as representative of a sense of continuity and connection with the industrial past— or indeed, like Quivik, as signifying the endurance of questions surrounding industrial environmental impacts— for Baird, industrial waste materials come to epitomise a fundamental point of rupture or aberration, where longer

histories of local environments are disrupted by the “violence and destruction” introduced by the advent of industrial development (ibid). Perspectives from academic and heritage contexts which view these waste materials as potential historical and cultural assets thus risk romanticising, and therefore delegitimising, harms wrought upon communities – in short, those rendered vulnerable by the ill effects of industrial wastes in their proximity cannot afford to celebrate them. Industrial wastes should thus be used, Baird argues, as a “teaching tool”, to criticise the systems that have writ waste as a debt to be paid by the vulnerable, rather than the powerful, thus moving these waste stories from those of “nostalgia, to repair” (ibid:6).

Through these discussions, we can recognise themes which have emerged and developed in sub-sections 2.1 and 2.2- the abilities of waste matter to simultaneously hold multiple meanings, but also how these various definitions can come into conflict when questions of what is to be done about waste— including here, how it is to be historicised— arise. In the works discussed above, geographical context forms a key dynamic informing how scholarly studies position industrial waste, yet what unites the concerns expressed, and to an extent drives the debate, is the assumption that a fundamental facet of these material legacies is one of toxicity and environmental degradation. As detailed previously, within my own research context, this particular waste identity was rendered negligible early on in the research process. The question that remains then, is how might industrial waste be entered into historical narratives when it is not perceived to be environmentally problematic? To think through a potential response, I will now turn to two scholars— a geographer and an archaeologist— who reflect on personal experience to consider how waste materials can interact with practices surrounding historical knowledge production. I will conclude this section by considering how these encounters refract through the relationships between industrial waste landscapes and their heritagisation.

In her work sorting through the contents of an abandoned Montana homestead, Caitlin DeSilvey’s work (2007:885) temporarily adjusts our focus back towards items of domestic discard. Faced with a setting full of waste objects, she quickly found that traditional archival practices such as categorisation and cataloguing faltered in the face of these materials – instead replaced by “the anxious questions generated by waste things”, including the “uneasy speculation” that dogged her efforts to determine if each item she encountered was a “treasure”, an “artefact” or merely “junk.” When viewed through the traditional curatorial

practices DeSilvey was trained in, every item in the homestead fell into the latter category, thus calling into question a practical way forwards in terms of how she might historicise these articles, as well as the value judgements underpinning her work. Ultimately, she developed a different kind of approach, less dependent on preserving or fixing the meaning of each object, and instead focussing upon how they became “reactivated” by her attention. In this way, she could appreciate how “the significance of objects altered as they moved through different contexts and came into contact with people who asked different things of them” (ibid:888). Situating her work within broader moves in historical geography, towards an appreciation of ‘small stories’ (Lorimer, 2003) and ‘overlooked histories’, DeSilvey reflects upon how the waste items she encountered caused her to question her own authority as a custodian of historical narratives, and instead adopt a more empathetic attitude towards “... these excluded objects on their own terms” (ibid:900).

Writing from an archaeological perspective, Michael Given (who has already featured in the introductory chapter of this thesis) also considers the intersections between authority, empathy, and industrial waste, in the context of a Cypriot copper slag heap. Given (2020:168) reflects upon how, as an archaeologist, he views slag as “a proxy for complicated technical processes.” Whilst working in the field with this material however, he found himself increasingly wondering how those who knew this slag pre-deposition— the copper miners and smelters themselves— felt about it. In Given’s narrative, a passing truck driver addresses this question. Learning of Given’s interest in the slag, the driver shares that he was formerly employed in local mines, extracting the raw materials that would lead to the slag’s eventual formation. To Given’s surprise, the truck driver “... suddenly jabbed his finger at the surface of the slag cake. ‘Blood’, he hissed. ‘It is blood, flesh and sweat’” (ibid:170). It is only when the reader is later reminded that Given is working on an archaeological site, and that the slag under consideration dates from the late Roman period, that we belatedly realise Given’s encounter was fictionalised, composed to demonstrate the considerable distance between ourselves, and those we try to access through traces of the material past. Such distance is exacerbated however, Given argues, if we do not consider the multitude of ways in which these traces have been, or can be, known. By playfully setting the scientific authority with which his archaeological techniques interpret the slag, literally in conversation with the empathetic leap required to imagine a less contemporary viewpoint, Given demonstrates how combining understandings of what an object ‘is’ can contribute to fuller comprehensions. Yet he also shows how such work is not uncomplicated, as the shifts in perspective required can

mean that “you begin to think your story [and the authority it invests in you] afresh” (ibid:180). DeSilvey felt similarly ‘re-arranged’ by the ways in which the ambiguous afterlives of waste challenged her expertise. Nonetheless, both DeSilvey (2006:336) and Given agree that “...the articulation of other histories and geographies” can be gleaned by listening to the waste stories of others, especially if they are from voices “... usually entered in the margins, or consigned to their own separate texts.”

DeSilvey and Given’s insights— on the multiple ways of knowing waste, as well as its capacity to challenge the classifications we try to impose on it— are scaled up in literatures that consider how historic industrial wastes are enrolled in the production of new futures. This becomes particularly evident in contexts located at the nexuses formed by these materials, place regeneration schemes and heritage practices. Spivak (2023:65) provides an example of how these relations can collide in her evocation of The Slate Landscape of Northwest Wales, which became a UNESCO World Heritage cultural landscape in 2021. The implementation of this status denied modern-day descendants of the historic slate mining industry a presence in this commemorative space, as active mining operations were not permitted in the areas newly bounded by heritage protection. Contemporary slate extractors thus faced “... a somewhat macabre situation, where quarries must become inactive and mineral permits expire” to enable the consideration of their sites’ inclusion into The Slate Landscape designation. Spivak observes “this forces a choice between two lineages... [that of] a heritage landscape or an industrial landscape. Within current world heritage frameworks, it cannot be both” (ibid:66). Yet amidst these tensions, an industrious relationship between local people and waste matter persisted. Despite the cessation of slate mining, lower quality rock discards continued their motion through time and space, extracted from their settings for personal use, or the making of small amounts of money through their resale. What’s more, this discreet activity formed a specific instance of living heritage that had been denied to the quarriers, mirroring as it did the historical use of industrial by-products as a source of free material or even profits in hard times (ibid).

Bartolini and DeSilvey (2020) meanwhile trace the planning discourses around the Great Treverbyn ‘sky tip’, made of waste material from china-clay production. The area local to this sky tip was once marked by several of these structures, but they had been levelled or vegetated through time. Archaeological surveys suggested that only 15% of tips remained in an area that was once known as ‘the Cornish Alps’ due to the preponderance of white

coloured waste heaps. The Great Treverbyn tip had become representative of them all, and had thus been shaped into an assemblage of conflicting values. When local people and press realised that the tip may be ‘in danger’ of being removed, a campaign was launched to save it. The waste material became codified as a monument to a lost industry, and any health and safety qualms about the stability of the tip by those looking to regenerate its site were viewed with suspicion, as just another way to use planning legislation to get rid of it. Once the future of the tip was secured however, an interesting shift was observed. The tip’s cultural identity was enfolded into its status as a natural object, allowing it to be subject to natural forces of erosion. This created a more ambiguous prospect, yet this fusing of nature and culture created the conditions for the future of the tip to be considered beyond simply its own preservation.

Both of these examples demonstrate place futures that remain unresolved, yet whilst one story rests for now in anticipation of more fluid heritage categorisations, the other opens out into the acceptance of uncertain waste trajectories. Both also provide instances of what Gardner (2024:482) recognises as the ability of waste landscapes to “... facilitate surprisingly generative and creative uses, and provide new forms of heritage value.” As we have seen, industrial wastes can become recognised as entities which share, and even shape, everyday lived experiences, “... creating zones saturated by constant visual, auditory and material encounter” (Venovcevs, 2022:5). Attending to the particularities of such encounters allows us to appreciate how industrial waste can be narrated differently, as both a “marker” of the past and a “maker” of the future, whilst not being entirely ‘of’ either temporality (Viney, 2014:12). This exemplifies how waste matter encourages many different ways of seeing. Investigating the identities held by a material before it became designated as ‘waste’ can offer insights into its production, circulation, and perhaps even the circumstances behind its discard. Yet attending to waste matter itself can also allow us to appreciate how it variously becomes known and transformed through its relationships with the experiences and agencies of multiple human and nonhuman others (Ureta, 2016b).

To briefly pause and reflect here then – this section has shown that when we choose to pay attention to waste, its ability to exceed our attempts to define or control it are revealed. Reactions to this dynamic in the work reviewed here have ranged from Hird’s advocacy for what she deems waste’s fundamental indeterminacy, to those who, like DeSilvey and Given, instead embrace the generative potential of the surprises waste matter can hold to think and act differently in their own work. The literature reviewed here also offers a simultaneous

reminder (such as through the interventions of Gille and Baird) that we must not forget the pasts, presents and futures of the communities who live and work alongside waste, nor those who decide what is, or is not done with it. Yet within these uneven dynamics, waste was seen (by both Reno and Spivak for example) to also reveal, complicate and partially challenge sources of authority, through the relationships we can build with particular waste materialities.

3. Post-Industrial Afterlives

Ureta (2016b:3) observes that including industrial wastes in our accounts of post-industrial places is something that is “seldom done.” This omission may be, as Pohl (2022) suggests, due to the fact that waste generally remains hidden— even in plain sight— to the general populace. Yet as Gardner et al (2023:3) point out, humanity’s wastes “... are now part of the Earth’s strata and play an ongoing and significant role in the activities that take place on it.” They advise that paying attention to “local manifestations” of these anthropogenic surfaces and sub-strata can allow us to explore “how waste is produced, disposed of, reused and re-imagined to shape and re-shape landscapes” (ibid). This section will proceed to consider a particular typology of Gardener et al’s ‘local manifestations’ through writings on post-industrial landscapes, to provide a conceptual scaffolding situating Glengarnock’s slag in literatures that engage with the kind of setting it occupies. I will begin by focussing on how the process of ruination shapes contestations regarding our use of post-industrial spaces, reviewing how a state of ongoing dereliction (as opposed to restoration) can become advocated for. I will then consider the extent to which a combination of entropic process and human presence in post-industrial sites can be practically achieved. Finally, I will consider literatures around memory, absence and forgetting, which position post-industrial ruination itself as a legacy which we may choose to embrace, or move beyond.

3.1 Ongoing Ruination

Writing on the context of a derelict Polish tram depot, recently ‘rediscovered’ and subject to calls for restoration, Kobińska (2014) observes that this location has been identified as a potential heritage site because originally, at the time of its abandonment, it was perceived as an eyesore to be best ignored. This paradox is important to bear in mind, he maintains, as it

demonstrates that with an appropriate passage of time, valuations of sites subject to dereliction (and thus formerly considered unworthy of attention) can alter, as their neglect enables them to endure to a stage at which they become recognised as representative of ‘the past’ and thus constitutive of ‘heritage.’ Meanwhile, a new kind of risk awareness can become central in how their continuation is realised. Harrison (2013:274) notes that heritage discourses commonly apply citations of rarity and exceptionality to sites deemed worthy of renewed cultural attention, rendering them by extension as “at risk” to lose this status if not “appropriately managed.” Kobińska (ibid:359) discerns how these risk conceptions permeate archaeological identities too, with archaeologists often painted simultaneously as the ‘saviours’ of heritage artefacts (recovering lost treasures from the obscurity of interment) and the source of “negative things” that can befall cultural sites (excavation unavoidably destroying the archaeological record, and therefore requiring meticulous record keeping to preserve it by proxy). Yet Kobińska also argues that ruined sites are still-living sites, with often unseen and underappreciated human and non-human existences proceeding within them. He therefore questions which versions of both the past and the future would be lost in turn if the tram depot’s character as a place of “non-memory” or “oblivion” was disrupted by the initiation of conservation instincts (ibid:362). Lucas (2013:201) sketches the differences between these divergent outcomes, citing Paul Connerton’s work on place memory to distinguish between how heritage approaches can create “memorials” and non-intervention maintains “loci.” The former “explicitly attempt to sustain memory” – but in creating places where “time stands still”, risk rendering a site “relatively passive and inert.” By contrast, in loci, time is allowed to continue to play out, dynamically and entropically (ibid).

Debates surrounding how best to handle the futures of the recent past’s remains have emerged from a proliferation of scholarly writing on ‘recent ruins’. Since roughly the start of the 21st century, both geographers and archaeologists have come to appreciate that the ruins of the near past unsettle us in ways that the ruins of antiquity do not (DeSilvey and Edensor, 2013). One figure who has been particularly influential in elucidating this developing realisation is Tim Edensor. Writing on post-industrial ruins in the British context, Edensor (2001:42) describes how a shift towards a service economy in the latter decades of the 20th century “... swept away many of the remnants of 19th century British industry.” Spaces previously dominated by industrial infrastructures gave way to environments that were notable for their lack of connection to this recent past, as indications of former industry were either repurposed or removed entirely from the landscape. These kinds of post-industrial spaces

thus became material manifestations of political narratives which promoted triumphalist advancement trajectories as a result of this economic transition. In post-industrial ruins however, Edensor finds spaces which have escaped this fate, and which by their very existence and alterity, could be explored as a means of resistance to these ideas of ‘progress’ – which, although often assumed to be a central guiding principle of earlier centuries, still drive societal expectations of perpetual forward motion and improvement today (Tsing, 2015). Indeed, he argues that an uncanny disruption to received narratives of the necessary sacrifices required for economic success can be felt particularly palpably through the endurance of post-industrial ruins, as in their original function, these sites ran according to values oppositional to their current state, such as order, control, and growth. Edensor thus describes the post-industrial ruin as a kind of “phantom limb”, amputated from the networks of reception, production, distribution and circulation that once sustained it, but eerily recalling those times all the same (ibid:46). Edensor (2005a:830; 2005b; 2007) later extends his arguments to encompass the potentials post-industrial ruins hold with regards to how memory can be inscribed on space. He positions ruins as existing in opposition to sites which affix “... authoritative meanings upon the past” such as museums. Evoking the “ghosts” that haunt post-industrial ruins as an “antidote” to determinative memory work, Edensor regards this disturbing potential in a more positive light, as “ruins are sites which have not been exorcised... they seethe with memories... haunt[ing] the visitor with vague imitations of the past, refusing fixity, they also haunt the desire to pin down memory in place” (ibid:829). This elusive quality, Edensor argues, recalls the fragmentary experience of remembrance more closely – memories catch us unbidden, and fade faster the harder we try to grasp them.

Edensor’s claims regarding the potentials of post-industrial ruins have not been universally accepted however. The focal point of criticisms of his work revolves around whose perspectives are privileged in ruin work. Edensor’s early research in post-industrial ruins is notable for the anonymity of the spaces he explores – he walks through abandoned factories and empty workshops, with no further distinguishing features provided. This lack of context thus positions critiques of his perspective within a broader concern – that scholarly work with ruins creates and maintains a form of distance from the lives of those affected by ruination (see for example Dawdy, 2010; Emery, 2019; High, 2013; Kisiel, 2021; Mah, 2012; Pohl, 2021; Pohl, 2022; Shepard, 2013). Yet whilst Edensor has been criticised for this kind of de-contextualisation, his more recent work foregrounds the need for “... critical tools for situating ruins in their particular spatial, historical and cultural contexts” (DeSilvey and

Edensor, 2013:480). A different kind of potential to be found in post-industrial ruins has thus emerged from these conversations, as scholars can approach these settings as both “... sites that need an alternative (human) story to be told, and sites that have a (post human) afterlife that is beyond human telling” (Penrose, 2017:177).

When faced with sites of ongoing ruination, Caitlin DeSilvey (2017:2) characterises the choice that awaits us as the decision to approach such places as either “half empty or half full.” For those adhering to “the school of half empty” approach, the deterioration of potential heritage objects triggers protection and preservation reflexes. Yet advocates of the ‘half full’ approach take abandonment as both the end of one story, but the beginning of other, alternate narratives. This dwelling, in the spaces between “abandonment and attention” (ibid:21) brings to mind a deliberate occupation of J.B. Jackson’s (1980:102) ‘interval of neglect’ – where the ruined state is positioned as one which “... provides the incentive for restoration, and for a return to origins.” Instead of taking what Jackson depicts as a sure route to restoration however, DeSilvey (ibid:17) argues we can alternatively use ruination to “countenance the release of some of the things we care about into other systems of significance.” Interestingly, DeSilvey notes that she tries not to refer to ‘ruins’ when describing the process of ruination, “... partly because this label would fix their identity, and what I am most interested in is how these identities can remain unfixed yet still productive” (ibid:18). Such approaches thus focus upon the active potential of the verb ‘ruin’ to denote the performance of processes that are world making, as previously redundant objects or spaces are consciously thought otherwise, and their ‘second life’ is newly appreciated (DeSilvey and Harrison, 2020).

As Flynn (2021) records, this shift in perception can yield both intellectually and materially transformative results, as renewed awareness of the multifarious afterlives of abandoned spaces— in part encouraged by popular texts such as Richard Mabey’s *The Unofficial Countryside* (1973)— have revealed an unexpected diversity, complexity, and rarity of non-human life therein, in some instances resulting in active campaigns against the redevelopment of sites undergoing ruination (see e.g. Olden, 2016). Recalling the ‘*vastum*’ or ‘wastelands’ of the 17th century— marginal lands such as “fens, swamps and marshes”— and considering their contemporary recognition as sites of environmental importance, Flynn wonders if a similar appreciation is growing with regards to ruinous, post-industrial locations. Gandy (2016:434) highlights “... cultural and scientific discourses that appear to work against the

grain in relation to more narrowly utilitarian approaches to marginal spaces” and in particular, the field of urban ecology, as an example of how “ruderal and post-industrial biotopes” have productively ‘unsettled’ conceptions of how human impacts are incorporated into environmental analysis (see also Paton and DeSilvey’s evocation of ‘recombinant ecologies’). For instance, ecologist Barbra Harvie found that the Five Sisters shale bings in West Lothian, Scotland, provided “... physically and chemically distinct substrates that are subsequently colonized in an idiosyncratic way by both native and non-native species” (Harvie and Hobbs, 2013:289). Whilst the bings were found to harbour niches for an abundance of rare plant species, this post-industrial ecology also resisted attempts to shape it based on knowledges imported from other settings. When some of the bings were covered in topsoil and grasses to ‘restore’ them to a more ‘natural’ environment, the supposedly hardy vegetation soon died without the assistance of intensive management (Flynn, 2021; Gardner, 2023). More recent scientific work on plant species and communities found on anthropogenic substrates has also demonstrated the heterogeneity of these assemblages, necessitating a management approach grounded in specific studies of each individual site (van Mesdag, 2024). A consideration of “... the scientific dimensions of unconventional landscapes” can therefore allow those landscapes to “serve as a laboratory in a material rather than metaphorical sense, which can help to elucidate the distinctiveness” of such spaces (Gandy, *ibid*:438), as well as the distinct futures that their ongoing neglect enables.

Tim Sørensen (2014:87) also embraces the potentials of ruination to be productive of novel insights in an archaeological context, arguing that the destructive nature of this process upholds the “sacrificial logic” underpinning the acceptance that certain archaeological methods, such as field excavation or laboratory analysis, will ensure that “cultural layers or samples are destroyed in order to achieve knowledge.” He argues that attitudes which perceive transience or ephemerality as a cause for mournful feelings thus can and should be transcended. In his exploration of some of the hundreds of former WW2 concrete bunkers that dot the coastal landscape of Jutland in Denmark, Sørensen describes each — “... seamlessly... merg[ing] into the gradual movements of gravel and sand grinding the concrete down, thus exposing and sharpening the iron reinforcements” — as holding the potential to be appreciated as a “cultural artefact in its own right” (*ibid*:88). He opines “... it would be more poetic and intellectually challenging to allow these ruins to disintegrate and collapse into the rhythms of coastal erosion” rather than fall subject to the wishes of the local authorities, and therefore become “... controlled and controllable, domesticated, and brought under the

regulation of the cultural system.” The fact that there was a great deal of local public support for just this kind of governmental intervention, and that several bunkers were demolished due to “a number of accidents” that had occurred due to swimmer/bunker collisions, perhaps calls into question Sørensen’s claim that the risk posed by these disintegrating structures was “ambiguous” (ibid). Yet the questions— and tensions— raised by Sørensen’s example of military ruins have wider relevance to the perpetuation of ongoing ruination in post-industrial sites. Spaces which have moved into at least a partial post-human state raise potential issues when we encounter them, including the extent to which they should operate to our benefit, convenience, emotional welfare or indeed, physical safety. These concerns become further complicated in turn when we consider that ‘humans’ are not a homogenous group, but present diverse needs within these settings. For this reason, DeSilvey (2017:15) concedes that a complete embrace of ongoing ruination could, at the very least, engender a complex set of reactions, even going so far as to admit that what she proposes may be “entirely inappropriate – as well as illegal.” As a result, she discloses that she is not sure if human co-existence with a total state of entropy is “actually possible” (ibid:9, see also DeSilvey, 2014; 2021).

Jonathan Brettell’s (2016:413) conceptualisation of “entropic heritage” functions as a potential response to this question, as it dwells within the apparent paradox created by the juxtaposition of these two words. Drawn from his experiences of the Purton Ships Graveyard in Gloucestershire, England— a site simultaneously shaped by geomorphological processes, the materiality of the former vessels, Brettell’s personal exploration and the meaning making practices of others— he observes “we find here a mix of stability and instability, of decay and regeneration, of erosion and accumulation, of life and death, of vibrancy and opaqueness” (ibid:428). The latent discord between these oppositional processes and qualities are not neatly resolved here, but unfold in relation to each other in open, unpredictable ways, mirroring the entropic nature of the ships’ deterioration. Brettell records how efforts to fix a historical narrative to the site emerge as sensitive to this sense of contingency in turn. Memorial plaques, attached by the Friends of Purton group to each vessel’s remains, to identify it with succinct details of its previous life, thus emerge as complementary to the Graveyard’s ghostly resonances, presenting “useful moments to return to more grounded realities” (ibid). Brettell argues that the tangible influence of this place’s complexity allows visitors to develop “... a sense of positioning” amongst the exchanges of physical geographies, material artefacts and personal and collective forms of interpretation. As these ‘intra-actions’ (after Barad, 2007) are moved in particular ways by the distinct forms of

ruination presented by this site, their potential dissonances thus instead combine to form a unique harmony. Whilst Brettell too feels that the current state of the site, leaving visitors free to “mooch about” and fold their own narratives into the immutable storying of this place, may soon be altered— “for health and safety reasons if nothing else”— he suggests that the Ships Graveyard may be “starting to get close... or as close as we can reasonably get” to realising a human co-habitation with ongoing ruination (ibid:429).

3.2 Memory, forgetting and legacies of the past in the present

Whilst the previous sub section emphasised how post-industrial setting can encompass, but also come to exceed their former lives through the process of ruination, here I will consider literatures which trace how the industrial past can re-emerge in present experiences and projected futures of material traces. To do so, I will begin by considering the matter of memory. Ruins, as both places and objects, can be positioned amongst disciplinary and cross disciplinary conversations on memory in both geography and archaeology. As one example, Pierre Nora’s work on *‘lieux de memoire’*, or sites of memory (see e.g. Nora, 1989) holds resonance for both disciplines, as it traces how objects and spaces become imbued with collective efforts to symbolise remembrance. Both Johnson and Pratt (2009) and Van Dyke (2019) respectively trace how geographers and archaeologists have worked with Nora’s ideas to explore the means by which different places and things become emblematic of commemoration – as well as (and partly stemming from critiques of Nora’s work) how they figure in grounding the counter-memories of marginalised social groups. Lisa Hill, who works at the interface of geography and archaeology, notes that this work therefore focuses less upon the act of remembering itself, and more upon how objects and spaces become carriers of certain representations of memory (Hill, 2013a). The emphasis here thus falls upon the material realisation of immaterial practices and experiences – indeed, as Bjørnar Olsen (2013:216) stresses, it is partly the material durability of these memory carriers that allows them to “... convey the past to us, make it gather. Without this persistency the past would be gone, memories lost, archaeology made impossible.”

A particular strand of work which has emerged in relation to material representations of memory is how absence comes to matter. Absence, Meier et al (2013:424-25) argue, is a varied phenomenon which, rather than existing as an immaterial “void” instead manifests “in concrete people, places and things.” Absence is “... embodied, enacted, remembered and

contested” but in different ways, and to different extents, by different people. Frers (2013:439) explores the relationship between memory and absence through an account by geographer Owain Jones to illustrate these points. For Jones, a bridge across a river, leading to his former home, acts as a potent symbol of absence (Jones, 2010, in Frers, 2016). Whilst the bridge, in stirring up Jones’ memories, appears to offer connectivity, in reality it functions as a denial of the kind of connection that really he longs for – a return to the past. As Jones appreciates that actually traversing the bridge would entail a fruitless search for a lost time and place, Frers reflects “the location still exists, it could be reached – but it is beyond the bridge and all different by now.” Following Levinas (2003, in Frers, 2016), Jones’ bridge thus functions as a kind of ‘trace’ – an entity which denotes the presence of something that is absent. As Frers explains, that which is absent is not found ‘beyond’ nor ‘in’ the trace, but is raised through the failure of its perceiver to truly access that which is lost. Different traces can however generate different intensities of response, and accordingly require various approaches to recognise their presence, and the absences that they signify. Whilst “... the experience of absence is stronger when it refers to practices, emotions and corporal attachments that have been deeply engrained into those who experience the absence” (ibid:431) for those who do not hold personal memories associated with a trace, it will “... not necessarily provoke an intense awareness of loss... but rather promote an empathetic conjecture, an imaginative response to often obscure or vague signs that something is missing from where it used to be” (Edensor, 2013:448). When the passage of time entirely extinguishes personal familiarity with a trace, leaving at best only inherited memories surrounding it, DeLyser (2001, following De Certeau, 1985) argues that these entities can instead come to operate as a kind of synecdoche. The trace is perceived as a carrier of memory, and thus, whilst only in actuality representing a fragment of a past landscape, becomes ‘amplified’ through efforts to use it to access an imagined whole. As these traces, and the absent pasts they signify, become progressively re-interpreted in the presents of each new generation however, the meanings of these traces, and of the landscapes they occupy, change in turn.

van Veldhoven (2014:330) therefore contends that the process of *forgetting* should be set alongside, rather than as oppositional to memory, as both have a “formative character” and act in relation to each other (ibid). He expands: “memory, composed of decisions of what we remember and forget, undergoes an evolution; an evolution that is tightly tied up with the changes we make in its repository, the landscape in which we stand” (ibid:341). He argues

that as time passes, it is increasingly the evolution of memory—including the process of forgetting—that shapes the afterlives of post-industrial spaces. These dynamics are particularly pertinent in post-industrial ruins which have been, as Anna Storm (2008:12) describes, “... reinterpreted to represent a new future with the past as a reference.” Storm sees the materiality of place as one way of reading how this negotiation is played out. She uses rust as an indicative example, explaining how this material trace comes to be understood as a symbol of redundant industrial knowledges, forming a veneer on the metals that formerly held their own operational networks of understandings. As certain materialities, and the knowledges that surround them, become associated with the past however, the meanings linked to these entities evolve, and so the materiality of place changes in turn. With time, rust can “become fashionable” and associated with new design aesthetics, as post-industrial ruins become redeveloped. Rust then comes to symbolise a kind of qualified hope, a new surface upon which different communities can project their desires and scepticisms, as the complex relationship between remembering and forgetting creates newly contested landscapes (ibid:168).

Through the complex relationships between memory-forgetting and absence-presence, we have seen how the legacies of the industrial past can continuously resurface, as the histories of post-industrial spaces “are rarely if ever settled” (Rhatigan, 2020:47). Rhodes et al (2021:11) point out that whilst much work on post-industrial spaces lays emphasis upon the outcomes of their ‘post’ prefix—that is, upon the process of “... moving on from the industrial past”—there are opportunities to alternatively consider “... the relationship between contemporary (post-industrial) places and (industrial) pasts and how these are embedded in the practices of realising imagined futures.” I will now review how these dynamics infuse the writings of three scholars, writing within and between geography and archaeology, who variously contemplate how the idea of ruination itself can function as a re-surfacing legacy in post-industrial imaginaries, and explore the discursive and material implications of allowing it to do so.

For Leila Dawney, the ruin emerges as a tempting lens through which to perceive post-industrial spaces, but ultimately one which should be resisted when enrolled in particular kinds of narrative. She argues that the condition of ruination is commonly chronicled as delineating the final stage of a trajectory frequently applied to these settings. Tsing (2015:18) describes these accounts as “stories that we know” – beginning with “pioneers, progress, and

the transformation of ‘empty’ spaces into industrial resource fields”, but transitioning to “... a bubble of promise followed by lost livelihoods and damaged landscapes.” Writing in the context of Visaginas, a Lithuanian ‘atomic city’, rendered post-industrial by the decommissioning of the local nuclear power plant, Dawney acknowledges that it is possible to read this place through “grand narratives of hubris and decline” – but that to do so would draw our focus away from more important stories that “interrupt” these imposed histories (Dawney, 2020:34, 46). By paying attention to how ruins can be transformed by these alternative narratives, it is possible to turn away from their potential role as “objects of melancholic loss” and instead perceive alternative small stories of hope, as those who continue to live in Visaginas show that the deindustrialised place they inhabit can instead form the “raw materials through which to forge ways of living in spaces characterised as surplus to requirement” (ibid:33). Attending to the “forms of living that burgeon in such ruins” thus allows us to understand how they are shaped by processes other than abandonment and decay. Dawney warns that her work in Visaginas should not be read as a “... redemptive tale” instead arguing that the endurance she witnessed emerged from “... stubborn drives to resist and retain form, in spite of ongoing processes that seek to redefine, erase and let die” (ibid:46-47). To succumb to the temptation of telling stories which emphasise ruination, about places still inhabited by humans, thus in Dawney’s eyes negates the counter narratives of the residents of Visaginas— and those in other places like it— which recount ways of living through structural violence (see also Tsing, 2015).

Whilst Dawney therefore proposes that the ruin legacies should be treated carefully, Gastón Gordillo explores how, in a different context, they can be actively embraced. Gordillo’s (2013:322) work is based in the Argentinian town of Piquete de Anta – a place not so much ruined by the loss of industry, but instead by it never arriving in the first place. Previously a regional hub, the routing of a railway in the 1930s which bypassed the town led to its decline and eventual abandonment just 30 years later. Yet Piquete de Anta is transformed each year by pilgrims, who flock to the site to commemorate “this town’s rise and fall.” Thus, “in Piquete de Anta, the negativity haunting its ruins (the absences and ruptures that define them) is transformed by a multitude, at least for a few days, into... a power of affirming, a power that cyclically injects festive life into a place destroyed by progress” (ibid:335). What interests Gordillo is how this approbative force can allow us to view “... spatial destruction positively, through the spaces it *creates*: new places and also ruins.” In this case, a place that was once considered abandoned and peripheral is once again temporarily centred as a “potent

node”, drawing together a myriad of people, places, and objects. The way in which this both recalls and transcends Piquete de Anta’s previous identity disrupts our geographical sense of taken-for-grantedness, as we see that abandoned places can become more-than-peripheral. Yet as Gordillo argues, it is the ruination of this place, and how this legacy has been conceived of by its pilgrims, that creates this change. Rather than “a bounded, self-contained, dead object, a relic of the past severed from the living geographies of the present” Piquete de Anta thus emerges as a place holding multiple and vibrant afterlives (ibid:324).

Anna Storm’s approach to the resurfacing legacies of post-industrial ruins is neither cautionary nor celebratory – instead, she categorises the ruin as a particular kind of ‘post-industrial landscape scar’. Storm prefers the image of the scar to navigate the complex afterlives of post-industrial places, as it allows us to address the harms wrought by deindustrialisation, but also the potential for healing, and the indeterminate spaces this process of recovery creates. For Storm, the material remnants of the industrial past, and the ways in which they intersect with immaterial imaginaries, position these traces as the physical manifestation of the scar metaphor she employs. She describes three broad categories of scar– reused scars, ruined scars, and undefined scars. Reused scars typify places where the industrial past is seen as an asset– they might take the form of refurbished warehouse apartments or post-industrial landscape parks. These scars are thus “commodified or domesticated, made visible, agreeable and respectable... [their] stories adapted for those who do not have personal memories of the place when it was in operation in its previous use” (Storm, 2014:17-18). By contrast, ruined scars are exemplified by “places where people have left their binders on the desk never to return, and where the shrubs grow through broken windows” (ibid:18). Storm argues that a ruined scar needs to be *seen* to exist as such, and emphasises the particular visual aesthetic that ruined places are often viewed through. Conversely, undefined scars remain unperceived, perhaps because they are inaccessible, or simply because they “... just do not stand out as important” (ibid:19). Their temporalities, in contrast to the reused and ruined scars, are harder to pin down.

To again then briefly pause and reflect here – this section has explored the tensions that can arise when humans re-encounter post-industrial places that have become subject to forces of neglect and ruination. Such tensions were seen to surface particularly around the early work of Tim Edensor, between those who value the materially affective and transgressive qualities of settings perceived to have been rendered post-human, and those who assert that complex,

contextual human existences remain in the pasts, presents and futures in these places. Debate additionally emerged around how to react when enough time has passed for the neglected and forgotten to become deemed worthy of heritage attention and protection. Some (such as Kobialka and Sørensen) focussed on what might be lost as a result; whilst others (such as Brettell) explored how a multiplicity of human and non-human dynamics could form alternative, tenuous and contingent relationships in entropic spaces. This section also reviewed literature that engaged with how the past can become inscribed on material remains, with the process of forgetting perhaps counter-intuitively emerging as a key force. This dynamic was further developed in the experiences of those who have had to decide how to respond to the ongoing legacies of being forgotten by global capitalist-industrial systems, with different modes of endurance (some stubborn, others celebratory, and others still unspoken) materialising. In her book *The Mushroom at the End of the World: On the Possibility of Life in Capitalist Ruins*, Anna Tsing argues “... we need to watch the unruly edges” of our landscapes, which exist precariously at the margins of the attentions of those in economic and political power (Tsing, 2015:20). By observing the human-nonhuman relations that actively transform, stoically persist, or even remain largely unnoticed within these post-industrial places, Tsing also contends that possible modes of Anthropocene living can be witnessed and explored. In charting the physical, political, economic, social and technological means by which humanity has become a geological force, and in anticipating the ways that our continuing environmental impacts will escalate, interpretations of the Anthropocene concept force us to contend with the possible ruins of our future, but also what Jorritsma (2020:197) terms “the other spectres that the Anthropocene raises: the ghosts that come from behind, from the past.” Dwelling within the afterlives of contemporary post-industrial ruination can therefore allow us both to narrate the Anthropocene histories that gave rise to these spaces, but also to imagine potential Anthropocene futures through investigating the modes of existence that have emerged within these sites. I will now turn to consider this proposed new epoch itself in more depth, in order to enlist a final theme to guide me in conceptually framing Glengarnock’s steel slag.

4. *The Anthropocene*

The Anthropocene Working Group (AWG), a former working group of the International Commission of Stratigraphy’s Subcommission on Quaternary Stratigraphy (ICSSQS) state

that the ‘Anthropocene’ is a term devised “to denote the present geological time interval, in which many conditions and processes on Earth are profoundly altered by human impact” (ICSSQS, n.d.). As this impact has “intensified significantly since the onset of industrialisation” the AWG contends that we have now exited “the Earth System state typical of the Holocene Epoch that post-dates the last glaciation” (ibid). Examples of the ways in which this Earth System state has been altered by humans include significant increases in sediment erosion and deposition, obvious disruptions to element cycles (including the carbon, nitrogen, and phosphorus cycles) as well as the results of these disturbances, including the current climate and biodiversity crises (ibid). Yet most significantly for our purposes here, the AWG also recognises “the proliferation and dispersal of many new ‘minerals’ and ‘rocks’, including concrete, fly ash and plastics” as symptomatic of the new Anthropocene Earth System regime. These materials, along with various indications of the Earth System changes noted above, are now being progressively incorporated into the rock record, to stand as material testament to the fact that humanity is now considered to act a geological force (ibid).

Just as I have previously used the themes of ‘Waste’ and ‘Post-Industrial Afterlives’ to explore literatures that will inform how Glengarnock’s steel slag might be positioned as a material legacy, I will now employ ‘The Anthropocene’ to consider both how anthropogenic materials have been recast as new kinds of Anthropocene ‘rock’, and the kinds of landscape readings these human-produced strata enable. Academic literatures surrounding the Anthropocene are particularly substantive, as although originating as a geological concept, the idea of this new epoch has since effectively “gone viral” (Larsen and Harrington Jnr, 2021:729), its implications acting as a kind of lightning rod to channel a wider sense of contemporary crisis. As Moore (2015:1) observes, “The Anthropocene is everywhere in academia: there are Anthropocene journals, Anthropocene courses, Anthropocene conferences, Anthropocene panels, Anthropocene podcasts, and more. It is very safe to say that the Anthropocene is having a moment.” It is necessary then to chart a particular course through this abundance of academic work, especially as the Anthropocene’s “rhetorical promiscuity” has engendered its adoption in different disciplines differently (Farrier, 2019:3). As I am working with literatures from three disciplines in this chapter, and as each of these disciplines encompasses a multitude of responses to the Anthropocene proposal, I wish to consider at least a sample of the intra-disciplinary conversations that have emerged in geography, archaeology and geology in relation to this concept. As we shall see however, some of these disciplinary responses, when put in conversation with each other at an

interdisciplinary level, can define the Anthropocene in conflicting ways. I will therefore work with Farrier's notion of an "inclusive approach to defining the Anthropocene, [where] each discipline must do so according to its own terms, and by implication... must reappraise its boundaries and assumptions in the Anthropocene's shadow." I will thus, as Farrier indicates, explore in addition how opinions have been put forward in each of the disciplines in my purview with regards to how they may be *changed* by the implications of this proposed new epoch. This will allow me to explore literatures that expose the developing margins of each subject area in relation to the Anthropocene – sometimes through finding fault with mainstream disciplinary definitions of this term, and sometimes through seeing its multiplicity of possible definitions as enabling potential points of interdisciplinary confluence to be found. Sub-sections 4.1, 4.2, and 4.3 will therefore take each disciplinary perspective that informs this research project in turn, to try to capture some of the ways in which geoscientists, geographers, and archaeologists have variously received the Anthropocene, and perceived potential intra- or cross-disciplinary developments as a result. In sub-sections 4.4 and 4.5 I will go on to explore how, informed by the exchanges raised in the previous sub-sections, using 'small stories', 'storied matter' and Anthropocene geoscience beyond chronostratigraphy can allow for a consideration of how Anthropocene materials and landscapes may be investigated and narrated.

4.1 Geology and the Geosciences- Defining the Anthropocene

The idea that the collective impact of humanity upon the planet has become akin to a natural force is not one which is new within the field of geology. Indeed, Hermann Häusler (2018:69) counts fifteen different scholars, who between the years 1854 to 1983, suggested neologisms to capture a similar state of affairs. These viewpoints encompassed various countries of origin, and a range of proposed nomenclatures. For instance, in 1854 Welsh geologist Thomas Jenkyn advocated for the term 'anthropozoic' to be applied to "the present-day human epoch" and its deposits, which were "already recording the influences of humans" (Walls, 2020:42). Instead, the term 'Holocene' (nominated by French geologist Paul Gervais, who was influenced by Scottish geologist Charles Lyell's proposition for a 'Recent epoch') became widely adopted, denoting the idea that humans were "... part of the definition of the most recent geological time unit" – although, as Lewis and Maslin (2015:173) note, there is evidence to suggest that this definition was more theologically than geologically inclined, becoming enrolled as part of efforts to "retain humans at the apex of life on Earth." By 1916,

however, German geologist Ernst Fischer had specifically diagnosed “mankind as a geologic factor” and in 1959 Heinrich Häusler, inspired by this verdict, developed a new kind of geology called ‘anthropogeology’ which would study “the relationship between humans and geologic processes not only in the past and present but also in the near future” (Häusler, 2017:70-71). Furthermore, as Lewis and Maslin (2015) record, the term ‘Anthropocene’ was already in use by non-Western, particularly Russian, scientists from the 1920s onwards.

It was not until the new millennium however, that this term began to attract fresh, and eventually increasingly prominent, adherents. Noel Castree (2014a) sketches a comprehensive timeline, charting the most recent re-emergence of the Anthropocene hypothesis, and how it progressed to far more established adoption both within and beyond geology. The idea that the Holocene may have ended— superseded by an epoch that denoted not just the presence of humans, but their cumulative impacts upon earth systems— was introduced by chemist Paul Crutzen and freshwater ecologist Eugene Stoermer in the year 2000, through an international research programme’s newsletter (Crutzen and Stoermer, 2000, in Castree, 2014a). Crutzen went on to debut the Anthropocene hypothesis to a much wider audience in a 2002 *Nature* article, entitled ‘Geology of mankind’ (Crutzen, 2002, in Castree, 2014a). Yet as the question of the existence of the Anthropocene became more settled in the minds of Crutzen and many of his colleagues, Castree traces how an additional matter began to emerge – “how precisely to *demonstrate* empirically the inauguration of a new phase of Earth’s history” (Castree, 2014a:438, citing Steffan et al, 2007). As the Anthropocene hypothesis rested upon the inception of a new subcategorization of geological time, geologists themselves began to take notice and, in 2007, Jan Zalasiewicz— then chairman of The Geological Society Stratigraphy Commission— proposed that stratigraphers could look into this question. Two years later, the International Commission on Stratigraphy (ICS), responsible for determining the International Geological Time Scale, established the Anthropocene Working Group, with Zalasiewicz as chair. In 2019, the AWG voted to treat the Anthropocene as a formal chronostratigraphic unit. The AWG also voted to use stratigraphic signals associated with the mid-twentieth century (the ‘sharpest’ and most ‘globally synchronous’ of which are considered to be artificial radionuclides from atomic weapons testing) to act as the primary guide to establish the Holocene-Anthropocene boundary. The search for a Global boundary Stratotype Section and Point, or ‘golden spike’— an agreed point in the stratigraphic record that would indicate the start of the Anthropocene— ended in October 2023, as the AWG formally proposed the year 1952 to mark the official start of the

Anthropocene, and a “succession of lake sediment from Crawford Lake, Ontario” to form the new epoch’s GSSP (AWG, 2023; McCarthy et al, 2023; Waters et al, 2023). In March 2024 however, the governing body reviewing the AWG’s proposal, the ICSSQS “... voted to reject the proposal for an Anthropocene Epoch as a formal unit of the Geological Time Scale” (ICSSQS, 2024). In their statement, the ICSSQS went on to note that despite this, “... the Anthropocene will nevertheless continue to be used not only by Earth and environmental scientists, but also by social scientists, politicians and economists, as well as by the public at large. It will remain an invaluable descriptor of human impact on the Earth system” (ibid).

Castree (2014a:439) also notes that the members of the AWG introduced the Anthropocene to non-geologists. As a result, “the broader environmental science community” was “drawn into a geological discussion of epochal markers, normally confined to earth science, and normally focussed on the deep past.” Almost simultaneously, “the concept has spread with extraordinary speed” through the social sciences and humanities, leading to multiple interpretations of what the Anthropocene constitutes (Gordon, 2021:243; Zalasiewicz et al, 2021). This diversity of opinion is reflected within the geological community, and the particular discomforts the Anthropocene concept can engender is captured well in snapshot form by Helen Gordon, who conducted several interviews with geologists for her book *Notes from Deep Time*. One participant opined “it’s not really old enough for me to care about... it’s geography, not geology”, whilst another considered whether the concept had been overhyped, pointing out “if someone came up with a new group stage in the Jurassic... it wouldn’t cause a ripple except with us lot” (Gordon, 2021:240). Others suggest that we may find ourselves in a transition period, moving towards an Anthropocene, but that for now, “we are just too close to the events to talk about them from a geological perspective” (ibid). Reflecting upon her conversations, Gordon perceives that the traditional role of the geologist is inverted when faced with the Anthropocene, as instead of reconstructing events of the deep past, from a rock record formed before our species’ existence, the rock record must instead be used to look for evidence of events “known and documented through human observation” (ibid:241). Yet the work and influence of the AWG provides some evidence of this change being embraced, as indicative Anthropocene deposits, ranging from concrete (Waters and Zalasiewicz, 2018) to plastics (Corcoran et al, 2018) and fly ash particles (Rose, 2018) have been sought to characterise the stratigraphy of this epoch.

Nichols and Gogineni (2018:109) argue however that there is further scope for geologists to be more fundamentally changed by the implications of the Anthropocene, beyond simply considering novel stratigraphic signals. They argue that traditional geology, immersed in deep time “... takes as axiomatic the separation of humans from nature” and thus contend that “to recognise such a thing as the Anthropocene is to reject” this guiding principle. Turning instead to the experiences of “short timescale geoscientists” who work with the rock record within the confines of human history— and calling to mind Heinrich Häusler’s mid-twentieth century proposals for an ‘anthropogeology’— Nichols and Gogineni posit that to fully recognise the Anthropocene, geologists need to develop “a new kind of geology”, one which sees the discipline becoming “*more anthropocentric*.” Recognising that this realignment stands in contrast to recent opposite moves towards the material and non-human in the humanities and social sciences, they argue “such an approach would develop by combining the epistemologies and ontologies of the natural sciences, social sciences and humanities in order to have a deeper understanding of why humans became a geological force.” Finding this “common ground” would allow the geosciences to move beyond purely chronostratigraphic definitions of the Anthropocene, and instead consider its consequences (ibid:114,116) – an objective that will possibly become more pronounced in the wake of the ICSSQS rejection of the Anthropocene’s inclusion in the Geological Time Scale.

4.2 Geography: Scaling the Anthropocene

Despite the recent surge in interest in the term ‘Anthropocene’ Larsen and Harrington Jr (2020) argue that it is possible to distinguish a longer disciplinary history of geographical engagements with Anthropocene antecedents. For instance, Alexander von Humboldt’s recognition of the wholeness and interconnectedness of the Earth established a precedent for the study of human-environment relations, whilst Élisée Reclus argued that humans were the embodiment of a self-conscious Nature. Close relations with the environment were therefore, in Reclus’s eyes, a requirement for the successful development of civilisations. Later, Peter Kropotkin’s sense of the reciprocal responsibility involved in inhabiting a planetary commons cast humans as “... nature’s conscience just as much as... nature made conscious” (Larsen and Harrington Jr, 2020:730). Larsen and Harrington Jr thus conclude “Anthropocene dialogues build upon insights posed by geographers of the 18th and 19th centuries” (ibid:729). Cook et al (2015:10) concur, noting that the modern-day notion of the Anthropocene intersects with “... many ideas and specialisms that have historically— if quietly and

somewhat obscurely— been the purview of geographers.” They view the Anthropocene therefore as an “opportunity for Geography and geographers” to share these seasoned insights with a broader audience. Many geographers have clearly taken up this task – after conducting a basic bibliometric analysis on the Web of Science platform using the keyword ‘Anthropocene’ Knitter et al (2019:453) conclude that geographers constitute “the leading contributors” in this area. Castree (2014b:454-455) provides a broad overview of the various ways that geographers have engaged with the Anthropocene concept. He traces how human geographers have recognised the potential of the Anthropocene to contribute to efforts which “bring the question of nature and environment into their ‘side’ of what, a generation ago, appeared to be a discipline of two halves with a vanishing centre.” The Anthropocene has therefore been incorporated into this wider endeavour, through diverse areas of study already interested in human-environment relations, such as political ecology and environmental justice perspectives; work on climate change adaption and mitigation; considerations of how nature is represented; and turns to the material, non-human world. Rather than dwelling upon the for now lapsed question of whether the Anthropocene should be introduced to the International Geological Timescale, and how this might be achieved, Castree observes that many human geographers have already recognised the implications of the Anthropocene (if not necessarily the term itself) as “matters of fact” (ibid:456).

Much of the resulting focus thus falls upon how changes might be made in order to live within an epoch which has already commenced. Some have proposed that this should be approached through a fundamental ontological restructuring of Western thought, as work with Indigenous or traditional ways of knowing has shown that it is not simply the case that different cultures know the same earth diversely, but rather, that multiple ontologies make their own worlds. The Anthropocene embodies the idea that the world as ‘we’ know it (as Holocene inhabitants of the earth, rather than Anthropocene forces acting upon it) is coming to an end, yet the perspectives of “indigenous scholars and others who have been colonised, enslaved, and exploited offer cogent reminders that ‘the end of the world’ is something that many peoples have already endured, sometimes repeatedly” as a result of “the catastrophes that the west has already inflicted on a world of others” (Clark, 2020:144, see also Davis and Todd, 2017; Yusoff, 2018). Partly influenced by these perspectives, and more generally by redirecting their attention away from the task of locating globally synchronous Anthropocene signals, those in the social sciences and humanities have therefore recognised that the localised effects of the Anthropocene are experienced unevenly, both in space and time.

Hesketh (2022:483) prescribes a consequent problem that lies within the promise of the Anthropocene – whilst collapsing geological history into human history suggests a confluence point for scholars of both the deep and recent pasts, the latter generally struggle with “unifying timescales or... singular stories” (see also Chakrabarty, 2015; Oppermann, 2018a). Human geographers, as Larsen and Harrington Jr (2020:732) argue, have thus generally come to view the Anthropocene as “more than stratigraphic”, instead adopting a “kaleidoscopic” approach to the term, as multiple, sometimes competing understandings manifest to accommodate the fact that no one perspective can truly capture the total complexity posed by this “super concept” (Castree, 2014a:445, see also Rickards, 2015a; Thomas et al, 2020).

Castree notes that this impasse in matters of definition and scale can result in a distinct lack of Anthropocene conversation between human geographers and the wider geosciences community. Despite this apparent incommensurability in views, Cook et al (2015:10) recognise that the Anthropocene still holds potential as a “meeting place” for different perspectives, therefore presenting a “tantalising” prospect, “for a family reunion for geography’s scattered tribe.” This opportunity has been recognised by those who argue that geographers on both sides of the disciplinary spectrum need to make changes to established epistemologies in order to find common ground. Rickards (2015b:338) posits that because “the call to the Anthropocene is a call (back) to science, for human geographers this involves trying to clarify our intellectual stance towards science in all its various forms.” This work requires moving beyond simply subjecting scientific perspectives to criticism, and in particular, merely pointing out the lack of objectivity in scientific Anthropocene discourses. Rickards argues that instead, “genuine engagement is perhaps what is most needed” to allow humans geographers to explore “the evolving science of the Anthropocene” as a much more diverse, messy, imperfect, and lively field than perhaps expected (ibid:340). Meanwhile, Knitter et al (2019:459) suggest that those practicing physical geography turn their focus towards “power structures in natural systems” and their own research practices, in order to “initiate change and bring new perspectives in the Anthropocene debate.” Returning to their earlier image of geographical ‘family reunions’, Cook et al (2015:10) reflect that such gatherings “... are sometimes awkward, and often remind us of why we keep our distance.” Castree (2014c:474) draws out these tensions, as he concludes his three-part overview of geographical engagements with the Anthropocene by reflecting on future directions. As we have seen, whilst geographers variously appreciate the global magnitude of the

Anthropocene, and the necessity of grounding its implications in local experiences, they also question how best to reconcile different perspectives and approaches when a “single picture” view of the world is rejected. Castree therefore diagnoses geography’s internal diversity as reflective of the Anthropocene concept itself, and calls for reciprocal considerations of how the Anthropocene and geography can mutually embrace this multifariousness.

4.3 Archaeology: Mattering the Anthropocene

Braje et al (2014) consider some of the tensions that have arisen as archaeologists have engaged with the task of determining an Anthropocene start-date. They argue that geologists and archaeologists work on fundamentally different timescales, where a considerable length of time in human history constitutes a mere blink of an eye when viewed from the perspective of geological deep time. If the Anthropocene was agreed to commence in, for example, the year 1850 (although widely contested as such by historians, here taken as the beginning of the Industrial Revolution) then this would, Braje et al contend, negate the idea that “humans have actively shaped environments and ecosystems for thousands of years, and their effects, sometimes subtle but often dramatic, have been compounding over millennia.” In short, the “epistemic distancing” (Lane, 2015:491) involved in considerations of geological deep time can dilute our abilities to appreciate “... the deep historical processes that created our human dominated planet” (Braje et al, 2014:28). Archaeologists therefore became concerned that a negation of their perspectives in the debates surrounding Anthropocene origins could reinforce “the faulty premise that pre-industrial humans lived in harmony with nature and that a ‘natural’ world existed in some idyllic pre-modern state” (ibid). A focus on locating “a priori... pre human impact baselines” was therefore held to nullify archaeological appreciations “... of the mutual, co-construction and production of the world through the ever-accumulating processes of human-thing entanglement” (Lane, 2015:5).

These perspectives reflect wider appreciations of the scalar incompatibilities that beset the Anthropocene concept, and González-Ruibal (2018:11) delves further into the issues presented by geological understandings of time, which he deems “too deep, too precise, too homogenous.” Attending to this last designation in particular, González-Ruibal cites a critique widely levelled at the term ‘Anthropocene’ – that the universalised ‘human’ implicated in this epochal designation does not fairly reflect who holds responsibility for the planetary effects encompassed by this name. The practice of suggesting alternative names for

the Anthropocene, to remedy this representational imbalance, has become popular – indeed, Mentz (2019, in Martynski, 2021) totals twenty-four different suggestions that have been put forward. Substitute proposals include the ‘Capitalocene’ (Haraway, 2015) where capitalism is held responsible for perpetuating the destructive relationship between global economic systems and unevenly exercised human domination over the environment, and the ‘Plantationocene’ (ibid) where the connections between colonialism, racism, and global environment altering systems such as food production are put in conversation with the inequities in power that manifest within the Anthropocene concept. Meanwhile, Haraway also suggests that these terms should be co-adopted, accompanied in addition by the ‘Chthulucene’ which denotes the possibilities for future human survival to be found by living ‘otherwise’, through establishing caring relationships within multispecies assemblages. Haraway and others (see for example Martynski, 2021) argue that this proliferation of replacement ‘-cenes’ demonstrates that ‘humanity’ cannot be applied as an all-encompassing term to denote those held culpable for the Anthropocene’s implications. González-Ruibal (2018:16) recommends that archaeologists adopt a new archaeological era, called “the Age of Destruction” both to reflect what can be found in the contemporary archaeological record, but also to free archaeologists from working within the confines of a concept devised with a different research agenda in mind. This would allow archaeology to move beyond the role of providing “data” (ibid:17) to chronostratigraphic debates, and instead deal with the Anthropocene on its own terms. González-Ruibal contends that the Age of Destruction could co-exist alongside the Anthropocene – just as the archaeological Palaeolithic period and the geological Pleistocene epoch occupy almost the same chronology in both earth and human history. The Age of Destruction would however readjust archaeological focus towards the material imprints of human structures such as modernity, capitalism, colonialism or nationalism, thus allowing for the uneven power differentials between the “anthropos of the Anthropocene” (ibid:19) to be acknowledged and investigated.

Some archaeologists have thus moved beyond the question of the Anthropocene’s genesis, to instead consider how Anthropocene materialities could differently orientate the discipline. Campbell (2021:1315) suggests that whilst traditionally, archaeology is defined as “the study of the past through material culture... in the Anthropocene, the archaeological record ceases to be observed from a distance, but is something we exist within.” He therefore evokes the contemporary archaeological record as a ‘hyperobject’ (borrowing this term from Morton, 2013) as the sheer abundance and diversity of contemporary material culture constitutes a

“time transgressive entity of vast geographical scope”, rendering traditional archaeological approaches “... problematic upon entering the Anthropocene.” Campbell projects how Anthropocene archaeologists of the future may operate, predicting conventional focuses upon localised field sites will become insufficient to capture the globalised nature of the Anthropocene record, and envisioning how standard methodologies will adapt to capture immaterial evidence such as atmospheric CO₂ and radiation, with archaeologists swapping their trowels for Geiger counters.

Póra Pétursdóttir (2017:182) also embraces the “jolt to the imagination” that the Anthropocene presents to archaeologists. She argues that whilst the Anthropocene denotes an ‘Age of Humans’ it is actually the “longevity and volitivity” of humanity’s *things* that forms the material basis of this epoch, forming a wilful, unpredictable, “more than human legacy” (ibid:178). She uses this assessment to argue that things are therefore “dark”— that is, inherently unknowable— as they “hold in reserve arrays of unforeseen capacities and unexpected alliances that far exceed any current relations and functions- and which may or may not involve direct human associations” (ibid:193). She thus recommends a radical departure from traditional archaeological perspectives— which generally use materials as proxies to reconstruct past environments— instead proposing that Anthropocene materials “... do not *represent* anything coherent or expectedly humanly rewarding (past, society, culture, and so on) – but are above all *presence*” (ibid:199). Such materials should be recognised as “... the initiation of our thinking, being, and action” for the uncertain futures we face. However, Alexandra Ion (2018:191) fiercely criticised Pétursdóttir’s perspectives, characterising them as “a fetishisation of things, an abandoning of responsibility and an alienation of humans.” Ion disputes Pétursdóttir’s claim that fully embracing the ‘darkness’ of objects can offer directions both for rethinking the Anthropocene and refashioning archaeology, asking how these aims can be practically achieved if humans “withdraw from meaningful interaction with the universe around them?” (ibid:194). Instead, Ion argues that following Pétursdóttir’s lead would entail coming up against a “dead end (or... a dark end)” as in accepting the unknowability of objects, the question of why we should be concerned with them at all arises. If we direct archaeological attention to contexts where humans have no influence, Ion thus contends, we cannot understand or further investigate human accountability, which, in the context of the Anthropocene, holds “... immediate important ethical consequences” (ibid:195-196).

At the heart of Pétursdóttir and Ion's disagreements is the question of what matters, which can be related to what McAtackney (2020:226) frames as "the existence of two very different formulations of contemporary archaeology... a current gulf between [those]... who want to focus on what things tell us about people, and [those]... who want to focus on things as non- or post-human." When centred in the sense of existential crisis evoked by the Anthropocene, these divergences arguably become increasingly charged. Yet McAtackney positions the Anthropocene as a concept which could offer "... cross-fertilisation and innovative archaeologies that meet somewhere between these standpoints" (ibid). Olivier (2020:162) observes that as the Anthropocene changes our conception of time— casting the past not as layered beneath the present, but as being reworked within it— archaeological understandings in turn can appreciate objects not only as witnesses to history, but, in undergoing changes unseen to us, also as "composite hybrids", thereby holding multiple meanings. In what is perhaps a slight qualification to her previous stance, Pétursdóttir (2020:167) asks how archaeologists can render these materials "intelligible beyond reduction" suggesting that recognising the inherent potentiality in things, and the provisional nature of our interpretations of them, may be a way forwards. Although questions around the validity of archaeological interpretations are not new, and indeed, have been enduring concerns in particular for those who have adopted post-positivist positions in archaeology (Trigger, 2006; Kristiansen, 2009) these matters take on new resonances when considering how our future material legacies can be conceived of.

As we have seen in all three disciplinary areas, responses to the Anthropocene have generated points of both consensus and conflict. I will again briefly pause here, to consider the insights offered from each of the previous sub-sections, and to in turn establish how I will go forwards in refining my approach to navigating the substantive body of work that constitutes Anthropocene literatures. For geographers, the different scales at which the Anthropocene can be conceived emerged as a key dynamic in relation to how this concept may be grounded in every-day experience. Localised readings of the Anthropocene were put forward as offering scope for acknowledging the diversity of its implications, as well as a potential lens which those within the discipline who subscribe to a bigger picture, planetary view of this concept may consider. To consider how I might understand Glengarnock's slag as a material legacy of the Anthropocene, in sub-section 4.4 I will thus review literatures which variously explore how the Anthropocene may be contextualised, through stories of everyday landscape encounters. In archaeology, questions around Anthropocene materials themselves, and the

sometimes fraught mattering of how they can evidence or exceed our increasing planetary agency, emerged as fundamental considerations in relation to how an archaeology of the Anthropocene might be practised, and how Anthropocene archaeologists might reappraise their conceptualisations of the relationship between humans and nonhumans. In sub-section 4.4, I will therefore also reflect upon perspectives which, in working through how our material legacies may be narrated, position the stories that we and our material signatures tell of each other in productive conversation. Meanwhile, a key issue that emerged from within geological and geoscientific discussions was how chronostratigraphic objectives have broadly thus far dominated approaches to the Anthropocene. As I do not propose to position the Glengarnock steel slag as a ‘golden spike’ to represent the chronostratigraphic origin of this new epoch, I will conclude in sub-section 4.5 by reviewing literatures which explore how the Anthropocene may be approached geoscientifically, beyond chronostratigraphy. It is also clear from the previous sub-sections that whilst geographers, archaeologists and geoscientists conducted Anthropocene conversations within their disciplinary confines, the wide-ranging nature of this concept also entailed varied reflections upon the affordances of extra-disciplinary perspectives. Throughout the remainder of this section, I will therefore also pay attention to how the Anthropocene may function as a means to further these cross-disciplinary considerations.

4.4 Small Stories and Storied Matter

As we have seen in sub-section 4.2, human geographers have been particularly enthusiastic in their support for the idea that diverse experiences of Anthropocene impacts create numerous ontologies of this term, which are in turn realised in multiple world-making manifestations. The notion that multiple Anthropocenes can co-exist is however strongly refuted by Hamilton (2016:103) who asks if proponents of such a claim would “... argue that the Jurassic has no privileged definition, so that anyone is free to define it as they chose?” Yet it is precisely this differentiation— between a geological past where humans did not exist, and the here-and-nowness of the Anthropocene, in which our agencies come to the fore— that lead scholars such as Matless (2017) to reach for another geological analogy. Casting the Anthropocene as an unconformity, representing a break from the past rather than an uninterrupted layer in cultures of stratigraphic nomenclature, he argues that as human experiences of this most recent epoch are not homogenous, they are therefore unlikely to reconcile into one accepted account. Olden (2016:251-252) similarly makes the case for a “proliferation” of ‘small

stories’ that have emerged to connect the “overwhelming issue” of the Anthropocene to “the world we witness.” Quoting from Lorimer (2010:268, in Olden, *ibid*) who describes how these “micro-scale enquiries” can “... find small kingdoms of worldliness... [by] craft[ing] short stories as outcrops of global history” Olden argues that “far from a turn away from the bigger issues” that the Anthropocene presents, stories exploring everyday, localised experience of this new epoch, are instead “a way into them.” Introducing the idea of an “Anthropocene anthology” Buck (2015:369-370) builds upon this idea of storying, contending that the Anthropocene should not be comprehended by means of a single narrative thread, but instead be understood as a “collection of multiple, related stories, each calling up reference of another— *People who like this also read*— the whole narrative assemblage adding up to more than its pieces.”

Matless (2016:118) offers an example of one lens through which such a compendium could be compiled. Responding to Castree’s (2014c:473) call for geographers to “... stand among the semantic weather makers... [to] actively participate in determining the frames of reference others use to comprehend life in a world where humans are said to be the equivalent of a geological force”, Matless puts forward “... the ‘Anthroposcenic’ as a semantic proposal.” Framing various ‘scenes’ as sites where Anthropocene concerns become concentrated, such as glaciers (melting), coastlines (drowning) and forests (burning), Matless posits that his concept thus encapsulates how “landscape becomes emblematic of environmental transformation” (*ibid*). Yet Matless also draws attention to how his notion of ‘Anthroposcenes’ grounds these “emblematic” landscapes in localised settings, mirroring how landscape itself encompasses the representative and the particular, in shifting between imaginative and material registers. In a later publication, (Matless, 2018:72) he turns his focus to landscape histories, suggesting that different periods on the timeline of a particular place could be read to explore how they can become understood as anticipatory or indicative of themes central to how we understand the Anthropocene, and thus situated as “... resonant for today” (see also, Griffiths et al, 2017).

Fredriksen (2021:531) provides an illuminating example of how past and present landscape histories converge unexpectedly in “the ongoing, everyday, more-than-human relationships, actions and less-than-planetary assemblages through which the Anthropocene is sensed and lived” – what she deems the “ordinary Anthropocene.” She traces the story of a stormwater treatment area in Palm Beach, Florida, USA, used to filtrate pollutants from runoff before it

enters the Everglades wetland ecosystem. This innocuous anthropogenic site became the setting for an extra-ordinary story – the return of wild flamingos to Florida after an absence of over one hundred years. Yet the flamingo’s choice to return to a human made setting, which unintentionally mimicked their natural habitat, rather than the nearby Everglades, introduced an uncanny note to their supposed homecoming. The flamingo’s relocation juxtaposed the way things were in the past, the inherited expectations of that history, and what had instead come to pass, bringing into sharp relief the extent to which human actions had altered the environment the flamingos of bygone times knew. Instead of celebrating the flamingo’s return as an uncomplicated ‘good news story’— as local media outlets had done— Fredriksen instead argues that by “pushing at the edges” of this tale, “larger entangled worlds” can be revealed. The flamingo’s story emerges as one of the Anthropocene’s “ghost stories... drawing in different times and places, fragments of what was or might be, brought into view— sometimes jarringly so, sometimes only flickering at the edges of perception—by the current onrush of disorientating ecological shifts” (ibid:534).

When viewed through the lens of the Anthropocene, landscapes can thus take on a “prismatic quality”, (Matless, 2018:72) forcing us not only to contend with the uncertainty of our futures, but also “... drawing our attention to suppressed and stowed away memories and geographies from the past” (Jorritsma, 2020:191). Landscapes can therefore encompass multiple temporalities, but other scholars have emphasised how they can be composed of many voices. Drawing on Kenneth Olwig’s (1996) use of the Germanic roots of the word ‘landscape’ Tsing (2017:7, see also Kirsch, 2015) interprets the term to denote sites that are made through the “gathering” of many entities, where “issues of importance” can be worked through. Landscapes can be understood not only as a means by which to represent an external environment, but also as emergent through the relationships between the humans, non-humans and physical processes that shape them. By following any one of these voices, a different way ‘through’ a particular landscape is offered, with “... a different storyline, a history with a different beginning, with different actors that change as a result of relationships with each other” (Matthews, 2018:407). Focussing on any one constituent of a landscape can thus reveal the multiple Anthropocene stories that co-exist within it.

Smykowski and Stobircka (2022:357) approach the relationship between particular places, their components, and Anthropocene storying from a slightly different angle. As archaeologists, they perceive the material constituents of Anthropocene landscapes as distinct

kinds of historical sources, and wonder how we should narrate them. They posit that to begin to answer these questions, we should work from the ground up, exploring different kinds of artefacts that have emerged in the Anthropocene, in the contexts of the landscapes that hold them. Inspecting plastiglomerate deposits (formed by the entrapping of anthropogenic and natural particles in a plastic matrix) during fieldwork in Lanzarote, Smykowski and Stobircka suggest that it is easy to imagine telling the story of these nature-culture hybrids by sequestering them in a museum glass case, to share a cautionary tale of our environmental impact. Yet they argue that context matters, and by leaving these deposits to be perceived where they have come to rest, they can "... redirect our attention to things we had stopped noticing: natural rock formations, pristine beaches and maritime flora and fauna" (ibid:357). This entanglement of material and landscape, "demands a historical narrative", and borrowing the term from material ecocriticism, they suggest that viewing these entities as 'storied matter' allows us to appreciate "the idea that matter is not only lively, agentic, and generative... but also densely storied" (Oppermann, 2018b:412). Just as the Lanzarote plastiglomerates hold together grains of different origins, storied matter exists as "a material 'mesh' of meanings, properties, and processes, in which human and nonhuman players are interlocked in networks that produce undeniable signifying forces" (Iovino and Oppermann, 2014:1-2, in Oppermann, ibid). These materials can allow us to tell their stories, but also themselves tell our stories as they form the traces that we leave behind us.

This latter notion of material legacy is of course one that is central to the Anthropocene. As Harvey (2019:143) observes "... the magnitude of its implications rests on a simple causal relationship between human action and a resulting material imprint." Harrison and Sterling (2020:22) consider some key questions that arise when considering this idea of material legacy, including "what is taken forward into the future, what is inherited under the concept of the human, and what survives it as excess or exclusion within its formations?" Answering these inquiries, they argue, necessitates thinking "geological, biological, chemical, and cultural activity together, as a network of interactions with shared histories and unstable futures." This is not a straightforward task, as Tsing (2022:309) recognises "... there are particular ways of telling stories about humans, and then there are wholly different ways of telling stories about plants and animals, or rocks and climate, and we don't know how to mix these up very well." By focussing on particular entities, and the ways in which they have exceeded the intentions and expectations of the imperial and industrial structures which have generated the Anthropocene, Tsing argues that we can juxtapose different disciplinary

tellings— simultaneously resisting their partitioning, whilst respecting the integrity of their perspectives— to narrate the “granular”, “patchy” nature of the localised Anthropocene experience (ibid:310,311).

4.5 Anthropocene Geoscience Beyond Chronostratigraphy

Mould (2019:92) notes that some scholars within the geosciences are responding to the Anthropocene by thinking about how both human and physical processes co-produce landscapes. He emphasises that these concerns go beyond simply considering the “human impacts” that can be recognised within a landscape, instead trying to understand how humans “... are acting *with* environments from within socio-natural systems.” Two strands of literature in particular emerge from such efforts, which I will briefly review here – firstly, studies which centre around *what* is co-produced as a result of these human-environment entanglements; and secondly, work which uses this context to consider how geoscientists themselves are “... social, political and environmental agents who not only investigate landscapes, but also remake landscapes through their positions, intentions, and analytical frameworks” (ibid). This latter perspective has been influenced by critical physical geography approaches in particular (see e.g. Blue and Brierley, 2016; Lave et al, 2014; Lave, 2015; Tadaki et al, 2015) which recognise that scientific training does not usually prepare an individual to consider the power relations inherent in both the landscapes they study, and the research practices they employ. Mould captures these dynamics as he reflects upon a photographic project, where he presented images of Anthropocene landscapes. Although, as a fluvial geomorphologist, he could be perceived as presenting an ostensibly ‘objective’ view, his pictures were instead constructed to allow considerations of the socio-politics behind their production. Mould positions his work as employing a dualistic vision, exemplifying how those with scientific backgrounds can turn to the perspectives of other disciplines, and harness the ways in which they converge, diverge, and hybridise with their own practices to consider them afresh. “Critical reflection on the place of geoscientists” can, he contends “contribute meaningfully to reframing public understandings of landscapes and environmental systems in ways that recognise relationships and agencies, and particularly, do not diminish the agencies of the geosphere” (Mould, 2019:99).

It is these latter agencies that Dixon et al (2018:118) evoke, as they argue that whilst considerations of Anthropocene deposits within geosciences have thus far centred around “... humans as agents of environmental change either developing new landforms or altering earth surface processes”, far less attention has been paid to contexts “... where environmental processes go to work on human-built structures to build hybrid landforms.” They note work in other areas of study that has explored this avenue of research— citing ecologically derived recognitions of how places abandoned by humans can be recolonised by plants and animals as a particular example— and thus posit that the study of geomorphological processes, human-made deposits, and the novel landforms their interrelationships create, can allow for a “less anthropocentric” Anthropocene to be practiced (ibid). For this to be achieved however, they argue that work across disciplines must be undertaken, “... since morphological and societal drivers and impacts of Anthropocene geomorphologies cannot be disentangled or dealt with in isolation” (ibid). Zalasiewicz et al (2017:9,10) recognise similar dynamics in their conceptualisation of “the technosphere”, which they define as “the summed material output of the contemporary human enterprise.” The technosphere thus encompasses “... complex social structures, together with the physical infrastructure and technological artefacts... that enable the system to work.” This combination of human and material agencies offers an “alternative prism” through which Anthropocene strata can be treated, whilst moving away from a chronostratigraphic focus on dating the epoch’s beginnings. Yet they also remind us that anthropogenic materials and structures themselves do not wholly represent the Anthropocene record, which is instead defined by all deposits— natural, human-made, and the hybrid entities that arise between them— that have been laid down since the start of the epoch. Edgeworth (2018:157) highlights how the Anthropocene record thus “cannot be claimed by any one specialism, since it is wider than all of them... a transdisciplinary phenomenon, manifesting, in one way or another, as relevant to a range of scientific, humanistic, artistic and practical fields.” He demonstrates in particular how this stratigraphy can be conceived of either geologically or archaeologically, citing the notion of the ‘Jinji unconformity’, (developed by Japanese geologists and loosely translating as “the conjunction of the human and natural”) as holding appeal to both disciplines (ibid:159). The fact that these deposits are being actively formed, and subject to ongoing hybridisations through interactions with both physical processes and human activities, therefore offers rich grounds for geoscientists and archaeologists to collaborate in its analysis.

To take a last, brief reflective pause here then, these final subsections have reviewed work that, in the words of Buck (2015:369) does not succumb to the temptations of turning away from the implications of the Anthropocene, in “grim resignation” or disgust. Instead, a deliberate attempt is made to examine how we might inhabit the Anthropocene in the contexts of our own, everyday worlds. This commitment was found to generate alternative ways of relating to non-human others, of storying these relationships, and of engaging with Anthropocene geomaterials to further underscore how this epoch can be approached differently, beyond the confines of chronostratigraphic dating.

5. Conclusions and questions to carry forwards

This chapter has taken a conceptual approach to the fundamental questions of what, where and when the Glengarnock steel slag is, reviewing three thematic areas of academic literature which speak to the particularity of my research context. As we have seen, each of these themes encompasses scholarly work engaging with circumstances where forgotten material legacies are re-encountered – whether this emerges through a deliberate personal commitment to pay attention to these traces and those affected by them, or through notice becoming unexpectedly drawn to broader re-workings of their meaning. To conclude then, I will lay out certain key concerns and questions that have arisen in the course of exploring each of these thematic areas, and chart how these connect with each of the research aims outlined in Chapter 1, forming exchanges between the reviewed literature and the empirical chapters of this thesis.

My first chosen theme — that of Waste — revealed the slippery nature of this designation, to which the many waves of scholarship working with its definition attest. As I worked through perspectives on how waste might be managed and historicised, the importance of recognising both that objects undergo often unseen transformations when we discard them, and that this transition from use life to afterlives may in turn affect us in unexpected ways, was highlighted in a myriad of ways. Given the fact that my initial assumptions regarding the chemical toxicity of Glengarnock’s slag were unexpectedly proved unfounded, it is clear that this particular waste material also held the capacity to surprise me. I therefore wish to remain alert to this element of surprise, and trace the effects of it through my own work. I am also interested in taking forward the question raised in the exchange between Myra Hyrd and

Zsuzsa Gille, concerning how we can accommodate the unpredictability of waste afterlives within efforts to listen to the seldom heard voices of those living with these discards. I wish to track how I manage this tension, as I produce new histories, alternative heritage narratives, and re-imagined management proposals with Glengarnock's slag. As I use archival sources to recover stories of this slag's past, I am interested in investigating whether this same sense of surprise is reflected in the experiences of those who also once knew it. I am also keen however to trace what happened *after* these moments of surprise – to see if I can foreground how these archival voices dealt with these unexpected, unpredictable slag materialities in their everyday lives. As I craft a contemporary heritage narrative around this slag, I also wish to extend this work, paying attention to how I responded to the surprises I encountered as I intermittently dwelt amongst this waste material, by weaving this disorientation and how it challenged my authorial authority into my telling. I additionally want to imagine what might be done with one surprising Glengarnock slag afterlife— and what unconventional management practices might emerge as a result— by speculatively envisioning how a particular carbon future might play out if those living alongside this industrial waste were empowered to enrol its capacity to mineralise atmospheric carbon dioxide into their future aspirations.

This chapter's second theme of Post-Industrial Afterlives examined how the processes of ruination, memorialisation and forgetting can be variously harnessed to find new futures in deindustrialised settings. Two key questions have emerged from my review of this work. The first relates to how we can engage with the temporalities that post-industrial landscapes can open out into, without simultaneously erasing the complex, contextual histories of these places. Secondly and relatedly, this review also explored differing views regarding the extent to which a state of ruination, or ongoing neglect, should be perpetuated in efforts to realise change in deindustrialised settings. I also wish to carry these questions forward in my research, and address the former specifically in my efforts to write through the complex legacies encompassed by the Glengarnock slag's history. I want to remain cognisant of how the past materialises within my contemporary explorations of the Lochshore slag landscape, and investigate how I can incorporate these histories into my own future imaginaries for this place. As material transformations were actively being pursued through the Lochshore regeneration project, I additionally wish to delve deeper into the implications of the Lochshore slag existing as a pocket of ongoing neglect within this context. With regards to my first research aim, I am therefore interested in appraising whether it is possible to

imbricate a situated, complex account of this slag's past with an exploration of its continuous, transformative potential. I also wish to explore how an intricate, multi-voiced past might be materialised in one possible future opening out of the Glengarnock slag's neglect in my fulfilment of my third research aim. In terms of my second research aim meanwhile, I want to remain alert to any tensions that may arise as I attempt to construct my own heritage narrative surrounding this material, particularly as I encounter the perpetuations of its ongoing neglect within an actively regenerating landscape. I wish to explore how my evolving relationship with the Glengarnock slag positions me with regards to an embrace of transience or an urge to conserve, as I come to make my own value judgments through the effects this material has upon me.

The last theme reviewed here firstly revealed a snapshot of the conversations elicited by the introduction of the Anthropocene to geology, geography and archaeology. These discussions were found to revolve in particular around the capacity of these disciplines to be changed by this potential new geological epoch. Geologists and geoscientists debated how they could better centre humans in their work; archaeologists grappled with the potential agency held by the material and physical worlds; and geographers considered how they might bring together the separate strands of their discipline, seemingly exclusively interested with each of these spheres. Yet in light of the recent rejection of the Anthropocene proposal by the ICSSQS, this review has also opened up newly pertinent questions with regards to how this unit of geological time might be storied differently. By positioning the Glengarnock slag as one localised instance of humanity's assumption of geological force, I wish to explore how I can discuss the material imprints of the Anthropocene beyond the narratives offered by a solely chronostratigraphic perspective. I am also interested in taking forward the question of how we can work alongside these anthropogenic geomaterials, and in particular, those which have been transformed by their surrounding environments, in our efforts to parse out what living within the Anthropocene might entail. By telling a history of one anthropogenic geomaterial, grounded in one place, I am interested in examining how taken-for-granted narratives surrounding slag's role in the Scottish steel industry might be reanimated, through an exploration of temporal trajectories that reach deeper and further than is often traditionally acknowledged. In my adaptation of traditional archaeological techniques, amidst the landscape changes set in motion by the Lochshore regeneration project, I want to survey how Anthropocene landforms— and even slag stratigraphy— can be interpreted in ways that move beyond debates surrounding chronostratigraphic dating. Finally, through my

speculative re-imagining of a Lochshore slag carbon future, I wish to investigate how putting natural and social scientific data in conversation might offer a proposal for one means of practising hope in everyday manifestation of the Anthropocene.

Finally, this chapter has also identified some latent, cross-cutting issues, which emerged in each of the thematic sections. The question of the privileging of humans or matter in research was at the core of three (sometimes reconciliatory, and sometimes tense) exchanges featured in sub-sections 2.2, 3.1 and 4.3. Meanwhile, a need for differing disciplinary perspectives to be in conversation, but uncertainties on how best to achieve interdisciplinarity in practice, also emerged in each of the thematic sections, particularly strongly in the reviewed Anthropocene literatures. In the following chapter, I will therefore go on to draw out these questions, as I consider how they intersect with my own approach to my research project.

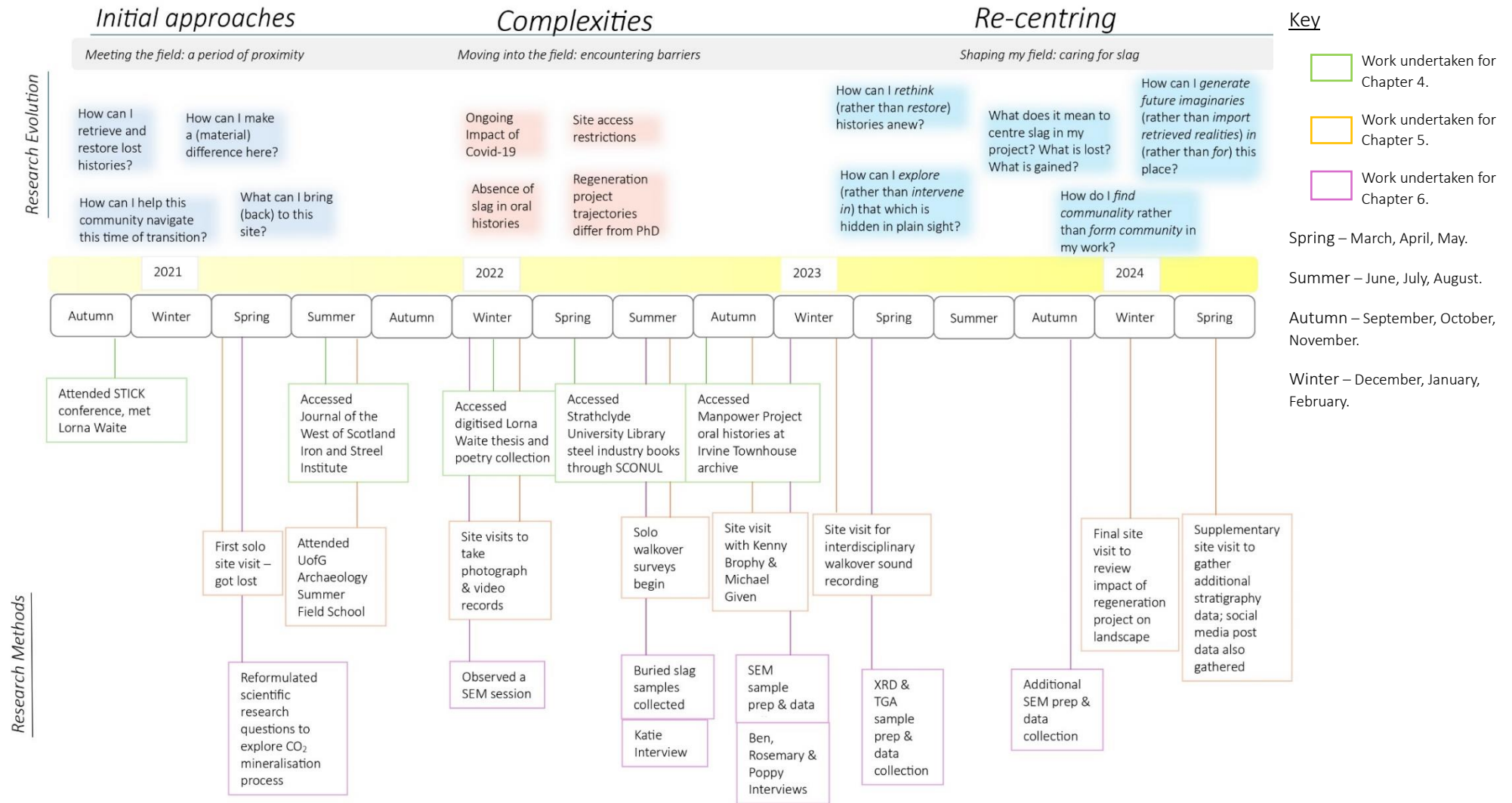


Figure 3.1- This diagram, presenting a visualisation of my research process, is intended to act as a guide, orientating the reader within the issues discussed in Chapter 3 of this thesis. A full explanation of the different elements that make up this timeline diagram will be provided in the introduction to Chapter 3.

Chapter 3: Research Approach

1. Introduction

As outlined in the introduction to this thesis, this chapter differs from what might be expected of a more traditional methodology. The decision to foreground accounts of my research methods in each of my empirical chapters was one to an extent made for reasons of practicality and clarity. As this PhD is interdisciplinary, the various methods I use are more diverse in nature than they might otherwise be had I adopted a single-discipline approach. As some of these methods may thus also be unfamiliar to the reader, it felt sensible to introduce them closer to their respective results. This will prevent, for example, a reader previously unacquainted with X-Ray diffraction analysis having to return to this chapter in order to remind themselves what this technique actually is, upon encountering the results it generated in Chapter 6. The challenge that faced me when conceiving this chapter then, was to determine how to summarise the evolution of my research approach, whilst still providing the reader with a sense of how these overarching developments were shaping the work I was doing on the ground.

A starting point lay in the recognition that this PhD project was one which received its funding through a ‘Supervisor Led’ approach. This meant that my supervisors themselves initially formulated the project’s research object, context and interdisciplinarity, and I then inherited these parameters to further shape throughout the course of my studentship. By spending some time compiling and reviewing a personal archive of this research project — formed of emails, supervisory meeting summaries, annual progression review materials, and even my own scribbled notes recording my thoughts at various junctures — I was able to trace how my own initial orientations towards these parameters were in turn shaped by the course of this PhD. Olden (2016:76) expresses a similar sentiment, but couches it in terms of the particular interchanges that took place between her research approach and her field site, in the docklands of Govan, Glasgow. She recounts “It was the shifting relations between me and the site” that drove the direction of her work, and visualises this process by depicting a project timeline, which she uses to chronicle interdependent transformations in self, site, field practices and overall methodology. Here, I have adopted this idea by presenting my own research project timeline visualisation (**figure 3.1**) at the beginning of this chapter, to guide

the reader through the discussion that follows. The timeline is split into two separate sections, divided by a central unit which charts the progressing seasons of my project. The timeline commences in the Autumn of 2020, and ends with the last of my field visits in the Spring of 2024. The section below this central unit maps directly onto this chronology, allowing the reader to gauge when the methods discussed in my empirical chapters were practised. The text boxes that hold these method descriptions are also colour coded, so that those appearing in green correspond to Chapter 4; those in orange to Chapter 5; and those in purple to Chapter 6. By contrast, the section above the timeline's central unit—conveying the evolution of my research approach—is not intended to speak directly to the central unit's chronology. Instead, it offers an overall summary of how the initial research approach that I anticipated employing as I moved into my field met a series of complexities, necessitating the reshaping of this approach as I re-centred my focus around Glengarnock's slag. This chapter will begin by relating this story, before going on in its second half to specifically consider how my interdisciplinary practice developed as I wrote my way through the various problems presented by my fieldwork. I will explain how my process of 'becoming interdisciplinary' thus largely occurred beyond the timeline presented here.

Throughout this chapter, I will engage with literature that, in keeping with my perspective as someone who has received their primary academic training in geography, derives mainly from this disciplinary area. This choice reflects the disciplinary identity I held as I came into this research project, and thus the perspectives which most resonated with me as I attempted to formulate my research approach. I will also foreground scholarly work that attends to the role of emotion in the research process, and which positions thinking through feelings as an activity that is both instructive and honest. It is also worth finally acknowledging here the baton that was passed from the previous chapter to this one. This chapter will indeed consider how to position differing disciplinary perspectives in relation to each other, and will dedicate space to the question of how I navigated the privileging of humans or matter in my own work. Yet each of these considerations also have huge areas of literature dedicated to them in their own right. Research on interdisciplinarity itself is particularly extensive, as scholars from every disciplinary area have contributed their own thoughts and experiences to the conversations surrounding this activity. Moreover, as Forman (2020:450) articulates, there are "... a plurality of approaches that each shares a sympathy, orientation, or sensitivity toward the social significance of matter and materiality." In this chapter then, I will focus in particular on the writing of geographers on interdisciplinarity, again reflecting my own

disciplinary starting point when first encountering this research project. I will also use the specific anchoring concept of ‘care’ in order to help me best express the particular human-material tensions that both arose within, and shaped my own research process.

2. Meeting the field: initial approaches

At the commencement of my PhD project, I held certain conceptions of the spaces I was about to enter. In particular, my anticipations of ‘the field’— the myriad of relations that I would grow from the slag deposits bordering the shoreline of Kilbirnie Loch— informed the initial approaches I took in the early stages of my research. Brunn and Guasco (2024:3) point out that the field is a “crafted geography” that comes into being through our engagements and practices within it. In this sense then, my expectations regarding what I would find when I started my fieldwork were not shaped by my own experiences of the Lochshore. Although I lived close to this landscape, and had passed by it twice each day for many years, I was still essentially coming to this place and this community afresh. The shaping of my initial approach did however come from *somewhere*. Wimarck et al (2017) observe that although fieldwork has been seen as a core tenet of the geographical disciplinary identity— and the same could be argued for both archaeology (see for example, Lucas, 2002) and geology (see for example Rogers et al, 2024)— it has also generally been viewed as a distinct phase of the research process, held separately from the life course of the researcher. Lewis (2017) expands on this idea by suggesting that both researchers and the fields they work in have their own life courses, which eventually intersect when the researcher enters the field. The collection of questions which are assembled under the Initial Approaches section of my timeline were thus generated in what I would term a ‘period of proximity’, as I met my field site. Here, as my PhD commenced in October 2020, I was aware of the Glengarnock slag’s existence (having made a preliminary visit to see it for the first time) but I had not yet fully encountered or come to inhabit the complexities that my fieldwork would present. The approach I initially conceived was thus instead generated through experiences in my immediate present and recent past.

One of these influences was the ghostly absent presence of the first iteration of this research project, where the Glengarnock slag’s assumed primary identity was as a chemical contaminant. Although almost immediately truncated, the idea of this project continued to

shape my early expectations of my research, even as I attempted to revise my approach to better match the new reality engendered by the unexpected emergence of the Lochshore regeneration project in my comprehension of this landscape's life course. I had originally planned to make some kind of intervention in this place, by conducting scientific and historical work in order to help its local community navigate the present day legacies of the industrial past. Now, I hoped to instead enrol myself in the regeneration process itself, to help project workers in making a material difference to this landscape whilst transposing my community based work to assist in the navigation of landscape transformation, rather than toxicity. Hammet et al (2019) describe a recent turn towards explicitly addressing notions of 'giving back', 'having impact' and 'doing good' in geographical methodological conversations. At the outset of this project, my sense of gratefulness for being a beneficiary of a PhD scholarship also fuelled a perhaps naïve, but nonetheless genuine desire to pay my own good fortune forwards through this re-articulation of my research approach. When reviewing the notes and correspondence I generated during the early months of this project, I was struck by the volume of material I found dedicated to plans for travelling to regenerated post-industrial sites beyond Glengarnock. I had purchased a book (Latz, 2017) on the Landschaftspark Duisburg-Nord, a former steelworks turned public park in western Germany, and researched a multi-media museum experience located at the site of the former Templeborough Works in northern England, to gauge how both told the story of their site's steelmaking past through reanimating its historic plant. My desire to 'give back' had clearly manifested in the sense that I could contribute to the regeneration project's work by *bringing back* insights from other contexts to this place. The physical and monetary expenditure required for me to gain this knowledge made me feel that its acquisition would be a worthy outcome of the investment that had been made in me.

The motivation to position myself within the process of shaping a new iteration of post-industrial change also partly stemmed from my own recent experience of deindustrialisation. Whilst conducting site tours of Hunterston B Nuclear Power Station, I had been mainly concerned with transmitting the stories of one of North Ayrshire's own last remnants of industrial activity. As mentioned in Chapter 1, I had also however been in this job when the results of a routine inspection revealed that the material which formed the station's two reactor cores was ageing faster than expected, and I subsequently witnessed the projected future of the site's lifetime receding before my eyes, as the date of decommissioning was repeatedly brought forward. Ross (2024) notes that from a heritage perspective, the

decommissioning of a nuclear power station is a curious process, as its stated aim is to ensure the eventual total erasure of all traces— whether they be structural or sub-atomic— of this particular industrial past. Whilst some futures of Hunterston B were made very clear in the wake of its January 2022 closure then, others remained uncertain – including how its histories would be perpetuated. By inserting myself into the realisation of a new post-industrial future for the former Glengarnock Steelworks site, I envisioned myself playing a role that I hoped would someday be granted to the forthcoming inheritors of Hunterston B’s legacies – a researcher who cared for the retrieval and restoration of neglected histories, at a time when the landscape which once held this past was once again undergoing change.

As I initially met the field around which this research project revolves, my approach to it was thus influenced by a number of value judgements, made of the knowledge I hoped to generate and the type of researcher I hoped to be. I resisted feelings of uncertainty brought on by the derailment of my preliminary project plans by transplanting the spirit of my usurped research objectives into an unexpectedly changed context, trying all the while to maintain the sense of self I had started to inhabit in my anticipation of my PhD, as it actually began. In my gratitude for receiving research funding, I also found apprehension, as I grew concerned about wasting this opportunity. I thus imagined myself into a role where, by going away from Glengarnock to experience other post-industrial afterlives, I could contribute to the Lochshore regeneration project’s aim to achieve material and social change, by bringing back new, useable ideas. As I grieved for a lost future of Hunterston B— one where I could continue to walk its site and tell others of its past— I saw my present in the Glengarnock Steelwork’s future, and recognised my worth in unearthing and reinstating the importance of its history. Yet these initial approaches were to be complicated, as I moved further into my experience of shaping and being shaped by my field, and the slag at its centre.

3. Moving into the field: complexities

A few months after my time as a PhD student had commenced, my own life course and that of my field intersected with global events, as a second Covid-19 UK national lockdown was announced in December 2020. Published writing from the perspective of PhD students who experienced the pandemic during their studies is now starting to emerge, and Saxena’s (2023) observation, that “... I was not simply doing my PhD in the pandemic. Instead, the pandemic

was in my PhD” is one which resonates throughout this at-present relatively small body of literature. The lockdown imposed immediate limitations on travel, but also cast a long shadow, as the re-opening of cultural spaces in particular did not often occur in the immediate wake of restrictions being lifted. Sites I had thus hoped to visit in the early stages of my project could suddenly provide no clear indication of when I would be able to access them. In one case, it was to be two years before I was able to spend time in a facility where archival sources of key importance to my project were kept (and at the time of writing, this repository had still not fully reopened to the public). In the face of this uncertainty, my plans to travel to other regenerated post-industrial sites unravelled, so I determined to refocus my fieldwork within the more immediately and reliably accessible vicinity of the Lochshore landscape itself – although with no clear plan as to what exactly I might do there.

Oliver (2022:82) captures well the anticipation that geographers in particular felt upon being permitted to physically return to their various field sites, in wake of UK lockdown restrictions easing in the spring of 2021. Yet Oliver’s own experience of this return mirrors my own, as she “repeatedly... found nothing.” For Oliver, ‘nothing’ manifested as a series of confounded expectations: places she travelled to visit were closed without warning; people she hoped to talk to were unpredictably busy; even her own presence was found to be unheralded, as a group she had arranged to work alongside had not been made aware of her plans, and so sent her away. In my own context, ‘nothing’ repeatedly presented itself as my initial research approach met a series of insurmountable barriers. I had hoped to work alongside the Lochshore regeneration project in making a material difference in this landscape, but as I returned to the field, I found that its work had progressed from community consultations to on-the-ground delivery. Contractors were due to move in to physically transform the site, and this in turn complicated my ability to access it, ensuring that I could only do so alone or accompanied by just a few other people. Meanwhile, it emerged that staff working on the regeneration project’s delivery had not returned to their offices following the lifting of Government instructions to ‘stay at home.’ Whilst extremely helpful in organising my site access permissions, and especially generous in giving their time to allow me to conduct interviews with them, direct engagement with the day to day delivery of these individual’s work would clearly not be possible over online calls. Other organisations I had identified as operating natural and cultural heritage projects within the Lochshore landscape had also been affected by the pandemic – as their own timeframes for delivery were disrupted, their priorities understandably became focussed on achieving their own objectives following the

lifting of restrictions, rather than engaging in new collaborations. My efforts to recover lost histories of the Glengarnock Steelworks also felt as though they were retrieving little. In the first month of my PhD, I discovered the location of an archive holding records spanning almost all one hundred and forty five years of the Glengarnock Steelworks' existence. By the project's second month, I had discovered that every one of these documents had some years earlier been destroyed by the private company entrusted with their care. In addition, the task of finding anyone with much to say about Glengarnock's slag was proving difficult. Over the summer of 2021, I contacted a range of people, from those involved in the historic management of the former steelworks site, to those who had contributed to the plans for its regeneration, as well as ex-steelworker contacts, to try to assemble oral histories of the steelworks' last material remnants. Those who replied had evidently tried their best to answer my questions, but my specific interest in the work's waste was undoubtedly eliciting appreciably thin answers.

As I neared the end of that summer, the 'nothings' I was turning up seemed to be in endless supply. I found myself becoming desperate as "... each nothing... chipped away at me, my research and my sense of the possible" (ibid:84). As the imagined potential I had anticipated in my contributions to the Lochshore's future communities, histories and landscape waned, my resentment towards its slag grew. It was not of course the only barrier preventing me from realising my intended research approach, but as I reviewed my initial research ambitions, I realised that I had never explicitly articulated how slag would figure in these objectives. Suddenly, the slag I was supposed to be working with, and the hope I had invested in my PhD outcomes seemed incommensurable. As my desperation grew, I started to consider re-recruiting research participants by playing down the centrality of slag in my research project description, to make the prospect of talking to me more appealing to potential interviewees. I subsequently spent weeks making continuous, minor adjustments to a new recruitment poster, but it transpired that repeatedly modifying this advertisement's background image, or interminably changing the font in which it was written was not bringing me closer to being ready to distribute it. With hindsight, I can recognise these unconscious delay tactics as a kind of pre-cognitive expression of discomfort, as I came perilously close to wasting potential participants' time by misleading them as to what my research was about. Hammet et al (2019) warn that if we do not pay sufficient critical attention to how our desires regarding the impact of our research manifest, we could, in the worst case scenario, actually affect ethical harms. They consequently call for the honest recognition that not all research can, or should, 'do

good' in the way we initially expect it will. This kind of reflection chimes with literatures that embrace both failure and humility within research spaces. Sambamurthy et al (2022:392) relate how their experience of the Covid-19 pandemic revealed different ways of working, as their PhD research "ambitions, timelines and expectations" were "humbled" by the magnitude of change engendered by a global health crisis. Forced to work within, rather than against the conditions created by the inevitable puncturing of their pre-pandemic aspirations, Sambamurthy et al advise that we transplant this acceptance of failure into a post-pandemic, 'new normal' version of academia. Oliver (2022:84) similarly argues that "making nothingness significant opens space for imagination and experimentation, as well as transforming how and why we not just do fieldwork but talk about it with one another."

It must of course be acknowledged that my experiences, although tricky to navigate, were embedded in a relative position of great privilege. As a PhD student receiving scholarship funding and living within an excellent support network, my difficulties pale in comparison to the physical, psychological and financial harms suffered both in and outwith the academy during, and in the aftermath of the Covid-19 pandemic. In addition, I do not wish to fall into a narrative whereby failure is simply presented as a precursor to eventual success. This would be to deny both "... the plurality of experiences that failure generates" and the fact that failure is borne unevenly within academia (Saxena, 2023:334; Davies et al, 2021). The emergence of calls for a more humble way of doing research resonated with me however, especially as I found that I needed to reorientate my approach to the slag at the centre of my PhD project. Expanding on what specifically 'humble geographies' could look like, Saville (2021:100) highlights the inclusion of the non-human in both qualitative and quantitative work. She suggests that by exploring methodologies that "... decentre humans, and take other species, places and material things seriously" we can learn to share our agency with non-human others in our attempts to generate knowledge. This will, she observes, likely result in our sense of self, assurance and authority being disrupted. Yet by remaining "... open to being affected by objects" we can explore "... the different limitations, knowledges, relations and identities that openness can bring" (ibid:102). I will next therefore consider how I moved from imposing my research aspirations onto the Glengarnock slag to instead grow more open to the knowledge-making possibilities it appeared to present on its own terms. To do so, I will frame my narrative around the notion of 'care' – a concept derived from science and technology studies which has developed to explore the dynamics of becoming entangled with others.

4. Re-centring around slag

Forman (2020) observes that over the past three decades, scholarly investigations into the possibility that materials may hold agency independent of humans, and the implications of this, have broadly coalesced under the umbrella term ‘new materialisms.’ As this thesis centres around a particular material, early in the research project my supervisors and I discussed the merits of adopting an overarching methodology wholly based within a specific new materialist approach (such as actor network theory or posthumanism). Yet we came to agree that the restrictiveness of a commitment to only one theoretical orientation might importantly hold the potential to close down interdisciplinary exchanges – particularly when attending to perspectives from within geology, a discipline which has not on the whole recognised the influence of new materialist contributions. In the chapters that follow, I will acknowledge the influence of particular new materialist theoretical perspectives as and when they arise, but when it came to thinking through the relationship between my own agency and that of the slag I was working with in my research, I found the specific concept of ‘care’ a useful lens through which to focus my discussion.

Scholarly work foregrounding care originated in feminist studies of women’s histories, which revealed the ways in which caring practices have been systematically gendered, devalued and concealed (Martin et al, 2015). With time, these analyses expanded to encompass “deeper stratifications in care work” along racial and class divisions (ibid:628). The term entered the feminist science and technology studies lexicon through the work of Annemarie Mol, whose collaborative research in various medical settings positioned caring as a commitment to persistent, trial and error efforts to do one’s best in a complex, unstable, and imperfect world (Mol et al, 2010). Mol’s notion of care has subsequently been adopted and migrated to a wider range of empirical settings (e.g. Ureta’s 2016a work on care practices in the context of a Chilean copper mine); has been applied to non-human others (e.g. de Laet and Mol’s 2000 exploration of their ‘love’ for a water pumping device); and has been subject to more critical appraisals, where care’s assumed ‘goodness’ is not taken for granted (Papazu, 2022). Of these last threads of work, I found Martin et al’s (2015:627) consideration of “care’s darker side” an especially useful starting point to help me acknowledge the choices involved in taking on a research project centred around Glengarnock’s slag. The authors note “care is a selective

mode of attention: it circumscribes and cherishes some things, lives or phenomena as its objects. In the process it excludes others” (ibid). By reaffirming this research project’s decision to care about slag, it was necessary to exclude many of the voices I had initially wanted my work to encompass. Whilst I had been keen to insert myself into active community dialogues around Glengarnock’s recent past and evolving futures, slag, it transpired, was not the ideal companion to introduce to these discussions – in its presence, conversation tended to dry up. Martin et al observe “... a person who cares must first be willing and available to be moved by this other. If we were to hover in the moments before a researcher secures an object to care about, we would encounter an open field of potentialities – indeterminate subjects and objects, and expansive possibilities for forms and temporalities of response” (ibid:635). Although I began my research project with the knowledge that it would in some way be about slag, I had, by this definition, evidently not yet come to care about this material. Instead, as I met and moved into my field, other, seemingly more obvious possibilities emerged as deserving of my attention. Despite having a predefined research topic, I found the process of navigating towards the ‘right’ thing to care about through my work one which took time, as other matters arising from my field— which were far easier to care about than slag— jostled for my notice. Yet Martin et al advise that lingering in this decision making space is an act which can “... slow care down, to expose and to question the self-evidences that would otherwise prescribe its proper objects, as well as its seemingly necessary directions, temporalities, intensities, and forms of action (ibid)” By interrogating and then coming to understand what this research project could and could not care about, I was also able to intentionally care more care-fully. Cognisant of the power held through practicing care, my approach towards Glengarnock’s slag was itself regenerated, as its presence in my work progressed from an inherited focus, to one which I actively chose to centre in my research.

Thinking with care also provided the means to generate a way forwards for my project. Annemarie Mol’s notion of care was latterly influentially developed in new directions by Maria Puig de la Bellacasa (Martin et al, 2015; Ureta, 2016a). Puig de la Bellacasa recognises that care is an orientation that can come into being gradually, as it requires a particular threshold of emotional investment to be exceeded. She draws out this argument by comparing the terms ‘care’ and ‘concern’ – although both have the same Latin root, the former enfolds a far greater sense of attachment and commitment into its connotations (Puig de la Bellacasa, 2011). “Transforming things into matters of care” thus becomes “... a way of relating to

them, of inevitably becoming affected by them, and of modifying their potential to affect others” (ibid:99). Considering how we might generate care also entails imagining what a cared for entity might become if others grew to be similarly affected by it. This kind of transformation holds particularly powerful potential when applied to neglected things, which “... have not managed or are unlikely to succeed” in speaking for themselves (ibid:94). The question of how exactly to approach a research practice informed by care is however not one which offers easy answers. Yet in her 2012 article ‘Nothing comes without its world: thinking with care’ Puig de la Bellacasa offers some suggestions. Drawing from the work of Donna Haraway, she first proposes that ‘thinking with’ a cared for entity entails the production of a particularly situated kind of knowledge, as the narrowed focus that caring demands encourages thick, multilayered accounts of its object’s stories. She goes on to consider the process of ‘dissenting with’, advising that we pay specific attention to points of tension or conflict in our caring relationships, when the things we have committed ourselves to fail to offer what we expected of them. In this way, we can recognise and trace how we are becoming affected and altered by their influence. Finally, she warns against the temptation of ‘thinking for’ those that we care about, thus smothering their own agencies.

The ways in which my research approach was fundamentally changed by my decision to care for, and therefore re-centre slag in my work can perhaps be seen most clearly through my altered use of verbs in the timeline visualisation that accompanies this chapter. The research actions I describe become less assertive, and not as focussed upon my own sense of agency. Rather than trying to *retrieve* and *restore* lost histories of the Glengarnock Steelworks, I consulted archival sources to instead *rethink* my perceptions of its slag. Rather than endeavouring to *intervene in* the emerging Lochshore landscape, I aimed to *explore* how I might be affected by the underappreciated slag features that were already within it. And rather than attempting to *import* the realities of other regenerated post-industrial sites to the Lochshore, I worked to *generate* future imageries for this place, based on a particular vision of how others might come to care for its slag. All of these revisions trace a progressive change towards a more humble approach, which is less concerned with making change, but more open towards becoming changed by Glengarnock’s slag. In attending to how this industrial waste held the capacity to surprise me, and then responding by exploring new legacies that might grow from the ways that it had exceeded my expectations, I felt that I had come to negotiate a shared research approach, which attempted to work through how this material might wield its agency.

My generation of the kind of thick, multilayered, situated knowledge that is evoked by de le Bellacasa (2012) was complemented by my exploration of interdisciplinarity. I will therefore turn finally in this chapter to consider how my initial aspiration to form a community around Glengarnock's slag was in time nuanced, as I sought to find points of communality between the different disciplinary perspectives I used in my work.

5. Finding communality by becoming interdisciplinary

This section will continue to reflect upon how my research approach developed, by foregrounding the often hidden emotional labour of learning to become an interdisciplinary researcher. I will first sketch how the literature on interdisciplinary research in geography reflects this turn towards introspection, through briefly reviewing the appearance of research projects funded specifically for their interdisciplinarity in UK university geography departments. I will then trace how my own understandings of interdisciplinarity changed throughout this project, by exploring a handful of experiences which exemplify the struggles I encountered in moving from disciplinarity to interdisciplinarity as these identities folded into each other. Finally, I will demonstrate how my own interdisciplinarity gradually emerged beyond the timeline visualisation presented at the beginning of this chapter, through the practice of writing through problems that were thrown up by the field I crafted around Glengarnock's slag.

Although geography has long conceived of itself as a discipline that is 'internally interdisciplinary'—encompassing as it does the humanities, social and natural sciences—it was not until a few decades ago that research projects specifically funded for employing an interdisciplinary approach arrived in UK geography departments. As Bracken and Oughten (2009) and Harrison et al (2008) recall, these opportunities coincided with a resurgence of conversations between human and physical geographers (beginning with the 'Across the Divide' sessions at the 2003 and 2004 Royal Geographical Society annual conferences) regarding the potential of their discipline to accommodate such work. Whilst some were confident that the value of interdisciplinarity was generally accepted in geography, others expressed concern that their departments could miss out on emerging calls for interdisciplinary projects due to a lack of appetite for this kind of work (ibid). In time, these

latter anxieties proved unfounded, as interdisciplinary projects funded through both the Rural Economy and Land Use (RELU) programme, and joint ESRC/NERC⁶ PhD studentships began to emerge in geography departments. Yet those involved in these projects often noted confusion around what working in an interdisciplinary manner actually entailed (Buller, 2009; Petts et al, 2008). Robinson (2008) sets out how this problem of definitions in beyond-disciplinary work has typically been navigated, through the choice of prefix attached to the word ‘disciplinarity.’ Thus, multidisciplinary work brings different disciplinary knowledges into the same space; interdisciplinarity to some extent integrates these knowledges; and transdisciplinarity actively challenges disciplinary boundaries by seeking to build new knowledge frameworks by uniting these different perspectives. As Petts et al (2008) note however, this middle ground positioning of interdisciplinarity does not in practice generally lead to one, cohesive research approach, as those participating in their seminar on UK research council funded interdisciplinary work attested. These views chime with Callard and Fitzgerald’s (2015:11) diagnosis that “there is no view from nowhere” in interdisciplinary work. For this reason, a consensus has emerged that it is important to pay attention to what happens ‘behind the scenes’ in interdisciplinary projects, to build up a truer sense of how this undertaking is navigated (ibid). Yet as Callard and Fitzgerald, Buller (2009) and Evans and Randalls (2008) all observe, existing work of this nature in geography tends to focus on collaborative projects, where multiple academics from different disciplines reflect on their experiences of working together. By contrast, I now wish to refract my own experiences through the limited literature that foregrounds the work of individual PhD researchers, who draw together these interdisciplinary conversations through their own projects.

One theme that resounds through the literature issued from geography-based PhD experiences of interdisciplinarity is that it is *hard* (see for example Donovan et al, 2011; Evans and Randalls 2008; Lau and Pasquini, 2008; Lyall, 2019; Petts et al, 2008). Lau and Pasquini (2008) pinpoint a particular problem in the lack of stated quality standards for interdisciplinary work specifically, which leads students to fall back on already learned, but not necessarily commensurable disciplinary expectations of how to conduct their research. Evans and Randalls (2008) provide an example of this dynamic, describing how they struggled during initial work on their thesis literature review chapter. As they tried to juggle

⁶ ‘ESRC’ is the acronym used to refer to the Economic and Social Research Council, whilst ‘NERC’ refers to the Natural Environment Research Council.

the breadth demanded by interdisciplinarity in their work, and their prior experiences with disciplinary expectations regarding depth of engagement, it felt at times like neither quality was being adequately achieved. This act of continuously walking back and forth between disciplinarity and interdisciplinarity is also picked up in Donovan et al (2011:10). Donovan received her undergraduate training in geology, and undertook an interdisciplinary PhD studentship which required her to work with perspectives from human geography to research cultural understandings of volcanic hazards. She describes how she often reverted back to her “geological ghetto” when overwhelmed by the differences between these two scholarly areas, but despite this, also learned to ‘enjoy the boundary’ as she discovered unexpected benefits in becoming interdisciplinary. In particular, she highlights her appreciation of the slippages that could be accommodated by her dual persona – on occasions where her work went well, she was praised for integrating diverse knowledges, but if her efforts were not as successful, she felt less pressure than she might have done otherwise, as her failures were perceived to simply be due to her lack of experience in human geography. Simultaneously however, she was haunted by the constant concern that her work “was not interdisciplinary at all” (ibid:11). Donovan’s reflections demonstrate what Petts et al (2008:600) characterise as the importance of “humility” and “humour” in negotiating disciplinary boundaries. I also found these experiences in my own work, as I traversed my own excursions between disciplinary and interdisciplinary identities. Two examples bear this out.

In the late autumn of 2023, I underwent a lab induction in the University of Glasgow’s Molema Building. Throughout the induction, I was at pains to joke with the (very patient) technician showing me around that I was “just a human geographer” with no real experience of doing science. As the training progressed, I became more comfortable in the lab space, but as soon as the technician left me to it, I began to panic. Surveying the assorted canisters, ball bearings and screwdrivers in front of me, I could not remember exactly what I was supposed to do with them. Sweating lightly, under the white lab coat which made me feel even more of an imposter, I recalled being told that if the equipment was not secured properly by the time I switched the lab machinery on, it could come apart rather violently. At this point, I should have of course again sought out the help of the technician, perhaps making some more jokes about being an incompetent human geographer. But I was impatient with myself. If I was going to become an interdisciplinary researcher, I reasoned, I had to pull myself together. I tentatively assembled the constituent parts of the machine I was using as best I could, took a deep breath, and flicked the on switch. Immediately, it began to shake loudly and forcefully,

causing me to flee rapidly to the opposite end of the lab. At that moment, to my immense relief, the technician re-entered. Above the din, I gestured fearfully to the agitated apparatus. She switched it off, and kindly assured me that what I had taken to be signs of an imminent explosion was actually supposed to happen. Outwardly I laughed my reaction off, but in reality I was shaken, and embarrassed by my inability to tell when I should be a geographer, and when I should be a geoscientist.

Meanwhile, in the spring of 2022, I attended a trip to Glencoe, Scotland with a group of archaeologists, to engage with a number of research projects that were taking place in the area. As I got to know my companions, I was struck by how often I re-asserted my disciplinary identity in the early stages of the trip, even though I was technically attending in my capacity as an interdisciplinary scholar. There was something oddly freeing however in humorously confessing “I’m really just a geographer” before venturing a contribution to each of the discussions taking place around the various ruins, excavations or enactments we collectively surveyed. My candour immediately invited curiosity from my companions, who brought forth their own reflections on how my perspectives spoke to theirs. As these conversations progressed, I became more confident asserting in turn how I saw confluences in thought between these two disciplines. “This actually feels like interdisciplinarity!” I thought, as we collectively reached consensus on how usefully archaeology and geography could speak to each other.

In each of these situations, I used very similar tactics to emotionally prepare myself to enter a space of anticipated interdisciplinary practice, by employing both humour and humility to pre-emptively assert my identity as a human geographer. Yet whilst one experience progressed through confusion and frustration, to fear and shame, the other ended in encouraging my advancement into, rather than retreat from embracing interdisciplinarity.⁷ There are of course differences between these examples – in one I isolated myself, and in the other I worked in community; in the former I tried to force myself into an identity I was not ready to assume, whilst in the latter interdisciplinarity emerged more tentatively, but organically. Yet these experiences also show that it is hard to control the fine line between

⁷ Although each of the reflections snapshotted here are couched specifically within the context of either the geosciences or archaeology, they are of course not intended to provide a microcosm of my overall impressions of working in an interdisciplinary manner in each of these disciplines. It is important to note here therefore that I had many other experiences in the geosciences which encouraged my advancement into interdisciplinarity, as well as a few in archaeology which caused me to beat a temporary retreat from this approach.

finding comfort in disciplinarity and ease in interdisciplinarity. As Petts et al (2008) note, this is a process that takes time – and not necessarily on a straightforward trajectory. My success during the Glencoe trip took place before my failure in the lab, and thus did not ensure that I had in any way solved the question of how to navigate working between disciplines, or even learnt how best to be “discomfited” when undertaking interdisciplinary research (Callard and Fitzgerald, 2015:11). Instead, I found my research practice to form a series of recursive, yet unpredictable loops, where each new encounter with the spaces that my crafted field came to occupy— archives, laboratories, computer suites and the Lochshore’s slag landscape itself— set off respective processes of multifariously trying to get to grips with disciplinary methods old and new, before working out how exactly they could be put in conversation. For this reason, most of the research methods depicted in the timeline that guides this chapter were conducted in a decidedly disciplinary manner. Interdisciplinarity generally emerged for me once I had moved through this fieldwork, and into the subsequent work of analysis and synthesis that writing entails.

A particular kind of laudability has accompanied perceptions of interdisciplinary research, as it has become esteemed as capable of solving global problems originating in the ‘real world’ (Last, 2018; Petts et al, 2008; Robinson, 2008). As I moved into writing up my thesis, I too discovered that interdisciplinarity could assist me in addressing problems generated in the real world, but at a smaller scale. Last (2018:199) observes that “the field... is where all good methodological intentions seem to fail.” This chapter has already detailed how my well-intended initial approaches to this research project failed as I encountered the complexities presented by my field, and how my attempts to practice interdisciplinary research often regressed into disciplinarity, as I grappled with the difficulties of learning to work at the boundaries of new subject areas. Yet I also came to re-configure my project around the slag at its centre, and in a similar manner, my methods became re-framed in relation to each other, as I worked my way through the problems I had encountered. This process can be illustrated by briefly turning to the list of activities assigned to each thesis empirical chapter in my timeline visualisation, and attending to the stories they seem to tell.

The methods itemised for my first empirical chapter appear to present a straightforward narrative of primary and secondary source gathering, yet this belies a tale of near total documentary destruction which, as mentioned previously in this chapter, I met soon after I began my project. This experience left me profoundly grateful that my PhD was not to be

conducted solely through the typical, archive based methodology of a historical geographer, but also scrabbling for any past depictions of Glengarnock's slag that I could find. The archival sources recorded here thus represent a highly diverse collection of fragmentary voices, punctuating the history of the Glengarnock Steelworks. Historical geographers are no strangers to the partiality of archives, but I needed perspectives from archaeology, and inspired by geology, to help me rethink how to put these archives in conversation with each other, to craft a history through the marginal presences of the slag recorded in each. The activities detailed for my second empirical chapter meanwhile similarly conceal a story of failed archaeological intervention. Site access restrictions allowed only small groups to walk over the Lochshore slag landscape at pre-arranged times, and this meant I could not conduct archaeological fieldwork in the way I had initially been trained. The methods listed represent sporadic, opportunistic attempts to gather data through repeated site visits, as I tried to explore the slag that lay in plain sight, rather than by uncovering new ground. It was only once I reviewed the results of this work that I realised interdisciplinary confluences had emerged from it, through the impressions and relations that built up in the spaces I visited. The final empirical chapter appears to employ two different kinds of method— quantitative scientific analysis and qualitative interviews— yet these activities proceeded in the field quite independently of each other. In truth, I was not entirely sure if I could use the interviews I conducted in my thesis, as the participants had relatively little to say about slag, although by contrast, much to share on their aspirations for the Lochshore's regeneration. Simultaneously, I was wary of producing scientific results which might prescribe a Lochshore slag future divorced from its historical and social context. It was only as I analysed their respective results that I realised these methods could be put in productive conversation with each other, though a thought exercise investigating how future imaginaries for a place might holistically be generated.

In 2018, Angela Last interviewed Nina Lykke, Emerita Professor at Linköping University, about her long career in conducting interdisciplinary research. During their conversation, Lykke reflects on the relationship between interdisciplinarity and research methods, stating "I have learnt to respect the way in which you really need to think in-depth about the analytical strategies and thinking technologies you mobilise when you grapple with your material" (Last and Lykke, 2018:232). As I grappled with the material I had generated through my research, I initially struggled with how I might use it to address the problems which had emerged during my field work. As I variously encountered archival destruction, prohibitive site access

restrictions, or even slag's near total absence in the thoughts of those I spoke to, I found that using perspectives from only one discipline made it difficult to realise accounts of the Glengarnock slag's past, present and potential future legacies. Yet by analysing and synthesising different strands of data and disciplinary thought, I was able to write my way through these problems, to find my interdisciplinary practice in the stories of slag that emerged. Dawney (2018:110) also finds a measure of reciprocity between interdisciplinarity and projects where a particular object is positioned at the centre of the research undertaken. She argues that it makes sense to read "... different disciplinary approaches against each other" both to expose our own role in "... the ongoing production of knowledge making that produces particular phenomena as objects" and to "make visible" material trajectories that have been neglected or "forgotten." Buller (2009:396) concurs with this position, noting that as particular objects are 'redefined' and 'recontextualised' when they meet the boundaries of different disciplines, the manner in which their meanings transform can be explored through, and simultaneously foster, "interdisciplinary articulation."

This section has reflected upon the strange position of the interdisciplinary PhD student, who must generate communality amongst disciplines by means of a research project that is designed to be primarily conducted individually. I have related how I eventually found these confluences in thought amongst the inter-application of my research methods, as I reoccupied my field by writing its story. I have moved from a starting position of simply understanding interdisciplinarity as a condition of my research funding to appreciate its essentiality fully in and through the context of my work. Reflecting on its meaning now, I find myself agreeing with Buller's (2009) description of the labour required to integrate disciplinary perspectives, as "... a creative and iterative process, that is by nature explorative rather than definitive." Interdisciplinarity emerged for me as my capability to move into and then between different disciplines proceeded at its own pace, and as I attended to the small scale, real world problems presented by my own field of research. It thus became a practice situated firmly within my own positionality, and a mode of working that allowed me to receive and articulate some of the stories of Glengarnock's slag.

6. Conclusion

This chapter has served two main purposes. Firstly, it has traced the dynamics behind the development of the research approach taken in this thesis. I began by exploring the ‘period of proximity’ that I inhabited as I anticipated how I might come to occupy my field, tracking how events in my recent life course shaped the questions I asked of myself as I entered my research process. I next recounted how the actuality of moving into my fieldwork itself threw up a number of complexities, stemming both from the aftermaths of the Covid-19 pandemic, and from the narrow nature of the conversations that could be held around Glengarnock’s slag. After a brief treatment of the potential ethical risks posed by desperation in fieldwork, I circled back to review contributions to the methodological literature from PhD students whose work had been affected by the global lockdowns. Picking up on the particular notion of ‘humbleness’ in research praxis, I then narrated how I undertook to re-centre my own research around slag, framing this experience through the concept of ‘care.’ By acknowledging that caring affords only a limited scope of attention, I reified the inheritance of this project’s research object and context as an active choice, newly alert to the sacrifices this specific focus would entail in my work. Drawing particularly from the contributions of Maria Puig de la Bellacasa, I then relayed how this process changed the nature of my aspirations for my research project, as I learnt to work with what Glengarnock’s slag offered up, rather than what I hoped to impose upon it. I then traced one of these new aspirations forwards, as I moved on to reflect upon how I could locate instances of disciplinary communality through the interdisciplinary nature of my work. Concentrating on the emergence of research projects funded specifically for their interdisciplinarity in the context of UK higher education geography departments, I surveyed both how calls for introspection around the ‘doing’ of these projects emerged, and how these calls refracted through the specific contributions made by PhD students, who, due to the nature of their particular degree requirements, conduct this work largely individually. Following their example, I then reflected upon my own interdisciplinary practice, contemplating both the difficult and rewarding nature of the recursive movements between disciplinarity and interdisciplinarity that it entailed. I finally outlined how my process of ‘becoming interdisciplinary’ was largely realised as I wrote my way through the real world problems presented by my research field – problems that I came to appreciate would have been far more challenging to tackle by using a single discipline approach.

This last point highlights the second purpose of this chapter, which is to lay the foundations for this thesis's empirical chapters to come. As discussed previously, it is clear that this chapter has followed a slightly unusual format compared to traditional methodologies, in that it does not feature detailed descriptions of the research methods I used during my fieldwork. Here however, I have established that the process of finding communality between geography, geology and archaeology was integral to the generation of my results. In what follows then, I will present each of my empirical chapters by firstly stating my particular intentions for the chapter, and then by outlining how I employed interdisciplinarity to counter the various problems I have introduced in this chapter. I will then proceed to relay the results generated by this coming together of self, site, slag and disciplinary subject areas.

Chapter 4: Past Accumulations

1. Introduction

During my early visits to Glengarnock's slag landscape, I spent time thinking about what this material meant to me, and why. My initial knowledge of slag was rooted in my high school education, and studying in a Scottish secondary school in the late 2010s, our lessons on western European industrial geographies focused upon the major story of the preceding decades – that of deindustrialisation, and its associated environmental, social and economic impacts upon post-industrial places. Slag was introduced as a material signifier of each of these categories of consequence. Environmentally, it was often hazardous, dumped in unstable heaps which required landscaping. Socially, the presence of these heaps became symbolic of the industrial decline of an area – and in economic terms, the potency of this material allegory often discouraged future investment. From our contemporary perspective, slag was clearly represented as a problem, and one which came to a head once the industry that had produced it was in more or less unassailable decline. From a historical perspective, this failure reverberated through how narratives of the past were framed. Whilst we were taught about the early 1800s rise of western European heavy industry, this context was then immediately bookended by the late twentieth century failure of those endeavours. All other dates encountered were offered as events, or lack thereof, which contributed to this eventual deterioration.

These particular histories and geographies then, were my introduction to slag, and it was these understandings which refracted through my early attempts to make sense of this material. Of course, the way I knew slag represented just one of its stories, seen through a particular set of spatialities and temporalities. Archaeologists Chris Gosden and Yvonne Marshall (1999:169) describe the emergence of a late 20th century realisation— in both archaeology and the social sciences more generally— that “... objects do not just provide a stage setting to human action; they are integral to it.” As human and object histories became recognised as fundamentally entangled, and indeed, co-constitutive, the view that “... people and objects gather time, movement and change, they are constantly transformed, and these transformations of person and object are tied up together” in turn became progressively more appreciated. In other words then, we engage in meaning making practices with objects as a

matter of routine – but the everyday nature of this action belies how our relationships with the objects we perceive changes over time. Considering the “accumulated histories” (ibid:170) gathered by a particular object can therefore allow a researcher to tease out the context behind a certain set of object-centric meaning making processes. Writing along similar lines, Hodder (2012:6) observes “... we forget that [things] have temporalities different from ours, until those temporalities intrude in on us, causing us to take action.” When I reflected upon what slag meant to me, Hodder’s words rang true. I could appreciate the context within which I had received my understandings of this material, but when I tried to situate myself within the longer temporalities of Glengarnock’s slag, the partiality of the story I knew became clear. By situating myself within slag’s accumulated history— as a 21st century student, from one of a number of regions still coming to terms with the loss of their heavy industries— I realised that I knew very little about how others had personally known this material, within the particularities of a local context.

In this chapter then, I wish to ‘take action’ as Hodder suggests, to explore how changing the spatial and temporal parameters of the Glengarnock slag’s story will allow me to change the particular histories I have inherited. Turning away from my already established perceptions of slag as representative of end-of-the-line decline and dereliction, and to counter this conception of finality, I will turn to the archival record, to instead focus upon the temporalities that lie on either side of this supposed conclusion, opening up new senses of what the Glengarnock slag was, both when the steelworks was in operation, but also through the modes of commemoration and endurance that emerged in the wake of its closure. In short, I wish to survey the “histories and genealogies that become lost as objects were being made into objects” (Dawney, 2018:110). By chronicling my attempt to receive new legacies of the steel slag at Glengarnock, this chapter will explore how the act of piecing together this particular material’s archive allowed me to rethink an object story I thought I knew afresh. I will next turn to review the various archival sources I use in this chapter, and simultaneously discuss the ongoing difficulties that the Covid-19 pandemic presented in terms of accessing archival spaces. The chapter will then explore how the synthesis of perspectives from historical geography and archaeology, and those inspired by geology, were employed to put these very different archives in conversation with each other. Finally, I will trace the transmission of Glengarnock’s slag legacies through and between each archive. By surveying how this object’s materialities and meanings transform through the eyes of each beholder I

consider here, I will draw out a history of successive inheritances, to craft one story of the entanglements between humans and the Anthropocene geomaterials we have created.

2. Finding an archive in the aftermath of a pandemic

My question of where in the Glengarnock slag's historical timeline *should* I begin was however rather rapidly superseded by a more practical consideration – where in the historical record *could* I begin? The pragmatic nature of this latter quandary was informed by the impact of the Covid-19 pandemic on my ability to access archival spaces. My initial efforts to locate archival sources were halted completely by the second extended Covid-19 lockdown, which (as previously described) came into effect in December 2020, two months after I started my PhD. I resumed my search in June 2021, in the aftermath of lockdown conditions. Whilst the restrictions which had limited the movement of people between local authority areas were gradually being lifted, the reopening of local authority libraries was at this stage still some way in the future. Covid restrictions were also still very much a feature of the higher education library landscape at this time, as access to physical archive records was assiduously geographically bounded — SCONUL access to the libraries of other institutions was suspended, as was the inter-library loans service.⁸ Having no access to primary sources directly related to the Glengarnock Steelworks, I therefore decided that I would have to widen my focus. This broadening of search parameters contrasted with the relative narrowness of what was available to me, as I had access only to the University of Glasgow library to locate possible resources. All of this meant that I had to hope that my own institution's library retained some kind of historical material of relevance to the Scottish steel industry. Luckily, its holdings included the entire catalogue of the *Journal of the West of Scotland Iron and Steel Institute*.

⁸ I had also been conducting online searches for archival materials prior to June 2021. Unfortunately, these searches were not particularly fruitful. There was little to be found relating to the Glengarnock Steelworks, although both the Grace's Guide ([Glengarnock Iron and Steel Co - Graces Guide](#)) and Scottish Steelworks History ([Glengarnock | Clydebridge \(cfindlay17.wixsite.com\)](#)) websites yielded useful general timelines of the Glengarnock work's history. Broader web searches on the history of the Scottish steel industry did deliver more results, but these lacked the required content on slag. Meanwhile, whilst some technical historical sources could be found in a digitised format online, I found that I required material written from a more contemporary perspective to make sense of what was discussed therein. These latter materials, which took the format of mid to late 20th century guides to steelmaking practice, were however much more rarely digitised, and so not generally accessible online. SCONUL access to the libraries of other institutions was not reinstated following the pandemic until the Spring of 2022, so it was only then that I could access the physical copies of these texts from the University of Strathclyde library.

2.1 *The Journal of the West of Scotland Iron and Steel Institute*

The *Journal of the West of Scotland Iron and Steel Institute* (hereafter referred to as the JWSISI) was the main publication produced by the West of Scotland Iron and Steel Institute (hereafter referred to as the WSISI). The WSISI was founded in 1892, and operated until 1974, when, in a bid to diversify, it merged with the Scottish local section of the Institute of Metals to form the Scottish Association for Metals, a society which exists to this day. In the intervening eighty-one years, the WSISI held regular meetings in various locations around Glasgow, and the JWSISI was produced to record the outputs of these gatherings. The Scottish Association of Metals, which includes a detailed history of the WSISI on its website, notes that each of these meetings featured the reading and discussion of technical papers, and that this “procedure... survived relatively unchanged until the demise of the Institute” (Scottish Association for Metals, 2024). The range of topics covered by these papers is considerable, as the WSISI drew its membership from a highly varied set of professional identities, and from a relatively expansive geographical area, stretching from Ayrshire in the south, northwards through the central belt, and on into Stirlingshire. Those in attendance at WSISI meetings included “owners, works managers, chemists, rollers, plate shearers... a cashier and a Professor of Metallurgy”, not to mention the representatives of companies ancillary to the iron and steel industry, such as colliers and brick manufacturers (ibid). This breadth of expertise was deliberately sought by the Institute’s founders. At the WSISI’s first meeting in 1892, inaugural president James Riley instructed that the institute’s diverse membership should pursue the advancement of knowledge predicated on the sharing of, and critical engagement with different experiences. This meeting of minds would thus constitute a highly efficient means to generate best practice solutions to technological problems (Riley, 1892).

The JWSISI comprises eighty-one volumes, and with such an abundance of material, I needed to find a way to narrow my search. Accordingly, I systematically went through each volume, noting the details of any papers or paper discussions in which slag was of particular relevance or focus. The result was a spreadsheet database of one hundred and sixty-six entries. After discovering that an early paper (on the chemical analysis of slag samples) was authored by chemists employed by the Glengarnock Steelworks (MacFarlane and Caldwell, 1892), I realised I could also use the JWSISI records to glean mentions of Glengarnock itself, by those who worked there. I therefore next went through each of my one hundred and sixty-

six slag-related papers, earmarking those in which Glengarnock appeared. Baker (1997:240) advises "... given a phenomenon chosen for study, it can sometimes be instructive to plot... its occurrence through time and space; in this way the basic pattern of its historical geography can be revealed." He continues "... [this] might suggest which particular periods or places would repay more detailed treatment." By pre-determining the place that I wished to subject to 'more detailed treatment' (Glengarnock), and applying this to my catalogued slag-related papers, the contributions of a particular institute member emerged as most prolific. Between 1895 and 1916, the Glengarnock works manager, a Mr Edgar Josiah Windsor Richards, figured in seven issues of the JWSISI. His presence in the pages of the journal stretches from the early years of his managership to those after his retirement, with his final reflections appearing less than a decade before his death in 1924. Richards generally made his contributions during discussions on other member's papers, and he positioned himself therein as an initially idiosyncratic, yet continuously experimental manager of the slag science practiced at his works. Situated in the crosshairs of the place and object based parameters I had necessarily applied to the abundance of the JWSISI collection, the fragments of Richards' presence in this journal's many volumes would allow me to trace an insight into how Glengarnock's slag was known during the steelwork's early operational years.

McGeachan (2018:143) however advises her fellow historical geographers "questions over whose life matters, and therefore whose life should be written about and remembered, are more pertinent than ever before in the sub-field." These questions refract through my choice to write about Edgar Richards, and the imperfect manner in which my use of the JWSISI captures the voices of those who worked at Glengarnock. The nature of the JWSISI records meant that I was only able to establish if an individual worked at Glengarnock if they specifically mentioned this fact. The filtering process I describe above— where the frequency with which a WSISI member speaks is the main metric used to determine their prioritisation in my thesis— has thus elevated the individual whose voice has, in effect, resounded most loudly through this archive. In comparison to the many other silent Glengarnock attendees of the WSISI meetings, Richards was in a position of significant financial and social power, occupying a top role in the steelworks management hierarchy. It is perhaps not surprising that his perspective dominates the Glengarnock contributions. I wish to emphasise here therefore that by foregrounding Richards' voice, I am by no means trying to tell a representative story – indeed, the perspective presented can be nothing more than avowedly partial. Instead, I wish to stress that this is just *one* story of a relationship between the Glengarnock Steelworks, its

slag and an individual, whose voice has emerged from the archive in no small part due to pre-existing privilege.

2.2 Conservation and Cultural Retrieval: The Glengarnock Steelworks Conservation Project and Dr Lorna J. Waite's PhD Project

I next turned to locate sources which would enable me to elicit insights into how Glengarnock's slag was known *beyond* the closure of the steelworks, through experiences of commemoration and endurance generated in the wake of its shutdown. Yet the stories of the archives I found intersected in unexpected ways. In this PhD project's very early stages (indeed, as part of my preparation for my studentship interview), I discovered a book in Glasgow University's library with a somewhat lengthy title: '*Glengarnock: A Scottish Open Hearth Steelworks: The Works- The People (A Report on the Manpower Services Commission Conservation Projects carried out at Glengarnock, Ayrshire, 1979-1980)*.' This text (hereafter referred to for brevity as the Manpower Report) published in 1981 and edited by Derek Charman, detailed the combined efforts of a group of researchers (including previously out of work members of the local community, who were trained and employed as part of the project's intended benefits), to capture the already disappearing culture of a Glengarnock with, rather than without a steelworks. Their ambitions gave rise to a suite of four individual projects, collectively referred to as the Glengarnock Steelworks Conservation Project. This endeavour consisted of:

- 1). An Oral History Project – to interview former steelworkers and Glengarnock residents.
- 2). An Archive and Records Project – to gather and organise the remaining documentary records of the steelworks, which encompassed material from the 1840s to the late 1970s.
- 3). An Archaeology Project – revolving around efforts to excavate the area where the ironworks blast furnaces were once situated.
- 4). A Plant Conservation Project – to dismantle, store, and restore plant and equipment from the steelworks “worthy of permanent preservation on historic grounds” (ibid:11).

Although the archaeology and plant conservation projects presented potentially interesting avenues for me to further investigate, these opportunities were not in fact workable. The archaeological excavation had been covered up following the project's completion, and soon after, a road had been built over the excavation site. Meanwhile the plant conservation project

appeared to have been largely unsuccessful, due to the project team failing to locate cultural institutions which had the space or finances to accommodate heavy plant and equipment. My focus therefore turned to the materials gathered and generated by the archive and oral history projects. Initially, I believed that these sources would prove invaluable in assisting me to build up my own archive of records relating to Glengarnock's slag. The Manpower Report included an appendix itemising the documents gathered by the archive project in particular, and many, including works manager records, notes on the furnace plant, and weekly output statistics, looked especially promising in this regard. I therefore determined that locating the archival records detailed in the Manpower Report should be my first step. Although the Manpower Report specified that these materials had been sent to the British Steel Records Centre at Tollcross, Glasgow, to be preserved for future researchers, after some investigation, it quickly became clear that this facility no longer existed, as a result of British Steel's dissolution in 1999.⁹ Further research online allowed me to trace the subsequent route that the Glengarnock records had taken, as I learnt that they had been sent to a private records management company in Shotton, Wales. Undeterred by the fact that the contact details on the company's webpage seemed to be more firmly aimed as potential clients, rather than prospective researchers, I prepared to compose a message to request a visit. However, unbeknownst to me, someone else had already followed this path.

I first came across Dr Lorna J. Waite entirely serendipitously, as I was browsing social media in early October 2020. Her name appeared in relation to an online conference, run by the Scottish Transport and Industry Collections Knowledge (STICK) network, where she would

⁹ The Glengarnock Steelworks Conservation Project had a somewhat vexed relationship with the British Steel Corporation (BSC). As Charman (1981) recalls, the BSC's 1973 conservation policy gave impetus to efforts to locate and preserve historical objects (including large plant, such as furnaces) still present in its steelworks. As it became clear in the late 1970s that the closure of several works was imminent, a catalogue of objects requiring the attention of conservators was produced for the BSC's Scottish sites. Yet the potential scale of the historical collections produced could not be accommodated by an existing museum facility. A number of interested parties (including those involved in the Glengarnock Steelworks Conservation Project) thus proposed that a new 'National Museum of Steel' be sited at the former Glengarnock works. Although initially in favour of a plant conservation strategy, the BSC leadership subsequently chose to abandon the implementation of their monetary support for their conservation policy, in favour of selling on former operational sites as financial assets. News of the failure of the Glengarnock Steel Museum circulated internationally amongst industrial archaeologists. At the International Committee for the Conservation of Industrial Heritage's 1981 conference, Alex den Ouden argued that the collapse of the Glengarnock Museum proposal held important lessons. Rather than focussing on the preservation of industrial plant, he concluded "what can – and should be done then is a different job. Complete documentation is required, so that the essentials of the now redundant steel making process are preserved – even if not in physical form" (ibid:99). It is a fact of great irony that this recommendation arose out of the ashes of the Glengarnock Museum proposal, as several decades later, this international resolution to refocus archaeological conservation efforts on industrial documentation could not prevent this very loss occurring to Glengarnock's surviving written records.

be delivering a presentation on the Glengarnock Steelworks, entitled ‘Cultural Retrieval, Land Use, and Post-Industrial Folk Memory’. Intrigued, I attended the conference, and was immediately struck by the evocative story that Lorna’s¹⁰ presentation told. A local of Kilbirnie (the town that adjoins Glengarnock – indeed, the two settlements are essentially conglomerated), with several friends, family members and ancestors employed in the steelworks, Lorna knew the Glengarnock landscape both before and after the steelworks had been removed from it. She recalled the closure of the Works as a collective trauma for the local community, and yet she also observed instances of collective forgetting or even self-erasure. Influenced by the work of indigenous scholars on traditional knowledges generated by young people to retrieve their own threatened histories, she started a PhD, to search for an archive which held “her history” (Waite, 2020). As her presentation proceeded, it became clear that Lorna had already travelled along the route that I was preparing to embark upon. She introduced the Manpower Report, the archival records it collated, and her own journey to the very storage facility in Wales that I was planning to visit. She then revealed that— after a lengthy process to gain access— she was informed upon her arrival that the materials she (and I) sought had been destroyed. Insensitive to her distress at hearing this news, her host reassured her “not to worry, because the records had been recycled... [and] turned into kitchen towel or toilet paper” (ibid).

As I sat digesting this unexpected turn of events, the irony was not lost on me that a key archive I had hoped to access to inform my research on a particular kind of waste product had instead itself met this fate. Lorna’s reaction to this dual destruction— of the Glengarnock Steelworks and much of its documented history— was to pursue a research project which harnessed her own creative practices to both highlight and refute this erasure, as she turned to her own experiences, memories, and networks to create a new steelworks archive. This work included the composition of a collection of poetry and a children’s novel, to symbolically represent her experiences to a wider audience. Considering my own research, I wondered if I could look to Lorna’s creative output as an alternative archive, intended as it was to complement that which had been lost. However I was unsure— and indeed, slightly doubtful— if slag would feature at all therein.

¹⁰ I will refer to Dr Lorna J. Waite as ‘Lorna’ throughout this thesis, as this is how I came to know her – alternative naming choices (such as Dr Waite, or Waite) thus feel either too formal or impersonal. During the STICK conference, I made contact with Lorna through the ‘chat box’ function, introducing myself and my project. The immediate warmth and enthusiasm with which Lorna received me was palpable, and her expressed support of my work has been a great source of personal motivation.

Yet it transpired that Glengarnock's slag did in fact form part of Lorna's steelworks archive. When I ordered a copy of her poetry book *The Steel Garden* (Waite, 2011b) in December 2020, I found that her verses contained multiple references to this waste material. Keen to learn more, I attempted to next access Lorna's thesis, but it was not digitised, and as national lockdown conditions were suddenly reimposed, it was to be almost a year (November 2021) before I was able to receive a copy, digitised by the British Library e-thesis service at my request. After reading, I was further convinced of the role slag played in informing Lorna's creative practices. In her thesis, Lorna recounts how, when walking through the former steelworks site, she did not recognise Glengarnock's slag for what it was, until it was pointed out to her one day by a companion. Once encountered however, she became "enchanted" by that first fragment of slag, despite its ubiquity in her surroundings. Her memory of the "beautiful object made from waste" (Waite, 2011a:132-133) in part inspired the crafting of her poetry. By elevating the mundane through a particular mode of artistic attention, she applied "... the literary imagination to the most humble of cultural products, seeing a form of the interior in the form of the exterior held object" (ibid:123). There is thus a strong autobiographical element in Lorna's creative works – this is an archive that is, in effect, telling its own story. It is also an archive that tells many stories – encompassing a myriad of objects, places, photographs, documents, languages, mythologies and relationships that became interwoven through her work. Using the Gaelic phrase 'dhealbh i a h-eachdraidh' or 'she wove her history' to describe her central methodology, Lorna employs the format of an inventory to detail how she intertwined each of these individual strands into the tapestry of her past, illuminating the story of her place, her community, the industry that connected them, and the research project through which she sought to give voice to them. Slag is just one element of this repository, and I used it to draw out a particular interpretation of the meaning that I found in Lorna's work. To do this, I turned specifically to an early version of her poetry collection *The Steel Garden*, which was featured in an appendix to Lorna's thesis, and included a number of additional poems.¹¹ I went through these sixty-four poems, and selected any which made direct reference to slag; indirect reference to this material through the theme of waste, or which provided key insights into Lorna's research process. I went on to reflect

¹¹ I have chosen to focus upon Lorna's poetry only, as the additional inclusion of her children's novel would have presented too much material for this chapter to accommodate. Her novel *Frances and the Blasties* is a work of great depth, and although it features a character named Slag, he exists in relation to a large cast. I found that in attempting to draw out his role, I had to strike a difficult balance between exposition and analysis in my writing, and I ended up feeling that I was doing justice to neither in the space afforded.

upon my personal response to twenty chosen pieces, my interpretations of these poems identifying points of commonality and conversation between them and the story of Lorna's archive. I then made my final selection of poems to feature in this chapter, which would best allow me to present my own narrative capturing Lorna's evolving understandings of Glengarnock's slag.

The final archive I accessed was the collection of oral histories generated by the Glengarnock Steelworks Conservation Project. This final remnant of the project's original efforts was held by the North Ayrshire Local History Collections, which reopened to researchers— following a lengthy pandemic induced closure— in August 2022. Thanks to the help of the archivist, I quickly gained access to view the thirty-one oral history transcripts. Here however, I found my exclusive focus on slag to be incompatible with the methodology underlying these sources. In the Manpower Report, Charman (1981) notes that those conducting the oral history project interviews received training from the School of Scottish Studies – a scholarly department which initially promoted the recovery of fading traditional knowledges from rural Gaelic and Doric communities (MacDonald, 2011:309), but which later applied these “salvage” techniques within deindustrialising contexts too. In practice, this meant that the oral history interviews were employed as an attempt to document and thus preserve a way of life – which centred upon, but was certainly not limited to the steelworks itself. For this reason, many of those interviewed had no direct connection to the steelworks, but were instead recorded to share experiences of living in Glengarnock, or working in other local industries. Meanwhile, interviews that did feature former steelworkers featured many questions that extended beyond the confines of their place of employment, including queries on for example, a participant's school days, or experiences of public holidays. When it came to transcripts that contained references to slag, the volume of relevant material was therefore significantly reduced to very partial extracts from just five interviews. I felt it was important however to include these histories in my attempt to transform my own understanding of slag. The voices therein featured those who, from either personal experience or firsthand retellings, knew something of what it was like to live and work with the slag that the operational steelworks produced on a day to day basis. Despite their relatively sparse nature, these accounts would therefore further nuance my sense of what a worker's relationship with Glengarnock's slag had entailed.

3. *'Making do' with entangled biographies in Anthropocene times*

My efforts to locate archive repositories that related to both Glengarnock and its slag had gradually introduced me to three very different kinds of source material. Historical-cultural geographers have engaged with scientific and technical sources (see for example Livingstone, 1995; Naylor, 2005; Finnegan, 2008) oral histories (see for example Andrews et al, 2006; Powell, 2008; Hampton, 2022) and literary sources (see for example Cresswell, 2014; Madge, 2014; McDonagh et al, 2023), yet although work in all of these areas have explored the ways in which people, place and knowledge mutually co-shape each other, very different voices are engaged with to do this. I was thus more interested in the question of how to manage my collections in relation to each other. Recent reviews of historical geography methodologies (Lorimer, 2010; Mills, 2013), document a distinct movement in thinking within the sub-discipline on the nature of archives. Initially conceived of as a problem to be overcome (see for example Darby, 1960:155 in Baker, 1997:239), the inevitable partiality of the archive is now generally expected and accepted, and the ways in which these repositories have been variously made, managed, and encountered by the researcher have therefore been brought into sharper relief (see for example Steedman, 2001; Bailey et al, 2009; Moore, 2010; Ashmore et al, 2012; McGeachan, 2018). In this context, Lorimer's (2010:258) depiction of a 'make do method' captures the practice of building up a collaged narrative from a variety of historical materials. This work requires the careful negotiation of archival diversity, but a make do archive gains its strength from both the juxtaposition of these different sources (often coalescing around a particular object of study in a particular geographical context) and the openness of the researcher in tracing their crafting process. Yet Lorimer also admits that "methodologically, what this all actually amounts to can be hellish hard to determine..." (ibid). I decided to find direction in Lorimer's evocation of poet Kathleen Jamie's practice. Through "happily shedding trained sorts of conservatism" as required, Jamie instead looks for outcroppings of "affinities" to draw together in her work (ibid). By partially shedding my disciplinary identity, to search out affinities between historical geography, and perspectives from or inspired by archaeology and geology, I was able to determine a path forward in terms of how my make do archive might explore the entanglements between the lives of its subjects and the slag they knew.

This chapter has already used one concept derived from archaeology to consider the ways in which an object can ‘accumulate histories’ as it persists, and thus enter into new relationships through time. Indeed, the method of writing biographically about objects has become popular in this discipline, since the idea was first proposed in 1986 by Igor Kopytoff (Joy, 2009). Burström (2014) notes that the attractiveness of an object biography approach is partly derived from the fact that it can be applied to a broad spectrum of entities. It also holds the potential to produce “fuller and richer accounts” as layered chronologies can be constructed, based on the consideration of an object’s multifarious life stages.¹² At the same time, an appreciation of objects as enrolled within broader networks of relations, allows for both ‘big’ and ‘small’ histories to be told about them (ibid:68).¹³ However, in spite of, or perhaps in part due to the traction gained by this approach, a wariness of potential inertia has more recently emerged. This caution, Burström suggests, is borne out of the recognition that object biographies show a tendency in practice to overfocus upon the task of collecting and presenting evermore facets of data about the entity under consideration. This instinct may have its roots in an elementary ambition of archaeological praxis – “to retrieve as much as possible”(ibid:69). Yet this goal, of achieving comprehensiveness through accumulation, is an objective that Burström argues requires reinvigoration. Historical geographers have also recognised drawbacks in striving for biographical fullness. McGeachan (2018:137) observes a recent re-engagement with the topic of writing the biographies of peoples past in the sub-discipline, as discussions have revolved around “the difficulties of creating biographical portraits from fragments and shards.” She notes that, in the face of such challenges, historical geographers can often feel uncomfortable about undertaking biographical writing – this reluctance due in part to a perceived inflexibility in form. Hodder (2017:453) concurs, noting that biographical approaches are often understood to involve a strict adherence to the

¹² Some have criticised the object biography approach for not being clear enough about the extent to which it endows things with agency, despite claiming to trace their various ‘lives’ (see for example Gosden and Knowles, 2001 and Steiner, 2001, in Patchett, 2010). To avoid this same critique, I will reiterate my own approach to the Glengarnock slag’s agency (as developed in Chapter 3) by specifying how it is applied in this chapter. Here, I will recognise this material’s agency by paying attention to its capacity, in both its use and after lives, to confound the expectations of the voices captured in my archives. At the same time, I will consider how these archival individuals demonstrated their own capacity to enrol these surprising materialities into their evolving understandings of what slag was, and what it could do.

¹³ This differs from another popular archaeological method, called the *chaîne opératoire*. This approach is used to trace a linear tale of the technical processes behind an object’s production and maintenance. Meanwhile, object biographies are “... characterised by a different flow: permanence, returns and abandonments” Porqueddu et al (2023:2). Porqueddu et al therefore argue that despite frequent attempts to conflate the two approaches, generally the *chaîne opératoire* works within human timescales, whereas object biographies can transcend the lives of individuals. These methods can thus complement each other, but do not operate through matching temporalities.

treatment of an individual's life experiences as a "text", composed through an intense concentration on the subject under the biographical gaze, and facilitated by a thorough gathering of corresponding details. Both Hodder and Burström suggest that working with biography can forego this need for completeness. They argue that the intersecting lives of people and objects can instead tell us something about the wider worlds they co-occupied and co-constituted. Echoes of this idea can be found in Edensor's (2022:32) invitation for us to explore new knowledges that could be produced about the emergence and experience of the Anthropocene through human-lithic entanglement, in the "tales that wait to be told" about anthropogenic materials. He demonstrates how thinking with geological concepts can also allow the stories we tell to traverse macro and micro scales. An exploration of our place in deep time can be accompanied by exploring our relationships with the specific materialities of the new geologies that we have produced, as we continuously re-negotiate our sense of self in relation to the landscapes that we have created, whose lives we can only ever partly know. Anthropogenic rocks are always becoming, yet they also have traceable histories, and these dynamic genealogies shape "the emergent places we inhabit" (ibid, 2020:26). Paton and DeSilvey (2016) explore similar themes in their consideration of 'recombinant geologies' arguing that enfolding an appreciation of the geological into our accounts of human-object inter-relations can reveal the fact that things can have lifetimes that far exceed our own. Capturing this dynamic through the respective processes of 'making' and 'growing' they describe how we can enrol meaning in a crafted object by working with its materiality. The everyday process of making is thus accompanied by our preoccupations with larger, more existential struggles – for instance, as the relative robustness of a granite headstone becomes entangled with our desires to extend the longevity of memory. Yet with time, these made objects 'grow' to enter new human and nonhuman relations, and by exceeding the original meanings impressed upon them, can become enrolled in new ones.

In the remainder of this chapter then, my make do archive will be used to explore a "composite biography" (Brophy and Edensor, 2023:81) of the Glengarnock slag. Informed by Edensor's (2020) employment of the new materialist idea that objects are always materially becoming through their varied relationships with humans, I will trace the various physical forms that this slag was caused to assume, yet also survey how the voices featured in my archives variously negotiated or transformed their own understandings of these materialities. Edensor (2020:23) also uses the concept of 'affordance' (from Gibson, 1979) in his work, defining this as an object's ability to "... stimulate different actions inspired by the

possibilities that seem to be inherent within it.” I will similarly track how the witnessing of different slag materialities by each of my archival subjects influenced the extent to which they could harness the ‘affordances’ offered up by the Glengarnock slag, to envision and realise imagined futures. Finally, I will survey the interface between ‘making’ and ‘growing’ slag meanings through time, as the voices extracted from my archives variously inherit, grapple with, alter and pass on these legacies. By mapping how these remnants pass through and between each tale I tell, I will explore how they became enrolled in the formation of wider realities and relations, to compose a fragmentary narrative of Anthropocene modes of being, in and of a particular anthropogenic landscape.

4. Edgar J. Windsor Richards: Slag Inheritor and Future Shaper

4.1 Legacies received: Bessemer

In 1843 the Glengarnock Iron Company was founded, operating for several decades using local seams of ironstone to manufacture its products. By the 1880s however, these local ore supplies had become depleted, and the company owners—a local family called Cunningham—decided that the production of steel was a viable route forward.¹⁴ To this end, they installed four steel making furnaces in 1884, which were in operation by the following summer. Glengarnock therefore became an early example of an integrated plant, where the iron required for steel production was generated by the company’s own blast furnaces. By contrast elsewhere in Scotland, it was common for iron to be bought in from external suppliers (Payne, 1979). The integration of Glengarnock’s iron and steel making processes was the first step in drawing together a constellation of scientists, industrialists, experimental

¹⁴ The Cunninghams were a wealthy local family who owned land across Renfrewshire (a county adjoining North Ayrshire, lying to its north-west). In 1731, they also became owners of land in Jamaica, purchasing the 3500-acre Grandville sugar cane plantation. This sale included the acquisition of nearly 300 slaves. By 1834, the family had profited from over 100 years of ownership, but their possession was finally terminated with the abolition of plantation slavery in 1834. The 14th heir, William Cunningham, was subsequently awarded £3278 in compensation for the loss of 185 slaves (about £200,000 in today’s money). The Cunningham connection with the Glengarnock Ironworks was initiated by Alexander Cunningham, the 16th heir, and continued by his son, John Cunningham, the 17th and final heir. Although it is not clear if funds attained from the Grandville Plantation were channelled directly into the Glengarnock iron or steel works, the Cunninghams were nonetheless a family holding a great deal of inherited wealth and privilege derived from the transatlantic slave trade. This endowment is one which must not be ignored when considering the deeper historical legacies of the slag that the Glengarnock works produced. I am indebted to Robert Hobbs for pointing me towards this information, which was obtained from the Renfrewshire Local History Forum at the following link: [Renfrewshire’s Slave Legacy 3: The Cunninghams of Craigends – Renfrewshire Local History Forum \(rlhf.info\)](http://renfrewshire.org.uk/renfrewshire-slave-legacy-3-the-cunninghams-of-craigends/).

trials and successes, and anthropogenic geochemical materialities, whose influence would echo through Edgar Richards' own slag legacies.

The steel making plant installed at Glengarnock in 1884 featured a type of furnace known as a Bessemer Converter. Its invention, by Henry Bessemer in 1856, constitutes what Carr and Taplin, in their *History of the British Steel Industry* (1962) deem the first revolution in steel metallurgy. The Bessemer Converter was invented in part to encourage steel slag to do its job better. Up until this point, steel manufacture had been very limited, as the means of production available were very time consuming (Barraclough, 1990). Iron manufacture was therefore far more ubiquitous, but an eagerness for new processes to produce larger quantities of steel was derived from recognised deficiencies in the iron making process itself (ibid). Early iron smelting furnaces used a draught of cold air to encourage the burning of charcoal. This carbon source was used to reduce iron ore to produce metallic iron. As the ore was also composed of other chemicals, and as the purpose of this exercise was to gain iron that was as pure as possible, these additional chemicals were dubbed 'impurities.' If the temperature was high enough, these impurities could be encouraged to form into a distinct, composite mass of slag, which could at least be partly removed from the furnace separately from the iron. Inconsistencies in heating often however resulted in an iron 'bloom' – a spongy mass of iron, with the slag entrained within it (Johnson et al, 2006). Later developments in furnace design had led to iron smelting taking place at higher temperatures. The blast furnace, which replaced draughts of cold air with a continuous current of heated air, rendered the contents of the furnace molten, thus separating the metal from its slag (which, with a lower density, floated on top of the liquified metal) and supplying higher yields of pure iron. As better means of heating were advanced through the introduction of coal, more carbon was absorbed into the iron. This held the benefit of reducing the melting point of the metal, so it was more easily rendered molten and thus separate from its slag. The resulting 'pig iron' (so called because the molten iron tapped from the blast furnace was run into lines etched into the ground, said to resemble piglets suckling from a sow) was however also brittle and unworkable. It needed to be remelted and worked further to reduce its carbon content. In so



Figure 4.1- A Bessemer Converter during a ‘Bessemer blow’ at the Glengarnock Steelworks. This photograph is not dated, but would have been taken between 1885 and 1920, when these furnaces were in operation here. Image from [Glengarnock | Clydebridge \(cfindlay17.wixsite.com\)](http://GlengarnockClydebridge.cfindlay17.wixsite.com).

doing, the melting point of the metal was raised, and slag once again became incorporated into the metal. This state of affairs was partially accepted, with the slag either physically removed from the metal through hammering, or in the case of wrought iron, even advertised as beneficial in terms of malleability (Barraclough, 1990; MacFarlane, 1917). There was however an appetite for a low carbon, slag-free metal, and the invention of the Bessemer Converter responded to this desire. By blasting air into a charge of already molten pig iron, and thus remelting it at far higher temperatures than had previously been seen, this material was converted to steel in just 12 minutes. This rapidity gave Bessemer steelmaking the reputation of being rather difficult to control. It was also dramatic, with sparks, fumes and flames of various colours

emitted from the convertor vessel, marking the different stages of the procedure (see **figure 4.1**). The temperatures achieved enabled the carbon level of the molten metal to be reduced, and simultaneously allowed the molten metal and slag to be kept separate. The resulting ‘mild steel’ could be produced in far higher volumes compared to previous steelmaking processes, enabling a move to “... the large-scale production of what is still the world’s most important metal” (Tylecote, 1991:164).¹⁵

¹⁵ It is important to note the Western-centric nature of the brief history sketched here. Highlighting the case of Chinese metallurgy, Fry and Willis (2015) observe that non-Western historical narratives of the iron and steel industry are particularly contingent upon how the historical record is produced, received and used. Until relatively recently, texts detailing Chinese metallurgy had predominantly circulated domestically, yet 20th century work translating these records has revealed that Chinese metal workers developed certain metallurgical technologies far early than their Western counterparts. For instance, the ability to produce temperatures high enough for liquid steel in the furnace is thought to have preceded the West by over 1000 years, and there is intriguing evidence regarding the migration of Chinese metal workers skilled in blasting air into molten pig iron just prior to the invention of the Bessemer process (Needham, 1958, in Fry and Willis, 2015).

The ‘Bessemer blow’ was driven by the exothermic reactions involved in ridding the molten metal of its impurities – and thus in part by slag formation. As each impurity was oxidised by the air blast, the temperature of the vessel increased, maintaining the molten state of its constituents (Barraclough, 1990; Fry and Willis, 2015; MacFarlane, 1917; Sharp, 1966). The high temperatures behind the success of the Bessemer process were thus predicated on slag creation, and simultaneously effected its separation from the steel produced. The celebrations which met this steelmaking solution were however quickly cut short, as slag derived issues almost immediately asserted themselves again. It was soon discovered that the high temperatures at which the Bessemer Converter operated now raised a new problem – that of a particular slag chemical impurity, called phosphorus.

4.2 Legacies received: The Basic Process

When Henry Bessemer announced the invention of his converter in 1856, he did not realise that he had hitherto happened to be using low phosphorus pig iron in his experiments. Low phosphorus iron ore—and the low phosphorus pig iron smelted from it—is relatively rare in Britain and indeed much of the world. As soon as the Bessemer process was employed using the far more common high phosphorus pig iron, the metal produced was rendered unusable. Tylecote (1991:166) describes this as “... a terrific blow” to Henry Bessemer personally, but also to his new mild steelmaking method more generally, as it could only be employed using rarer and thus expensive low phosphorus ores, which had to be imported from abroad. Upon further investigation, it was discovered that high phosphorus raw materials could not be used in the new steelmaking furnaces, as the pioneeringly high temperatures therein caused phosphorus pentoxide held in the slag to become unstable. This compound then reacted with the silica bricks used to line the furnaces, with the result that the phosphorus reverted back into the metal. Phosphorus was already universally known as an “evil element” (Turner, 1900) for its mal-effects in iron and steel, and now it was inhibiting slag from carrying out its desired function. Again however, a potential solution lay within the slag itself. It was recognised that if slag was chemically manipulated, it could be made to react with, and thus capture phosphorus back from the molten metal. Yet there was a further problem with this solution – the modified slag would then chemically attack, and physically destroy, the silica bricks lining the furnace. Furthermore, silica was the only known refractory material able to withstand the high temperatures of the Bessemer Converter. It is little wonder that this catch-22 situation led a chemistry lecturer at the Birbeck Institution, London, to comment in 1870

“the man who eliminated phosphorus in the Bessemer Converter would one day make his fortune” (Carr and Taplin, 1962:98).

The idea of chemically altering slag to enable it to recover phosphorus from molten metal was first suggested in the 1860s, by Dr R.H. Collyer and Professor L. Grüner. Both posited that this could be achieved by introducing the chemically basic (or alkaline) substance calcium oxide (more commonly known as lime) to the slag bulk. These hypotheses had not been tested however, until amateur metallurgist Sidney Thomas, and his cousin, Percy Gilchrist, began (at first secretly, and then with the support of works manager Edward Martin), experimenting with this idea in 1877 at the Blaenavon Steelworks, where Gilchrist was employed as a chemist (Almond, 1979). Proving that the application of lime could indeed achieve the removal of phosphorus, the cousins next turned their attention to the development of a chemically basic furnace refractory lining, which could be used as a basic-slag-withstanding alternative to silica bricks (*ibid*). During an 1878 meeting of the Iron and Steel Institute, Thomas fell into conversation with another attendee. His companion was the manager of the Bolckow, Vaughn & Co works in Middlesbrough— and Edgar J. Windsor Richards’ father— Edward Windsor Richards. Edward Richards subsequently travelled to Blaenavon to view the experiments taking place there, and impressed, he offered Bolckow, Vaughn & Co as a location where this research could be carried on at a larger scale (Almond, 1979). An interview with a J.R. Skinner who “... was a youth in the laboratory at the time” provides an intimate insight into the everyday experiences of Thomas’ work in Middlesbrough. He remembered “... the almost heartbreaking knocks Mr Thomas received with so many failures... [he] was repeatedly upset by these failures, and often came to sit for a cup of tea in a room set aside for his materials. At the same time as drinking tea he would watch the blowing of a Bessemer heat” (*ibid*:188). Edgar J. Windsor Richards, employed at this time as a trainee chemist with Bolckow Vaughn & Co, may well have also occupied this space.¹⁶ In the discussion that followed the delivery of a paper titled ‘Refractories’ at a WSISI meeting in 1916, he reminisced at length about his own experiences witnessing the trial-and-

¹⁶ This information can be found in the 1881 census records (‘Edgar J. Richards’, 1881). At some point in his mid-teens, Edgar became employed at Bolckow Vaughn & Co. serving his apprenticeship under the general managership of his father, and thus enlisting in a multi-generational line of father-son working relations (*Journal of the Iron and Steel Institute, 1924*) – Edward himself had been apprenticed at the Rhymney Iron Company, then under the general management of Edgar’s grandfather and middle-namesake, Josiah Richards (*ibid*:1921). Bolckow Vaughn & Co. was an auspicious place to be serving a traineeship in the works laboratory at this time, as it became the centre of “... sensational experimental advances” in steelmaking chemistry (Almond, 1979).

error work of Thomas and Gilchrist – “... very old friends of his, with whom he worked and helped to perfect their process under the direction of his father” (Richards, 1916:152). “The great point” he continues “was how they were going to overcome the destruction of the convertor lining” (ibid). Eventually, it was found that by binding bricks made of magnesia limestone with hot tar, a furnace lining could be manufactured that would tolerate the chemical effects of basic slag. Once this was discovered, the ‘basic process’ was ready to be witnessed more widely by means of public demonstrations. These took place in the spring of 1879, as first British spectators, then visitors from continental Europe and further afield, travelled to view this method in action (Almond, 1979). Edward Richards recalled “the news of this success spread rapidly far and wide, and Middlesborough was soon besieged by the combined forces of Belgium, France, Prussia, Austria and America” (Richards, 1880, in Burnie, 1891:125-126). Speaking in 1916, his son Edgar Richards “... could well remember... the Germans coming over to Bolckow Vaughan’s to learn the process... they were allowed to go through the works and see the whole business that was going on. They had any amount of phosphoric ore in their country, and they came to Bolckow Vaughan’s to learn the process, and afterwards erected magnificent plants in their country” (Richards, 1916:155). The global predominance of iron ores high in phosphorus meant that the basic process signified “... an important change in the outlook for steelmaking... on a worldwide basis, beginning in 1879” (Almond, 1979:181). Soon, representatives of steel companies were literally racing to secure terms to use the new method (see for example Burnie, 1891:128 for an account of two competing Belgian steel manufacturers, who dashed through the streets of London to locate Thomas and negotiate the necessary permissions).

Despite these successes, it would require a further two or three years for the basic process to be perfected and proven as reliable. Edgar Richards was in no doubt that his father Edward played a key role in this period, stating “... he did not want to boast when he said that the success of the basic process was primarily due to the energy of his father, and this, he thought, was well known to the members acquainted with it” (Richards, 1916:154). Although Richards may be understandably biased, this assessment is borne out by later commentators. Carr and Taplin (1962:101) note that in the face of a myriad of challenges, Edward Richards “never lost heart, and it was largely due to his persistence that success was finally achieved.” Sidney Thomas’ health declined during these years, and he was often forced to travel to warmer climates to ease the effects of his illness. Yet he lived long enough to witness the success of the basic process. Writing to a family member in 1879, he confirmed “Yes, after

some work, we have solved the greatest industrial problem of England” (Burnie, 1891:129). Sidney Thomas died of consumption, aged 35, in 1885. By this time, the steelmaking attentions of father and son Edward and Edgar Richards had turned north, to a steelworks pioneering the basic Bessemer process in Scotland.

4.3 Experimenting in an expanding Glengarnock Steelworks



Figure 4.2- A picture of Edgar Richards, from his time as works manager at Glengarnock (1890-1913). Image from <http://myweb.tiscali.co.uk/steelworks> Image from [Glengarnock | Clydebridge \(cfindlay17.wixsite.com\)](http://Glengarnock|Clydebridge.cfindlay17.wixsite.com).

In 1885, the American Society of Mechanical Engineers received a paper, delivered by a Mr T. Egleston, on his travels around the basic Bessemer plants of Europe. Egleston had visited four British works, including Bolckow Vaughn & Co in Eston, Middlesborough, which he lauded as “... the experimental ones for all England, and the school for all the others...” (Egleston, 1886:35). He also travelled north into Scotland, where he spent time at the newly established Glengarnock Steelworks, which “... was constructed especially for the basic process, having the benefit of the experience gained at Eston...” (ibid). Here we can find evidence of early connections between Bolckow Vaughn & Co and Glengarnock, although it is not clear if the Richards family specifically were the source of the ‘experience’ that Egleston describes. By 1890 however, there is more obvious proof available that both Edward and

Edgar Richards were involved with Glengarnock. In this year, the Glengarnock Iron Company underwent a reorganisation, resulting in the founding of the Glengarnock Iron and Steel Company Ltd. The Articles of Association for the business show that Edward Richards was nominated the first chairman of the board of directors (The Registrar of Companies for Scotland, 1892). His son Edgar had since moved on from his chemist training at Bolckow Vaughn & Co. He travelled internationally, moving rapidly into management positions in the

steel departments of two American works (at the Scranton and Carnegie Steel Companies) before returning to manage the steel department of the Barrow Works in the North of England (*Iron and Steel Institute*, 1924). Now, in 1890, he was appointed general works manager at Glengarnock (see **figure 4.2**). From 1895 onwards, he begins to appear in the *JWSISI*, sharing his experiences of managing Glengarnock. At a formative age, Richards witnessed the utility of experimental practice in altering the chemical composition of slag, so that it worked for, and not against the steelworker. His contributions to the WSISI meetings thus display an enthusiasm for continuing this legacy, rooted as it was in past evidence of success. This inheritance propelled Richards' consequent faith in the application of invention and experiment to an innovative future, even as his particular vision for its realisation was challenged by his peers.

After the revolutions the global steel industry saw in the 1850s to the late 1870s, there followed a period of relative calm. By the 1890s therefore, "... the story is not of any further world-shaking developments, but rather of consolidation..." (Barracough, 1990:262). Bud (2018:44)— borrowing from Koselleck's (2011:10) term "Sattelzeit"— similarly categorises late 19th and early 20th centuries as a kind of "Saddle Time" in British science, where transformative changes led to a popular sense of a new age being breached. Terminology, practices and ideas that were in operation before these changes were not immediately abandoned however, but rather carried over the crossing of this collectively imagined threshold, leading to energetic debate between the adherents to these old ways, and those promoting the adoption of new methods. This dynamic could be seen in the British steel industry, as "there were many and vigorous discussions at the Iron and Steel Institute and other technical and scientific bodies... on the relative merits of... the acid and basic processes" (Carr and Taplin, 1962:155). Proponents of the 'acid' process— including amongst their number most of the Scottish steel industry at this time— adhered to the use of globally scarce low phosphorus raw materials and furnaces lined with silica bricks, and doubted the newly invented 'basic' process, which, as we have seen, enabled the use of high phosphorus materials by chemically altering both slag and furnace lining. Their mistrust lay in what Campion and Longbottom (1912) later recognised as a common but erroneously employed suspicion – that putting 'bad' materials into the furnace automatically led to poor quality materials coming out of it.

It was against this backdrop that Richards began to make his case for basic Bessemer steel to the members of the WSISI. His general *modus operandi* was to wait until the discussion that followed the delivery of a paper to make his comments. The first instance of this approach can be seen in the ‘Discussion on Messrs A.M. Dick and C.S. Padley’s paper on ‘The Chemistry of the Siemens Furnace.’ Richards was the first member recorded as providing his thoughts, and whilst commending the paper on its “instructive” nature, he “was very disappointed that the authors of the paper had confined themselves to the acid process” supposedly as “... basic work is of little moment in Scotland” (Richards, 1896:178). Richards went on to point out that the basic process should not be ignored by the members, as it represented “an important branch nowadays” of the steelmaking industry, but also because Scotland’s own domestic ore supply was high in phosphorus, which the acid process could not utilise. He went further, claiming that the steel produced by the acid process is “... not so good as the basic process” (ibid). This last comment clearly raised some objections amongst fellow WSISI members, as much of the discussion thereafter moved away from Dick and Padley’s paper, and circulated around Richards’ remarks instead. A Mr James. B. Allan noted that although he had “... no intention of discussing the paper that night... he thought the surprising statement made by Mr Richards called for a remark or two” (Allan, 1896:179). He, along with other attendees, countered that basic steel was in fact the inferior product. Others still however, seemed more obviously interested in hearing more on the topic, with the Institute President noting that he would like to hear further instances of “Mr Richards’ championing of basic steel as against acid steel” (Sexton, *JWSISI* 1896:181).

Richards took his opportunity to do so four years later. True to his previous form, he used the discussion of another paper, delivered by a Mr Thomas Turner, to return to this theme. Turner was one of a small number of speakers who were, by the start of the 20th century, beginning to travel from England to Scotland to share positive testimonials of the basic process (see also Wilson, 1903). In his comments, Richards identified himself as “... the only maker of basic steel on a large scale in Scotland” and perhaps anticipating the astonishment of his fellow members, he conceded that “... they would perhaps be sceptical when he told them that only a few days ago he bought some iron which contained 25 per cent of phosphorus” (Richards, 1900). The remarkably high proportion of this chemical was not however intended to contaminate the steel. Instead, Richards was experimenting with raising the phosphoric acid level in his slag. Sidney Thomas was amongst those who had recognised that the phosphorus content of basic slag could be utilised as a source of nutrients to grow crops. All that was

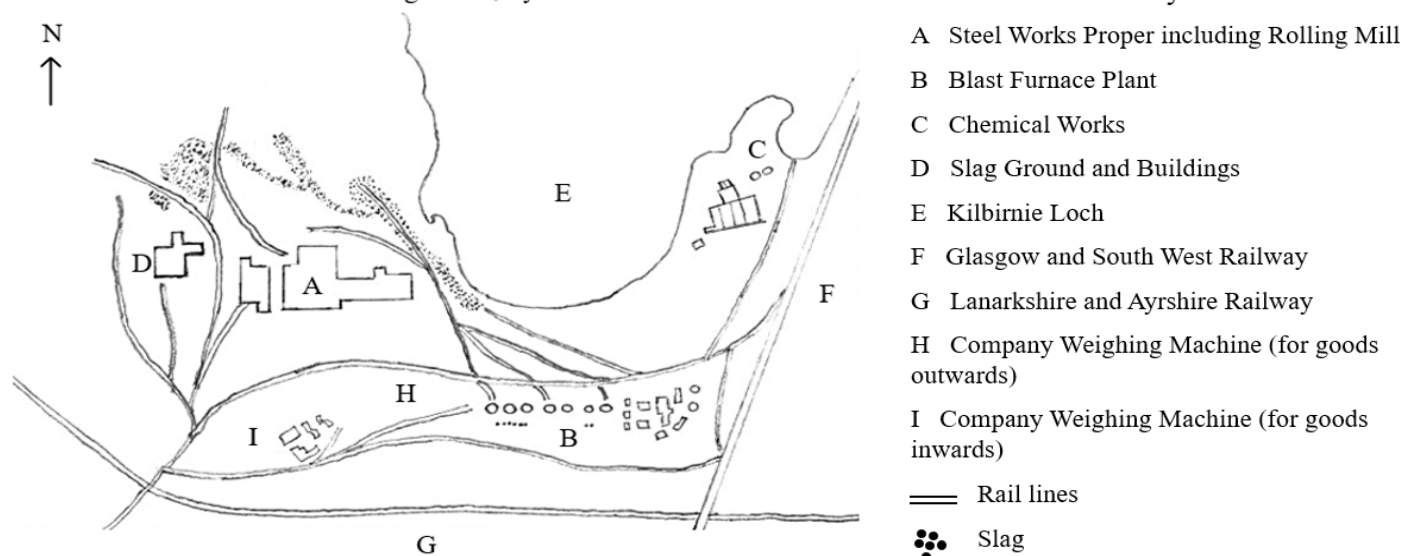
needed was to pulverise the slag into small particles, and it could be used in a similar fashion to a fertiliser (also referred to at this time as a manure). Almond (1979:224) observes “the Germans arrived at this fruitful conclusion before those in Britain, and by 1885 were scattering sizeable quantities of the powdered slag... onto their soil.” Prior to this discovery, slag was being produced in such quantities that in some cases, it was dumped in desperation into the North Sea (Barraclough, 1990). Now however, basic slag could be shipped across this waterbody to a waiting market in northern Europe. Basic Bessemer slag was the best material for this job, and MacFarlane (1917:96) notes “the greater the percentage of easily soluble phosphoric acid in the slag, the higher is the price it will fetch.” It was for this purpose that Richards was conducting his researches with this material, which he claimed was “remunerative” (Richards, 1900:144) and “... very good as a manure, especially for beetroot growing” (Richards, 1903:85). In fact, Richards had introduced the infrastructure to produce basic Bessemer slag manure very early in his tenure as works manager, in 1891, and the scale of plant and grounds given over to this by-product was considerable (see **figure 4.3**, overleaf). For the most part, Richards’ peers saw phosphorus, and the slag that held it, as an embodiment of malevolence – especially if these impurities appeared ‘out of place’ in the metal from which they were so carefully kept separate. Richards himself however sought to surpass convention— both in terms of prevalent perceptions and phosphoric percentages — and by installing new spaces for his slag to operate, enrolled this material into the success of his steelworks.

4.4 Aftermaths

The realisation of Richards’ experiments with slag geochemistry indelibly shaped Glengarnock’s slag landscape. Yet it also enrolled his works and this material in a number of emerging global stories. Richards left the Glengarnock Steelworks in 1913, having served 23 years in his role as general works manager (*Journal of the Iron and Steel Institute*, 1924). His departure was followed by a period of economic depression, and by 1914 the works was producing steel at far less than its usual rate, whilst the iron producing plant had become redundant altogether (Charman, 1981; Payne, 1979).¹⁷ However, the advent of the First World

¹⁷ There is evidence of hard times during Richards’ tenure as works manager too. An article on the North Ayrshire Heritage website notes that: “For the remainder of the 1890s and early 1900’s the Glengarnock Iron and Steel Company struggled to get by. In November 1894 continued stoppages meant that many families working for Merry & Cunninghame faced near destitution” (North Ayrshire Heritage, 2024).

1900 General Plan of the Glengarnock Iron and Steel Works,
Glengarnock, Ayrshire



1900 Enlarged Plan of Manure Mill Buildings with Railways and
Grounds for Slag Tips in connection with Basic Slag

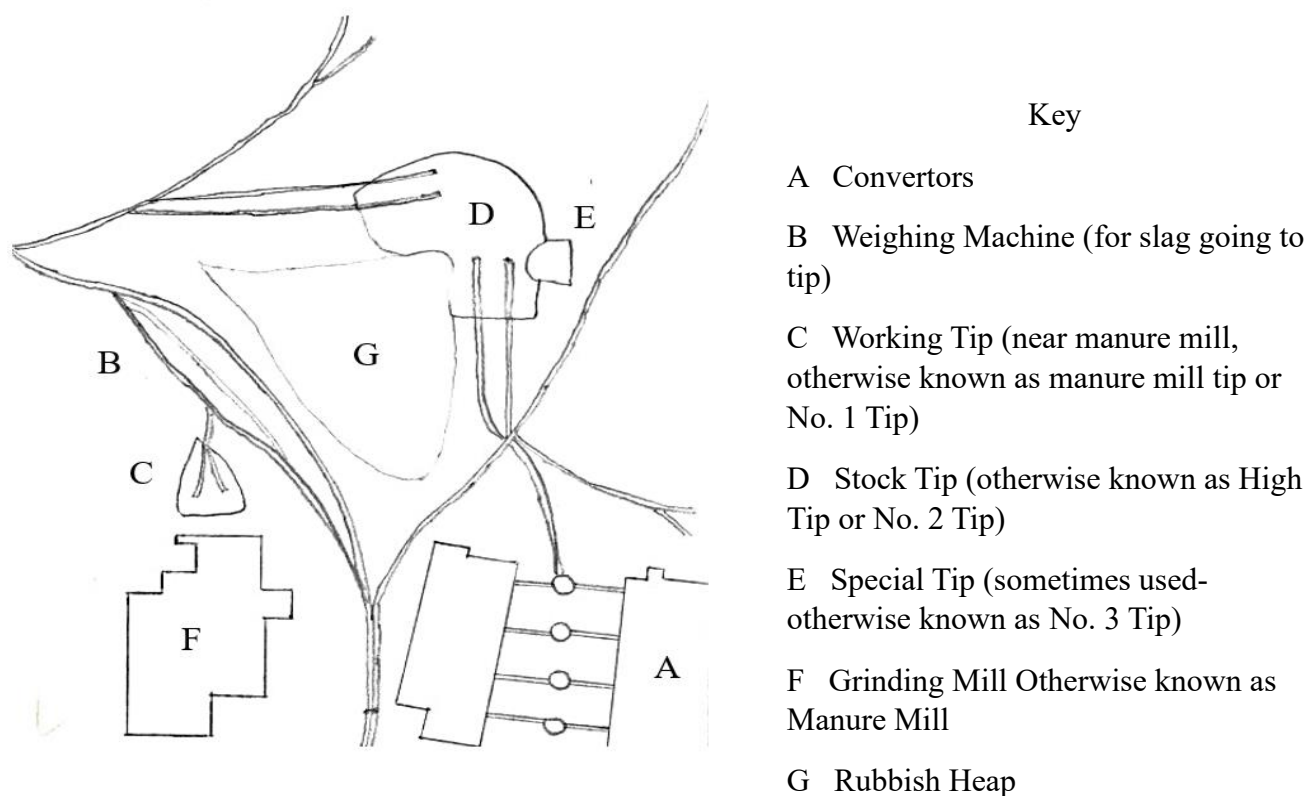


Figure 4.3- Reproductions (not to scale) of plans from the year 1900 depicting the Glengarnock Steelworks (top image) and the infrastructure associated with the slag manure works (bottom image). These plans were accessed through the National Library of Scotland, but as photographing or printing out these documents was not permitted, they were instead drawn from sketches made during my visit. Additional information which accompanied the Manure Mill plan gives the dimensions of 'High Tip' (marked D) which stretched to 230 feet wide, and extended to a maximum of 18 feet above ground, and 15.5 feet below ground.

War heralded great change for the Glengarnock Steelworks, and Richards' predictions regarding the utility of basic steel came to pass. Carr and Taplin (1962) portray the metallurgical shortages the wartime government encountered as a spiralling series of delayed realisations. The unavailability of steel to meet military demands was found to be due to a lack of pig iron. This deficiency was in turn discovered to be derived from a scarcity of foreign ore, and the widespread inability in the British steel industry to process ore from home shores. Stringent limits on imported materials meant that the acid process— dependant on these foreign ores to produce pig iron low in phosphorus— was thus almost entirely superseded by a national drive to convert plant to operate under basic conditions. The Ministry of Munitions launched “The Basic Programme”, a wide-ranging effort to accommodate the chemistry of domestically sourced raw materials (Hatch, 1919:43) – and of course, the slags they produced. By 1916, “... steel had become the dominating factor in munitions programmes” with Minister for Munitions Winston Churchill declaring in 1917 “... that the country was fighting ‘A Steel War’” (Carr and Taplin, 1962:299). Meanwhile, Glengarnock existed within a context of “... increasingly feverish appeals by the Ministry of Munitions to increase Scottish steel output” (Payne, 1979:126). Already possessing a reputation prior to the war as an integrated plant, capable of producing pig iron from domestic ores to manufacture basic steel, the Glengarnock works must have presented an attractive proposition. To this end, in 1916, David Colville & Sons (encouraged by the Ministry of Munitions) bought the works, and embarked upon the task of producing home-grown iron and steel. In 1917, a new ‘Scheme B’ steelworks plant came into operation, to further increase production (ibid; Hatch, 1919; Charman, 1981). Richards was thus proved correct in his advocacy for the basic process – and the manner in which he sought to realise his formative experiences within his management of the Glengarnock Steelworks ultimately proved advantageous to the war effort.¹⁸

The 19th century invention and 20th century uptake of the basic process enabled steel to be made in far greater volumes, yet as demand for steel rose, the global environmental consequences of manufacturing this product also increased. The International Energy Agency

¹⁸ Not all of Richards' legacies were perpetuated however. Although there is evidence that during his time as the Glengarnock works manager, both Bessemer and open hearth furnaces were in operation (utilising both the acid and basic processes), his particular enthusiasm for the Bessemer process was not shared by David Colville & Sons, who built the new Glengarnock melting shop to accommodate the slower, yet more easily controlled open-hearth method. By 1920, the Glengarnock Bessemer furnaces were no longer in use, and in 1923 the melting shop which Richards had overseen was closed (Charman, 1981).

(2023) estimates that globally, the steel industry currently emits 2.8 gigatonnes of carbon dioxide each year, which accounts for a conservatively estimated 7 to 9% of global greenhouse gas emissions (Kim et al, 2022). In *Steel: A Design, Cultural and Ecological History*, Fry and Willis (2015:227) argue that this state of affairs reveals how “iron and steel have become part of the very fabric of our taken-for-granted world to the extent of obscuring our ability to critically reflect upon what these materials have created or destroyed.” They contend that the writing of steel industry histories should therefore be approached differently, through an interrogation of what has been ‘made’ and ‘unmade’ by former technological innovators. Fry and Willis’ notion of ‘unmaking’ complements and extends Paton and DeSilvey’s (2016:234) recognition— through the processes of ‘making’ and ‘growing’— that the act of generation can have multiple outcomes. Paton and DeSilvey note “most made things produce a shadow object, the overlooked other to the finished product. Both of these products have a life journey of equal significance...” By recognising that the future is “... in large part filled by the ongoing agency of things created in the past” Fry and Willis (ibid) suggest that we can unpick and illuminate situated legacies of the steel industry in the contemporaneous presents of the historical subjects we study. By paying attention to the trajectories of one of the steel industry’s ‘shadow objects’, I will next therefore trace the particular ongoing agencies of Richards’ slag by considering how his experience of the geochemical manifested in other, far more problematic materialities, before turning to the archive produced by Dr Lorna J. Waite, to explore how she enrolled slag in her own attempt to re-frame of the production of history through these complex legacies.

5. The Glengarnock Steelworks Conservation Project Oral Histories: Dangerous materialities and fading memories

As we have seen, Glengarnock’s slag landscape evolved under Richard’s tenure as works manager, and these particular legacies are evident in the Glengarnock Steelworks Conservation Project oral histories records. Richard’ own name is only mentioned once in the oral history transcripts, in the reminiscences of one of the oldest community members recruited. This gentleman (whose name, in common with all participants, was redacted from his interview transcript, presumably to preserve anonymity) was born in Glengarnock in 1895, making him 85 at the time of his interview. When asked by the interviewer about the

various works managers who ran the plant, he associates Richards with a specific change in technology:

“Interviewer: You mentioned horses there. Did you have horses in the Work?”

Gentleman: Aye, they hid mibbae a couple o’ horses for sortin’ the roads an’ that.

Interviewer: When did they stop?

Gentleman: Oh, whenever the motors jist come intae... The manager— Richards— was it Richards? Aye, Richards, the manager, he hud a big open car – wan o’ they... It wid freeze ye sittin’ in it. The next thing we seen, a big fancy car an’ a chauffeur... But he driv’ the car, used to go tae the Isle of Man for his holidays... “ (Mr [redacted], Interview by Lorna Lewis 10th April 1980:90).

This recollection of Richards, who would have left his managership of Glengarnock when this interviewee was 18, does not deal with his accomplishments in the Scottish steel industry. Instead, he is remembered for possessing his own car, which replaced the horse-drawn coaches that had previously transported him from Glengarnock train station— where he could request an unscheduled stop to be made for him to alight— to the works. He is also remembered for taking holidays – at a time when the only holidays workers were granted were unpaid weeks during the Glasgow Fair¹⁹ and New Year (ibid). Richards’ legacies are thus preserved here— in this last recorded instance of his presence in living memory— as underpinned by inequity.

Similar instances of social division can be found in these oral history extracts, and in particular, Richards’ relationship with slag had specific effects upon the Glengarnock landscape and those who worked within it. An interview with a 77-year-old ex-steelworks employee, who had served 50 years at Glengarnock, reveals the scale of the slag heaps that had formed around the works:

¹⁹ Wilson (2020:84) identifies the Glasgow Fair as “... one of the oldest of its kind in the United Kingdom, dating from the late twelfth century.” Initially, it was a time set aside annually, in the month of July, for the agricultural community to come together and trade in animals and labour. By the 1800s however, its purpose had changed, and it became the time in which industrial labourers took their holidays. In this way, “the annual fair acted as a barometer for the industrial health of the city and country” as in years of good profit, more leave was offered and vice versa. At first, these days of leisure were spent in Glasgow itself, often at a city park called Glasgow Green, but latterly, trips began to be taken ‘doon the watter’ by steamship to the Clyde Coast. This holiday thus became associated with a period of mass travel or “exodus” from the city, and it is still observed as a public holiday for Glasgow workers even today.

“That, ah, the slag – the slag first of aw they used tae pit it up in wan o’ they aerial – an aerial thing up the slag hill tae take away the – they had this wee tub – they could lift aff the – lift oaf the top and take the slag just like a sandcastle – it was the shape like a sandcastle.” (Mr [redacted] Interviewed 11th January 1980:8).

What is being described here is a kind of aerial railway, consisting of multiple carriages (named bogeys) pulled by a small steam locomotive (called a pug), which conveyed the slag from the steelworks furnaces to the site of its deposition. The height that these mounds of accumulated material had gradually reached presumably formed an elevated barrier between the works and Kilbirnie Loch, preventing the previous practice of simply dumping slag into this waterbody and thus necessitating a more vertiginous approach. The huge volume of these deposits did not however guarantee their stability:

“But there was a bad accident there wan time – well, very near a bad accident; and it happened on the night shift. The railway took – before they tipped the slag – the pug had just come aff the slag hill when the whole thing just went doon. Quite a section a it went doon – the whole side went doon and cracked up quite a bit, mibbae say ten feet mibbae or something like ‘at.

Interviewer: And where was this slag held?

Ex-Steelworker: The whole slag – it was oan mud. See the lochside – ken...

Interviewer: It was just at the lochside was it?

Ex-Steelworker: Aye the lochside... Well ye see, it was awfy marshy there... you could see it’d bent wi’ the weight – that slag hill was daein this tae it. It was always like cracked: the water was always in between: it was cracked wi’ the weight. Well, this is what happened in this case: they just dropped! It’s a good job – if the driver an’ his bogeys... they just came aff in time.” (ibid:9).

Taking up employment in 1966, a recently employed manager recalled being told by his new landlady that the Glengarnock works was still known locally by some as “the slaughterhouse” (Mr [redacted], Interviewed 23rd January 1980:49, see also Charman, 1981:77). The particular dangers posed through direct contact with slag were not confined to collapsing heaps however, and injuries or conditions inflicted by this material are recorded in the oral history transcripts as having long lineages. The paternal influence that Edgar Richards experienced through his father Edward was replicated in many of the Glengarnock workers, with several

generations of fathers and sons employed in the steelworks. The 77-year-old ex-steelworker with 50 years of service counted his own father amongst this company. His family's patriarch was Lithuanian, and came to Scotland to escape conscription into the Russian army.²⁰ He found employment at Glengarnock during the years that Richards was in charge, and held positions in the basic Bessemer shop and the basic slag manure mill – the plant that Richards championed at the WSISI meetings. His son's recollections give a vivid insight into the physical experiences of the workers who actualised management blueprints – both during Richards' tenure at Glengarnock, and in the slag legacies left in the wake of his departure. One incident, recalled from a time when the ex-steelworker was just a young boy, concerned his father being brought home from work early, with his "... claes... almost burnt aff him" (Mr [redacted] Interviewed 11th January 1980:32). He supposes that the Bessemer furnace vessel his father had been working alongside had produced an unusually large volume of slag that day, and "... the wye it bubbles oot... it caught alight" (ibid:33). He continues:

"Ah remember comin' in the hoose... an' he come in, he was – oh he wis an awfy state. Oh, and would you believe that the treatment he got after that – Ah remember – leeches pit on his back – leeches! ... This is a doctor's idea. Aye, they did that wi' leeches ken – burns – bad burns. Ah seen it – Ah seen as much as three leeches on his back, ken – his bare back" (ibid).

When the interviewer enquires how long his father was off work with these injuries, the ex-steelworker answers that he would have tried to return to the furnace face as soon as possible, as leave was not financially compensated by the company. Some years later, after the Bessemer plant had been shut down in 1920, his father became employed working in the manure mill, with the large bulks of remaining basic slag it had produced, which his son describes as "an awfy stoorie [dusty] job" (ibid:10). The powdered slag continuously streamed down a chute, where workers stood waiting to catch it in sacks. Writing on similar settings in works located in the North of England, Almond (1979:225) observes "plant operators suffered much from the 'slag cough' resulting from the high concentrations of dust that pervaded the atmosphere, and several medical investigations were carried out during the

²⁰ This particular gentleman was not the only worker from Lithuania to travel to Glengarnock to escape conscription into the Russian army. Indeed, the Manpower Report notes that a number of Lithuanians, particularly from agricultural communities in "... the Suwalkija and Kovno regions" made the same trip. Although certain cultural memories were retained by those with Lithuanian heritage (memories of Lithuanian recipes were especially evident in the oral history interviews) it is noted that the anglicisation of surnames in particular aided the desire of these individuals to integrate relatively rapidly into the local community (Charman, 1981:81-82).

last decade of the 19th century.” These reviews resulted in the Inspector of Factories ordering that respirators be worn by slag mill workers, although Almond notes that it is doubtful that this command was largely upheld. Often, the only steps which were instead taken to improve these environments was to invest in sacks which were slightly less permeable (although a cynical interpreter might question if the additional benefit of losing less slag by-product was perhaps the main priority behind this action). During his interview, the former Glengarnock worker mentions that his father did not develop lung disease, and remarks upon the fortuitousness of this, given his employment in the slag manure mill. Whilst it is uncertain which, if any, protections were offered at Glengarnock, it is evident that labouring closely with slag in this capacity was not something which was particularly relished.²¹

During his interview, the 85-year-old gentleman who remembered Richards’ car and holiday destination, was asked what happened to the slag after it was deposited. He replied, “that was aw that happened to it” (Mr [redacted], Interview by Lorna Lewis 10th April 1980:10). Despite the varied relations the Glengarnock workers and management held with their slag when it was operational and productive (and notwithstanding the account of the partially collapsed slag heap), this statement, and the absence of any further reflections upon the deposited slag within the oral history interviews, suggests that the attitude held towards the Glengarnock slag once it had come to rest was one of general indifference. One further interview does however acknowledge this slag in this phase of its history, as the local GP reflects briefly upon its recent disappearance from the landscape:

“I believe the old slag hills have been removed or smoothed out. Large quantities of earth have been moving through this town for some considerable time and spread on top of it! I presume they are going to plant grass on that... there are a few small businesses now taking over the lower part of the site” (Mr [redacted] Interviewed 24th January 1980:26).

²¹ Although I have limited my descriptions here of injuries, accidents and medical conditions directly related to the Glengarnock slag, there was another ailment described in the oral history transcripts which arose from contact with dolomite, a fluxing agent used in encouraging slag formation viscosity control. An interview with the local GP— whose reminiscences encompassed the work of his father, who held the same position— reveals that workers often suffered with “dolomite burn”, an eye condition derived from this material “... because it both penetrated the eye and burnt it at the same time.” In the latter half of the 20th century, goggles were introduced to prevent this injury, but prior to that, no protection was offered to workers (Mr [redacted] Interviewed 24th January 1980:16).

Edgar Richards witnessed and then perpetuated the manipulation of slag geochemistry as a means of achieving industrial advancement. Returning to Fry and Willis' (2015) call to explore what is 'made' and 'unmade' through the ongoing agency of steel ecologies, it is clear that the realisation of these slag materialities, through their imposition on generations of steelworker bodies, resulted in human-lithic entanglements that were appreciably different to Richards' own. The making of vertiginous slag heaps resulted in an unmaking of topographical stability, as the land beneath the heaps subsided, and one of these new landscape features partially collapsed under its own weight. The invention of the unpredictable Bessemer blow lead to an incident at Glengarnock where a sudden surge of molten slag incinerated a man's clothing and seared his flesh. The creation of a slag fertiliser to enhance crop growth undid the health of those working amongst its swirling particles, as it perniciously passed into their lungs. Yet these knowledges of slag were themselves becoming unmade, even as the oral history recorders attempted to salvage them. Although the final closure of the Glengarnock Steelworks was still a few years in his future, the final oral history interviewee featured here could anticipate the changes this loss of the local industry would bring about, through the already-initiated landscaping of its slag heaps. These transformations in Glengarnock's slag landscape, and the simultaneous erasures of the experiences it had once held, became central to the work of Dr Lorna J. Waite, whose life straddled a historical geography of Glengarnock both with, and without its works.

6. Dr Lorna J. Waite: Maker of Glengarnock Histories

6.1 The Opacity of Slag Hill

"The train slowed on approach to the station, braking in a leisurely way as it trundled towards the head of Kilbirnie Loch with a view of the ever present steelwork²² always the visual marker throughout childhood that meant I was hame, a silhouette of

²² There is an instance of deliberate word choice employed in this opening quotation which is worth briefly commenting on here. Reference is made to the "steelwork" – the 's' which I have routinely employed throughout this thesis is absent. This is a deliberate statement on Lorna's part, as she explains "The Work is the steelwork. Glengarnock Steelworks. Locally, it was always 'The Work' never the steelworks" (Waite, 2011a:18). When I first read this information, I was faced with the question and potential implications of how I should refer to the Glengarnock Steelworks. If I was to similarly drop the 's' would this choice indicate respect for local naming practices, or perhaps represent a form of cultural appropriation? Ultimately, it felt most fitting for me to continue to refer to the steelworks, in recognition and acknowledgement of my dual outsider status – spatially, as someone who is not immediately local to this community, and temporally, as someone who had no inherited knowledge of the Glengarnock Steelwork's existence until I was introduced to it through this PhD project.

chimneys framed against the oval loch” (Waite, 2011a:69).

Looking out of the carriage window, as she approached her hometown following a spell away at university, Lorna J. Waite expected to see, as she had done countless times before, a comfortably familiar scene. Her story begins however with the realisation that this view had radically altered from all of her previous journeys. On this day, “no visual sign remained on the horizon, no sign of the work at all” (ibid). In her absence, the Glengarnock Steelworks had been removed from the landscape that had once held it. Later, she reflects that this moment of erasure should not necessarily have come as a surprise – it was well known that the works was condemned, and there were signs for weeks prior that its dominant visual presence was receding. Yet the community’s final impression of the steelwork’s removal was not one of gradual, cumulative loss, but rather of a sudden, shocking eradication. The “folk memory” of the Garnock Valley thus became “inscribed with the monumentality of the image of sudden death, metaphorically and literally, in the social imagination” (ibid:70). Of course, there was a gulf in familiarity between those who had always known the steelworks and those who never would. This had emerged gradually, and with a more liminal generation situated in between. Lorna identified as belonging to this borderline grouping, who were youths when the works was lost, and thus perceive it as “witnesses but not workers” (ibid:20). Yet as she received stories about the works from an old friend and former steelworker, she realised that this identity had subtly shifted. As she became enrolled in her elder’s recollections, and then concerned with enabling the perpetuation of these past knowledges, she committed to becoming “... a holder of lost memory” (ibid:17). Here however a dilemma arose, one which was intimately connected to the limitations of Lorna’s own generational positioning – how can we counter the absence of stories, when the only stories we know are those of absence?

This tension is evident in the opening verses of *Shift Change*, a poem in which slag constitutes a place where the nature of memory can be contemplated:

Shift Change²³

(*Waite, 2011a:183; Extract: stanzas 1-3*)

Where are the words o my steel imagination?

Fettle

Bloom

Tap

Teem

Whaur did they take the lost furnace?

Whit wir their names, they aa had names?

Men intimate wi their temperament

Ca'd tae name their world.

Are there shiftin teams o steelworkers

Oan the shores of Slag Hill

Waitin to be remembered

Am I the only wan who

Sees the land like this?

The poem begins by exploring the relationship between language, naming practices, and where these take place. Lorna locates the metallurgical terminology she has learned within her “steel imagination” positioning the immateriality of this setting in contrast to the men of the steelworks, who employed these words in practice, in the total physical immersion of “their world.” In the final stanza of this extract, the incommensurability of these perspectives collide within the present-day physical landscape, “oan the shores of Slag Hill.” Slag Hill is the name given for the peninsular area of made ground created by slag infilling the south western flank of Kilbirnie Loch. As detailed in Chapter 1, slag dumping extended out from the new position of the ‘Scheme B’ steelworks plant which began operating in 1917, and a great mound of this material subsequently accumulated here through the decades. By the time Lorna came to know this landform more intimately through her poetry, it had already been

²³ Full versions of the poems that appear in extracted form here will be reproduced in Appendix 1. I am extremely grateful to Professor Murdo Macdonald for permission to share these pieces.

landscaped, its anthropogenic geology hidden beneath the ‘large quantities of earth’ referenced in the local GP’s oral history transcript. On Slag Hill, only the slag which lay along the immediate shoreline of the loch actually remained visible. In her use of this vernacular reference, Lorna is thus employing “... a language map of community, and the intangible linking of places of belonging.” Such a map is however, she observes, “... dramatically broken when inner and outer landscapes of reference are distinctively marked by different historical and economic contexts” (Waite, 2011a:18-19). This dynamic plays out in how Lorna presents Slag Hill in her creative work. As understanding the origins of its name relies upon knowledge of a lost context, this landform appears in *Shift Change* as a kind of in-between place, at once straddling the material imprint of the steelworkers’ world, and the hollowed-out feeling of their absence. This liminality is representative of the breakage in this community’s place knowledge, a rift that is inherently destabilising, as can be seen in this poem by the questions that encircle Slag Hill’s presence. Uncertainty imbues Lorna’s visioning of this landscape, especially in the final lines of this extract, where she asks “Am I the only wan who/ Sees the land like this?” In making the choice to seek forgotten knowledge about her town’s steelworks, Lorna develops a kind of double vision, which she applies to this landscape – simultaneously apprehending the present, but also glimpsing the possibilities of recovering the past. The questions posed at the end of this extract of *Shift Change* also reveal an underlying ambivalence as to whether the recovery of memory from this landscape is in fact a viable objective – Lorna does not assert confidently that there are steelworkers waiting to be remembered on the shores of Slag Hill, but instead appears to be weighing up the likelihood of their presence.

Considering the marks that we make on a landscape’s biography, Lorimer (2015:17) reflects “on occasion, evidence of authorship exists to such depth and degree, that landscape seems somehow fashioned in the author’s own image... such strong biographical legacies can produce landscapes as ongoing re-readable phenomena.” Entirely ‘authored’ by the steelworkers whose memories Lorna seeks, Slag Hill may appear to offer this kind of “readability.” This however, Lorimer qualifies, is “... a quality derived from direct experience.” Lorna’s mind’s eye — cut off from the transmission of knowledge that once sustained this place’s formation, and only populated with fragments of regained information— cannot replicate a steelworker’s reading of this landscape. Her interpretation of it will thus be authored through her own experiences. Standing or looking upon Slag Hill, she can appreciate that memory was once alive and operational in this landscape. Yet at this

intersection of place, material culture and imaginative limitation, Lorna realises that Slag Hill in fact functions as a “site of the mark of memory” (ibid:199) revealing only that the remnants of the works that are carried within once dwelt here, but are now concealed to the generations who cannot intimately know the steelworkers’ world. Echoes of Levinas’ (2003) ‘trace’ can be heard here, as Slag Hill signifies the presence of something that is absent. Edensor (2022:25) observes “because of its durability, stone has been integral to the commemorative impulses of humans, a key constituent of memorials and other structures intended to last across time... [and] to inscribe meanings upon place.” Slag Hill functions as a kind of accidental memorial, which formed through the utilitarian dumping of a waste material, but which nonetheless now operates as a kind of memento mori for the industry which created it. Yet the symbolic significance which Lorna finds in this landform is only that of uncertain meaning. This opacity²⁴ renders Slag Hill a monument to unknowability, “ineffable... mysterious and spectral” (Edensor, 2020:10).

Lorna circles back to Slag Hill many times in her work, suggesting that its relationship to her memory work is not uncomplicated. In the opening verses of *On Slag Hill: Make New Plans for the Loved Land*, she explores forms of inherited memory, dwelling on the expression of inter-generational trauma and mourning practices:

**On Slag Hill: Make New
Plans for the Loved Land**

(Waite, 2011a:221; Extract: stanzas 1 and 2)

On Slag Hill

Stains of iron rust the bank of the loch

²⁴ This material property of slag is drawn out in another poem *On Slag Hill: Make New Plans for the Loved Land*. In the third stanza of this piece, Lorna describes the peaceful scene before her: people fishing in Kilbirnie Loch, sheltered by 'half moon tents.' Yet this contemporary setting belies the losses endured as a result of the changes that were wrought here. Hands that now grasp fishing rods 'no longer grasp the tap hole' (an aperture in the furnace, opened with a metal rod, from which the molten steel would flow) – but the speaker suggests that the fishermen can perhaps at least perceive the remnants of those times through the 'rivers of metal' that 'run through/The veins of the black iron land' staining the slag shoreline. In the next line however, there is a familiar sense of ambivalence as to how far this means of looking will take them, as these 'men sit and contemplate/The stir of surface meaning.' Although we can picture these figures keeping vigil, staring at the loch surface and trying to make meaning of any disruptions to the water, this one dimensional reading allows them a limited gleaning of what truly lies below. The world of the fish they wish to catch is unknowable to them. The opacity of the loch and by extension, the slag which accommodates the 'rivers of metal' evoked previously thus both hint at, and deflect efforts to access a further, deeper knowledge.

In resigned geologic neglect
 Manganese, iron ore, sulphur
 A waste tip of memory.

I stand on the metal of the fathers
 The workers of the furnace rolled steel
 See the teardrops of the last tap –
 In the steeltown all is quiet now
 Still the sound of metal on land
 The swans keep faith with water
 The oystercatcher in the early morning
 Reverie sounds the Blastie²⁵ call to wisdom.

The naming of chemical elements in the first stanza of this poem echoes the invocation of steelworks argot recited in *Shift Change*. Again, the enumeration of terms presented here might to most hold little or no meaning in this context, especially when compared to the experiential knowledges of the steelworkers whose memories have been lost. Here however, these words relate directly to slag, as Lorna names some of the chemical constituents that make up the most voluminous final material imprint of the works. In these lines, we can also see instances of where this land itself seems to reflect the inner emotional terrain of Lorna and her community – pitted with “the teardrops of the last tap” and stained by “resigned geologic neglect”, Slag Hill almost personifies an acquiescence to pain, experienced as a mode of endurance since the steelworks was removed from this setting. Lorna argues “... the body has symbolic and muscle memory of landscape which persists years after the visual landscape has changed for the following generation” (Waite, 2011a:21). Lorna contends that a mourning process which is sensitive to inter-generational trauma fundamentally requires a lost entity to continue to be valued, despite its absence. For those who bear this loss directly, grief must be acknowledged publicly and collectively; for those who inherit it, knowledge of the lost entity must be transferred, and not considered redundant. Sitting somewhere between these needs, Lorna could nevertheless see that they were being denied to her community.

²⁵ ‘Blastie’ is a term used to refer to a person from the town of Kilbirnie. The term originates in Robert Burns’ poem *The Inventory*, where he indicates his approval of a horse he purchased in Kilbirnie by describing it in this manner. A matter of local pride, the name ‘Blastie’ thus transferred to the people of the town, and eventually became additionally conflated with the blast furnaces of the local industry (Waite, 2011a).

With a few exceptions, she experienced the steelworker's grief as unspoken, with many engaging in acts of self-erasure – clearing the works was an exercise in mass disposal, and the decision to rescue and retain any remnant in the face of this was an act of real resistance. Writing in the context of the late 20th century demise of the Western European coal industry, van Veldhoven (2014:332) notes that for those “sandwiched between” the industrial and post-industrial, this initial desire to forget is not unusual, and can be viewed as a response to trauma, and associated emotions or experiences such as acrimony, despair, or subjection. Lorna argues however that being denied the means to mourn compounds, feeds, and perpetuates this trauma, which seeps into our perceptions of the cleared land. Existing as a place in which to remember, but unaccompanied by the necessary tools to process grief, Slag Hill thus becomes a place where mourning is imperfectly enacted. In failing to enrol the lost steelworks in intentional, communally recognised practices to mediate its community's bereavement, its sense of worth is also devalued, reflected in the depiction here of Slag Hill as “A waste tip of memory.” Positioned thus, as a stratified repository of recollection, this landform exists as a site where memory is discarded, yet also accumulated, and with time, gradually transformed. At this point in the poem, the reader is left wondering how exactly this metamorphosis will be realised, and what will emerge as a result.

6.2 *The lustre of slag glass*

As Lorna continued to pursue past knowledges of the Glengarnock Steelworks, she met a series of multiple, nested erasures – the self-imposed silence of her community; the dearth of working class voices in the socio-economic histories of the steel industry that she read; and of course, the destruction and ‘recycling’ of the works archive that she discovered in Shotton, Wales. All contributed to a sense that the history she sought had been deemed valueless by a delocalised, neoliberal logic, used by the British state to justify the choice of a distant, privatised company for the storage of the Glengarnock Steelworks records, as well as the decision that the works itself was economically unviable. It was in the context of another discarded pile of industrial history however that Lorna found the means to transform her understandings of archives, waste heaps and herself, as she found kinship within an artistic community that established its foundations amidst a series of ‘bings’ produced by the Scottish

shale oil industry.²⁶ Artist John Latham had, starting in 1975, and for years thereafter, lobbied for these features to be reconceived “as works of art in their own right” created through decades of hard, repetitive, unheralded labour (Rycroft, 2019:298, see also Brophy, 2021; Flynn 2021; Gardner, 2023). Yet it was conversations with Latham’s former wife and lifelong colleague Barbara Steveni that guided these revelations closer towards Lorna’s home shores. Walking together across the shale bings in the years following Latham’s death, Steveni stressed her own role in the commemoration of their work – “... as a repository of memory” yes, but also an adherent of “... the need to place her own experience in the foreground and yet take it forward, walk with it into the future rather than looking back only to see the past” (Waite, 2011a:121). Steveni’s archive was therefore a place of creation and generation, and was to be found within oneself. In the first stanza of Lorna’s poem *Fur Me, It Wiz Sculpture: A Blastie Honours Glengarnock Steelwork*, the influence of these perspectives on waste and history are intertwined within her own home landscape:

Fur Me, It Wiz Sculpture: A Blastie Honours Glengarnock Steelwork

(Waite, 2011a:272; Extract: stanza 1)

Fur me they wur sculpture
 Nae kennin how tae say this
 Fur we nevir gie the status o art
 Tae oor repeated memories o formation.
 A rescued masel fae the tragedy o the unloved
 Fae the view through the windae o the wurk
 An oan the tap o bings, hurlin the rid blaze o blame
 Doon they gentle, slopin banks
 Ahint whaur we used tae play.

Here the speaker is learning to ‘gie the status o art’ to Glengarnock’s own slag heaps by folding the landscape of her childhood into that holding her epiphany regarding how the past

²⁶ This enterprise was founded in the 19th century, as it was discovered that oil could be extracted from shale rock. Millions of tonnes of this material was consequently mined and then heated to extract the hydrocarbons therein. By the early decades of the 20th century, peak production levels were reached, but declining fortunes led to only a handful of operations surviving into the 1960s. Thereafter, the dominant material imprint of the Scottish Shale Oil industry took the form of large piles of spent rock, burnt red, which were named ‘bings’ (Northern Mine Research Society, n.d.)

might be retold. Still uncertain about how exactly to express this, she nonetheless begins by ridding herself of the inherited sense of shame that infuses her community's memories of the works' closure. The gradient of the bings' "gentle slopin banks" seem to invite this act, and the shift in focus at the end of this extract, from the stratigraphy of their "rid blaze" to the topographical backdrop of the speaker's own childhood memories, suggests a turn towards home, where the detritus of past indignities have accumulated in preparation for new layers of meaning to be laid down upon them. Yet a resolution to learn to see differently requires continuous, intentional practice, and Lorna refers to these efforts as the "industry o history" (from *A Am Done wi the Daein*, Waite, 2011a:268), acknowledging that the production of historical knowledge demands of the individual hard intellectual, emotional and even manual labour, as they are simultaneously embedded in an operation shaped by many voices, actions and varying levels of power. Her description also implies that whilst history can be mass produced, with certain discourses widely and thoroughly circulated, it can also be handcrafted. Ready to craft her own history as an artisan, rather than as a receiver, Lorna was also ready to enrol the materialities and meanings which had grown out of Glengarnock's slag into her own work, as a maker of her home landscape's story.

In the penultimate stanza of *On Slag Hill*, Lorna's return is grounded within this landscape, and new beginnings are also being realised in conversation with the past:

**On Slag Hill: Make New
Plans for the Loved Land**

(Waite, 2011a:222; Extract: Stanza 5)

On Slag Hill, iron tears run rivers through my face
 Craters of metal moon pit the surface in grief
 Tell tales of lost faith, the injured bodyland
 A collective trauma of sorts,
 The wise doctor would intone.
 Still felt keenly in the throat
 A choking voice strangled
 By removal of the chords of history
 We still sing our song
 An elegant refrain of friendship

Nameless Blasties wi the steelwork blues
 Breathe the air of the bird
 Make new plans for the loved land
 She is in us all, bear her wound
 Extract seeds and fruit of story from the relics.

This is a verse of two halves – the first recalls the trauma still present within the layers of this landscape, and the bodies of its people, whilst in the second, Lorna asserts that the act of making “new plans for the loved land” can be progressed through cultivating ownership of the numerous narratives stratified in the record of Slag Hill. To “bear her wound” the community must not forget the sources of their history’s erasure – yet they must also recall the difficult inheritances of the works itself. This idea is picked up in the poem *My Body is a Work of Steel* (ibid:74), where Lorna writes “Peer through the telescope to the early days/Your stars of coal mine and iron/Forged empires and destroyed towns./We bore the ambivalence of metal/In magnetic fields of iron belonging.” These lines reference the extractive forces that fuelled the steelworks’ operation, and the colonial powers who paid for its products – a major early 20th century purchaser of the steel rails that Glengarnock produced were listed in company catalogues that Lorna procured as “Indian and Colonial Governments” (Waite, 2011a:131). Here then, through evoking a disseminated network of past wrongs, linking the self, the colonial subject and the degraded land, Lorna demonstrates the paradoxical feelings that can arise when multiple shames are uncovered in a history that has previously been revered, and acknowledges a competing pull and resistance to a sense of belonging with the land that holds these complex legacies. In *Hope and Grief in the Anthropocene: Re-conceptualising human-nature relations*, Head (2016:21) suggests that grief for an uncertain future— in part rooted in the planet altering impacts of industrial geographies now past— must be recognised as an ever present “companion” that will accompany us in this new geological epoch. Lorna grieves for the future that was denied to her community’s steelworks, even as she recognises its complicity in perpetuating “inter-human violence” and inequity (Last, 2017:149). Yet she also realises that “making new plans for the loved land” is not a practice of one-dimensional devotion to, or straightforward replication of the past. Instead, it is a process of interrogation, as old ways of seeing, knowing and doing are held to account. The Glengarnock Steelworks made steel, slag, and thus an anthropogenic landform where Lorna could explore her relationship with her steelworks’

history. It also contributed to the unmaking of precolonial autonomy and global climate stability (Fry and Willis, 2015). By recognising that “our complexity is loadbearing” (from *The Repetition of Naming: For Barbara Steveni*, Waite, 2011a:204), supporting the reading of intrinsic value in all of the stories of the steelworks’ last material remains, these traces can remind us to conceive how to better live our own lives differently, in our own presents and futures.

In the final stanza of *On Slag Hill*, Lorna concentrates upon an individual piece of slag glass, which “glistens” on the shoreline of Kilbirnie Loch.²⁷ She portrays the slag glass as an archaeological artefact, which catches the eye and draws the viewer to apprehend the myriad of materials that constitute Slag Hill, “the landfill of rubble, an ancient world.” Although it is the subtle, light catching qualities of this object that draw’s Lorna’s attention to it, it is significant that it is only truly illuminated for her when it is re-visioned through her own meaning making – it “Lies waiting to be seen... shining/Through the empathy eyes of the giver.” Here, the original tension that emerged for Lorna in this landscape is finally resolved, as she recognises that although the Glengarnock slag can only reveal the site where the steelworkers’ memories were once held, it is also invested with meaning in its own right when she, having come to view the land, her story and herself with empathy, folds it into her story. She depicts this fragment of slag glass as forming part of her “reliquary” – a beautiful container for treasured items, which is ultimately found to be empty of the memories of the steelworks precious to Lorna. Yet a piece of slag glass also appears as a holder of fresh memory, in her inventory of the new archive produced by her research (Waite, 2011a:165). The loss of the steelworks and the covering over of Slag Hill signified an interruption in the transmission of Glengarnock’s slag legacies. Yet once Lorna was able to recognise this material as both a relic of the lost steelworks and an object which could become imbued with her own meaning-finding, it finally materially and symbolically shone for her. Ultimately, Lorna realises that her story is also one which should be transmitted in turn to future researchers. She acknowledges that as her history is received, new meanings will in turn be

²⁷ There are three possible definitions for the term ‘slag glass’, including the waste produced from the glass manufacture industry itself. The second definition encompasses iron and steel furnace slag which, due to a rapid cooling rate, has taken on a vitreous appearance. The third denotes a secondary, often decorative product made from vitrified iron and steel slag – either directly (with slag glass produced from the furnace) or indirectly (with crushed slag used to add a range of colours within the glass making process) (OED, 2024d). It is most likely that Lorna is referring to the second type of slag glass defined here, as it is found amongst the remnants of the waste heaps produced by the steelworks, and there is no evidence to suggest that it has undergone any kind of secondary processing.

generated from her archival records. With the end of Lorna's work— as “ma shift will change wi the burden released” (from *The Work Likes Tae Be Remembered*, *ibid*:78)— Slag Hill is opened out to new visions and new stories in “an ecology of possibility” (from *Dreaming My Ancestors*, *ibid*:60). Cultural geographer Harriet Hawkins (2020:xi) describes the creation of “generous poetics” as an act in part predicated in the realisation and sharing of “the force of poetry as a world making practice.” Lorna's poetry lays down a vision of how words and worlds can be interwoven to realise new futures, through the accumulated labours of those who choose to re-explore and re-tell that which remains unsaid – our neglected histories. Audre Lorde's (1977, in Hawkins, 2020:xiii) insight— that poetry is essential to “... what we need to dream, to move our spirits most deeply and directly toward and through promise”— echoes through Lorna's example. As “stillness returns” to Slag Hill with her departure, the land remains in a “transitional state” (from *Dreaming My Ancestors*, *ibid*), ready to be endlessly renewed through the readings of successive witnesses.

7. Conclusion

This chapter began with the realisation that the manner in which I was finding meaning in the Glengarnock slag was bounded by limited, received histories and geographies. In order to transform my own understanding of what this material is, I explored the contexts and relations that it has captured, by turning to alternative historical geographies offered up by this material trace, enclosed in form of archival voices. Although it transpired that much of the documentary archive for the Glengarnock Steelworks had been destroyed, I was able to assemble a ‘make do’ archive amidst these ruins, with three very different kinds of record. By putting perspectives from and inspired by historical geography, archaeology, and geology in conversation, I developed an approach which, in rejecting the notion of biographical completeness, allowed me to trace the ongoing intersections between the Glengarnock slag's various materialities and the voices of those who knew them.

Through Edgar Richards, I came to appreciate how an inheritance of experimentation with the anthropogenic geochemistry of slag was made to work. By struggling with, and yet overcoming the material difficulties it presented in the steel making furnace, slag was reharnessed to play its part in a metallurgical revolution. Richards subsequently advanced his control of this waste material, and enrolled it in a series of broader, lasting changes to the

Glengarnock landscape, the global steel industry, and the earth's atmosphere. Richards' own slag legacies thus simultaneously grew into, and shaped futures that he at once could, and perhaps could not anticipate. Yet the tenor of these futures altered in turn when I turned to consider the surviving testimonies of those who lived through them. Whilst those privileged to occupy the higher echelons of the steelmaking hierarchy envisioned what might be made with slag, those working on the slag heaps, in the manure mill, or at the furnace face often came to understand and experience its resulting materialities viscerally differently. For some, the Glengarnock slag threatened or caused serious injury, whilst for others, it ultimately held little meaning once it was deposited. Yet after the closure of the Glengarnock Steelworks, and the subsequent transformation of the site that once held it, the presence of slag heaps in conceptions of this setting receded. Through the naming of one place within this landscape however— Slag Hill— material memory of these anthropogenic landforms was retained. Dr Lorna J. Waite describes her work as “a cross section of time itself” and thus “a multitude of potential stories” (Waite, 2011a:468). Through my particular response to the slag which appears in Lorna's poetry, I drew out a story of human-lithic entanglement, which began in a present where the past had been lost, and which ended in a future imaginary filled with possibility. On Lorna's Slag Hill, the symbolic and the material become one and the same. The opacity of the anthropogenic rocks which comprise this landform deflected her attempts to use them to make already lost memories. Yet under certain furnaces conditions, this material can also grow vitrified, and thus reflect whole spectrums of accumulated meanings, including the pain of a vanished industry, the complexity of steel legacies, and the freedom to grow new plans for a physical landscape, by transmitting these messages to future others, who will dwell on its figurative shore line.

By incorporating the insights of Fry and Willis (2015) and Paton and DeSilvey (2016:234) into my analysis, I have traced a fragmentary path of intermittent inheritances, surveying how individual relations and collective lived realities were both made with and unexpectedly grown from the Glengarnock slag's ongoing trajectories. By additionally positioning Glengarnock's slag as a “shadow object”, whose afterlives are reciprocally haunted by those of the steel products it was enrolled in producing, I have also explored some of the worlds — of distant others and of voices closer to home— that were unmade through the destructions wrought by this steel slag's parent industry. The resulting narrative occupies the same time period as that of my original introduction to this waste material, concerning an industry that rose and fell, and a place which suffered the effects of deindustrialisation. Yet

what has emerged here is a different kind of historical geography, one which engages with the heterogeneity of biographical practice to go beyond my initial understandings of slag's legacies, which were bound up in what Tsing (2015:18) deems "... a story we know, of pioneers, progress..." and the eventual, inevitable decline of the industries they built – in short, a simple tale of "promise and ruin." By tracing the reciprocal transformations that Glengarnock's people and slag have effected upon each other, and having found a myriad of meanings in this material as a result, I have responded to Edensor's (2022) invitation to craft a tale that was waiting to be told about an anthropogenic material, and thus one story of the Anthropocene itself.

Work conducted within my home discipline of historical geography has formed the basis of this first empirical chapter. Yet discovering the obliteration of the Glengarnock Steelworks records made it clear that a space which is often regarded as a natural habitat for the historical geographer—the documentary archive—can offer me little further in this context. In the following empirical chapters, I will therefore next turn to utilise methods predominantly based within archaeology and the geosciences. Rather than tracing how the meanings to be found in Glengarnock's slag have been inherited, perpetuated and transformed through the contemporaneous pasts, presents, futures, and imagined futures of archival voices, I will instead move on to examine how its legacies have grown to manifest in *my* present-day landscape, to envisage stories that this material might tell in turn to future audiences, who are yet to notice these enduring traces.

Chapter 5: Present Transformations

1. Introduction

Thus far, this thesis has dwelt in Glengarnock's slag landscape through the eyes of those who knew its past. In this empirical chapter, I will re-occupy the present, to consider how an in-person engagement based within the developing heritage narratives of the Lochshore Park can allow me to explore slag legacies through first hand encounters with this material in situ. This landscape underwent significant change throughout my PhD project, as the former Glengarnock Steelworks site gradually evolved to occupy its new designation as the Lochshore Park. Indeed, this simple alteration in this place's nomenclature encompassed noticeable geographical and material effects. The first time I attempted a solo field trip to visit the Glengarnock slag, following the lifting of local Covid restrictions in April 2021, I became hopelessly lost. This was in part because the former Glengarnock Steelworks site was not recognised on the mapping app I was using to navigate. It was simply depicted as an unnamed area of land lying between an industrial estate and Kilbirnie Loch. Using the latter as the closest 'destination' the app could recognise, I was recommended an impassable route, with the suggested walk somehow concluding in the middle of the loch.²⁸ Later, I repeatedly missed the entrance to the former steelworks site, as the sign indicating the correct path to follow had fallen face first onto the ground, the steel supports holding it in place entirely corroded away. The route to the site's visible slag was similarly neglected. It consisted of interwoven, overgrown, and frequently waterlogged desire lines, maintained only by the intermittent passage of those seeking the isolated, peninsular landform that the slag had advanced into Kilbirnie Loch over the centuries. There was a transformation in this state of affairs during my final visits to this site, three years after my initial attempt to find it. The site now appeared as a destination in its own right on my mapping app, pinned in place alongside its latest name. The entrance to the park was marked by a new sign, crafted from a steel alloy,

²⁸ I now know that the correct route to the former steelworks site involves turning left after exiting Glengarnock train station. On this first trip however, guided by my mapping app, I turned right. My walk culminated in a state of high confusion as, about 40 minutes later and after a long walk down a dirt track, I came upon a security sentry hut. Barriers beside it blocked the way to the loch, which glittered in the distance. The cheerful guard informed me that I could not go any further, as I had hit private property (a collection of warehouses storing whisky). The cartographic absence of the former steelworks site had generated a new oral place naming tradition – my mistake was a common one, the guard assured me kindly, so much so that this setting was dubbed locally as 'Wrong Turn Hill.'



Figure 5.1: The new sign at the entrance to the Lochshore Park. In her 2008 study of post-industrial landscapes, *Hope and Rust*, Storm notes that the rusted surface "... represents industry becoming something that belongs to the past... but nevertheless forms an important part of the new hope" for a regenerating place (Storm, 2008:168). The Corten steel from which this sign is made becomes more resistant to corrosion as it experiences weathering. This choice of material should thus have a greater longevity than that of the previous incumbent in this position. It is however tempting to find a symbolic layer of meaning in this selection of patina too. I felt myself signposted to how this place has endured the hardship of deindustrialisation, yet will incorporate that past into efforts to sustain its future.

whose rusted surface belied its ability to resist corrosion (see **figure 5.1**). A smooth-surfaced trail escorted me on a route parallel to the loch shoreline, whilst a series of freshly constructed drainage ditches ensured that I did not become mired in saturated ground. Interpretation boards illuminated aspects of the site's history and ecology, and at certain points, I could even pause to contemplate these features on newly installed benches. Repeated visits in between these first and final trips, each spread a number of months apart, allowed me to observe a kind of protracted stop-motion reel of landscape modifications, where gradual changes, progressing by degrees each day, appeared sudden and startling to me. Due to the jumps in time between my trips, construction work seemed to bloom out of the landscape in every direction, whilst the skeletal etchings of new buildings, car parks and pathways on its surface became abruptly fulfilled, and then suddenly occupied by fellow visitors.

Throughout the span of time encompassed by my successive visits, I found that the regeneration project work intersected with the site's slag with varying degrees of intent. The slag's presence was most obviously highlighted by its own

interpretation board, which had been placed at one end of the new 5km route that traversed the park. The interpretation board explained how the deposition of slag into the loch had caused the waterbody's extent to alter through time (see **figure 5.2**). Yet the chosen location of this source of information gave me pause – positioned on the south-eastern shoreline of Kilbirnie Loch, opposite the slag-formed peninsula it was in part depicting, the interpretation board was placed at a physical remove from the artificial landform it described. This situation probably afforded the best view of the slag's described *effects*, but consequently offered little

opportunity for one to be *affected by* this anthropogenic geomaterial. Indeed, on the whole, I noticed that the Lochshore's slag did not itself appear to have been deliberately affected by regeneration project. For the most part, it lay along the shoreline of Kilbirnie Loch in much the same state as I had originally encountered it – forming a surface layer, overlain in some places by a bewildering jumble of anthropogenic objects, and in others, petrifying these entities in its conglomerated bulk. Further inland however, some changes had been unintentionally wrought by the construction work. The digging of the new path's foundations had cast previously buried slag onto and along the margins of this route, whilst the construction of drainage ditches had cut fresh, vertical exposures of slag stratigraphy into the landscape. There was nothing to suggest that these alterations were anything other than the unavoidable results of construction – yet rather than being 'tidied away' once the first phase of regeneration work was complete, I was struck that the slag remained, visible and accessible. Anna Storm's (2014:7) conceptualisation of 'undefined post-industrial landscape scars' — that is, "... places and processes that are... left outside the arena of contemporary heritage recognition" — captures the potential affordances of this situation well. Beyond a (justifiably) distant interpretation board depiction, both the Glengarnock's slag's enduring and recently exposed material remains were not incorporated into the Lochshore Park's heritage narrative. Storm however recognises that these kinds of marginal materials, if opened up to be encountered in



Figure 5.2: An interpretation board installed in the Lochshore Park, depicting how slag deposition altered the shape and extent of Kilbirnie Loch through time. A series of map records, held by the National Library of Scotland (extracts of which are reproduced on the bottom right of the board) can be used to gauge the past topography of this landscape from the 1850s to the present day. The central picture on the right hand side of the board shows the slag which can be found on the opposite shoreline of the loch.

their "... liminal, uncertain position", can represent an opportunity to envision new forms of temporal storytelling, as their resistance to easy narration complicates our efforts "... both to look back to the past and forward to the future" (ibid:19).

In this chapter then, I will investigate how the Glengarnock slag's legacies could be encountered differently, through a more intimate form of engagement with this material in the landscape it both occupies and constitutes. By exploring the multiple temporalities that this slag holds, I will also consider if some of the disorientation I felt when first visiting the former steelworks site can be retained in a place that is becoming more interpreted, and put in productive conversation with the question of how to approach heritage in and of the Anthropocene. It is important to stress at this juncture that in doing so, I do not wish to adopt a position that is critical of the decisions made by those who devised and realised the forms of heritage interpretation that I met whilst exploring the regenerated Lochshore site. Although my opportunities to observe the inner workings of the regeneration process were limited, it was evident that the matter of integrating the area's industrialised past within the new park was approached carefully, through repeated consultations with the local community. The result is an assortment of already-accomplished and still-planned-for developments which actively commemorate and celebrate the history of this place. I however wish to consider how this thesis chapter might contribute a distinctive addition to the ongoing creation of this place's heritage. Having conducted this work in the throes and aftermath of the first phase of this site's regeneration, I will chart the evolution of a personal engagement with the Lochshore slag, generated through my struggles to answer the questions it posed. I will adopt an approach that is grounded in archaeological methods, but I will also pay attention to how these techniques became metamorphosed, both by the interpretive challenges posed by the slag I worked with, and resulting interdisciplinary conversations with human geography and geological perspectives.

This chapter will next turn to consider literatures, in both historical geography and contemporary archaeology, that explore the role of the present and future in heritage practice. I will then think through how these ideas can be put in conversation with post-industrial landscape deposits. The chapter will subsequently outline how I developed a fieldwork practice based upon interdisciplinary adaptations of traditional archaeological survey methods, and reflect upon how this can be used to create instances of everyday heritage. Finally, drawing upon Lorimer's (2019) notion of 'passing places' and Di Paola and

Ciccarelli's (2022) characterisations of disorientation in 'Mashed Up Anthropocene Environments', the chapter will present a narrative essay, guiding the reader through four multitemporal stories of encountering dynamism, difference and doubt.

2. Finding alternative heritage futures in post-industrial wastes

In the last of a series of reports which sought to excavate emerging forms of historical geography research, McGeachan (2017) pinpoints the latent connections between historical geography and contemporary archaeology as deserving of increased attention. In particular, she draws upon Michael Shanks (2016) notion of the 'archaeological imagination' and the manner in which this conceptualisation foregrounds the "'creative impulse'... operating at the heart of archaeological practice" (Shanks, 2016:17, in McGeachan, 2017:353). It is interesting to note that Shanks himself, in reflecting upon the longer genealogy of his conceptualisation, credits the shared disciplinary struggles of geography and archaeology as a central influence in its gestation. Working in an unusually interdisciplinary environment at the University of Wales, Lampeter, in the early 1990s, Shanks' human geography and archaeology colleagues identified a common interest in building bridges across the humanities/sciences divide present in each discipline. A particular focus for Shanks was integrating an appreciation of our own individual endeavour and experience into more general understandings of archaeological practice. Yet the idea of the *geographical* imagination, in its various guises, partly inspired Shanks' developing exploration of how archaeologists perform their disciplinary identities. The way in which the geographical imagination situated the means by which we produce geographical knowledge (and thus act within and upon the world) within an individual's capacity to envision, represent and render space illuminated for Shanks the personal and generative labour of producing archaeological knowledge. Everyday practices, such as excavation, cataloguing, writing and presenting thus emerged for him as "creative and constitutive" knowledge interventions in the present, generated by engagements with "the remains of the past" (Shanks, 2016:17-18; see also Hill, 2015, on how Shanks' archaeological imagination has opened up opportunities for contemporary archaeology to 'push at the boundaries' of other disciplines). Efforts in an Anglophone context to pursue a form of archaeology with the remains of a more contemporary past had remained marginal until scholars such as Shanks engaged with questions as to how archaeology was done (Harrison, 2016). The sub-discipline of

contemporary archaeology continued to attract those questioning disciplinary praxis, until it experienced a “relative explosion” of interest in the early 2000s. This enthusiasm was driven by the ability of the contemporary archaeological gaze “to destabilize aspects of contemporary quotidian life that would otherwise be overlooked” – and in particular, to highlight the silencing of voices at the margins of past and modern day societies (ibid:167). McGeachan (2017:353) argues that these insights reflect a similarly timed turn towards creative practice in historical geography, as experimentation with new ways of “... doing, interpreting and telling the past” in the now is particularly evident in instances where historical geographers are faced with seemingly unsurmountable archival absences, which push the agency of the researcher’s attempts to retrieve fragmentary knowledges of these neglected pasts to the foreground (see also Lorimer, 2010:267 on how this embrace of researcher positionality, especially since the turn of the millennium, has altered “methodological inclination” in historical geography “... from the predominantly arithmetical to the knowingly artful”).

This question— of how to respond to our own role in the constitution of the past — has continued to resound and draw out new responses in both historical geography and contemporary archaeology. Recently, Marković (2024:27) has worked with the idea of the ‘specious present’ (from Dodgshon, 2008) to argue that as the past and future are, first and foremost, projections crafted in the now, so the “partiality, contingency and situatedness” of the historical geographer must be considered an onto-epistemological constant, underlying our fundamental conception of time (rather than simply a prompt for increased reflexivity in archival praxis). This assertion, he notes, is not a novel contention newly brought by himself to the attention of historical geographers – it is instead an explicit expression of a theme that has been developing in the work of those interested in spaces typically considered to constitute the material remnants of the past. Places such as ruins (DeSilvey, 2019) heritage assemblages (Edensor, 2023) and former slave plantations (McKittrick, 2013 – all in Marković, 2024) have instead been conceptualised as “sites of spatial continuity” where a perceived march of progress from the past to the present is rejected in favour of a curiosity as to how the passage of time is realised in our contemporary understandings of multiple temporalities (ibid:35). Such work thus concentrates upon “... the types of historical geographies that emerge in the research encounter” (ibid). Similar attempts to realise this sense of situated ‘polychronicity’ (ibid) can also be found in research that seeks to enrol the Anthropocene in new understandings of our temporal agencies. Often writing from the

intersection of geographical and archaeological praxis, DeSilvey invites us to “experiment with other ways of storytelling... framing histories around movement rather than stasis, and drawing connections between past dynamism and future process” (DeSilvey, 2012:31). Whilst contemporary archaeology’s status as “a material-discursive intervention in the present” is now generally acknowledged (Harrison, 2016:170), scholars in this area have also suggested that we take the step to consider how “emergent futures” are assembled from the ongoing legacies of the past (ibid:165). Practices in and around heritage spaces have received particular attention in this vein, especially in terms of the received philosophies that the maintenance of such spaces operate through. Writing from within the field of critical heritage studies, archaeologists Colin Sterling and Rodney Harrison (2023) trace how a myriad of forces associated with the advent of late modernity interrupted Western ideas of inheritance as a straightforwardly linear progression (see also Harrison, 2013; Harrison and Schofield, 2010). The resulting separation of a ‘historic’ past and a ‘modern’ present led, they argue, to a vision of heritage practice focussed upon preserving the remnants of bygone times into the far future. Such efforts are in part driven by a sense of risk, as our capacity to perpetuate the long-ago is hampered by its distance from today, and thus haunted by the threat of degrading memories and materials. As the Anthropocene concept has emerged as a potential new ‘rupture’ in our understandings of time, those working at the interface of historical geography, contemporary archaeology and critical heritage studies have thus recently engaged with how new spaces of heritage in and of the Anthropocene might function.

This work has taken particular form in the *Heritage Futures* project, an interdisciplinary collaboration that sought to examine the means by which sites which lie outwith typical notions of ‘heritage spaces’ can also collate and care for the inheritance of the past in the present, into a multiplicity of possible futures. The resultingly wide-ranging exploration of alternative heritage sites encompasses such varied settings as homes, laboratories, data banks, national parks, rewilding landscapes and outer space (Harrison et al, 2020). One example of especial pertinence here however concerns sites of deposition. Spaces such as seed banks or nuclear waste storage sites are designed—voluntarily or through necessity—to perpetuate material remains of our agency into the future. In this way, ungerminated seeds or canisters of high level nuclear waste are, as Harrison (2020) points out, remarkably similar to more conventional heritage objects – all have a sense of redundancy tied up in their identities; all require active care and maintenance for their upkeep; and all occupy ‘other’ spaces, kept separate from those of the everyday. Some of these delineations do not however necessarily

hold up when applied to the site of waste deposition at the centre of this thesis. The Glengarnock Steelwork's slag has not been subject to especial care in order to extend its afterlife – indeed, its endurance is owed in part to its neglect (as well as to its material fixity). It could perhaps once have been regarded as occupying an ‘other’ space— constituting a landscape of relative post-industrial seclusion— but as we have seen, it now exists in the midst of an intentionally re-populated place of recreation. The contributors to the *Heritage Futures* project note however that their intention in delving into particular case studies was to “open up” new spaces and means of approaching heritage-making practices, “rather than [to] close down” future research in this area through the sometimes context-specific conclusions they reached (Harrison et al, 2020:487). I will therefore turn finally here to consider literature that engages with how best to enact different, future forms of heritage practice through the particular geographies and materialities of formerly deindustrialised sites.

In a paper entitled ‘Making Sense of the Future: Valuing Industrial Heritage in the Anthropocene’, Ingrid Birkeland notes that recent confluences of enquiry around heritage enactment and planetary futures echo what has already been observed by industrial heritage practitioners for some time – that approaches to heritage can be re-assembled to re-imagine and realise different futures for places that were once considered to simply be without one (Birkeland, 2017). She reminds the reader that despite increased public policy interest in the preservation of industrial heritage (particularly in a European context) post-industrial sites were not long ago (and indeed, in many cases continue to be, see Spivak, 2023) considered too problematically *recent*, compared to more mainstream, appropriately ‘historic’ heritage spaces. Birkeland argues that there is thus still much to be gleaned about alternative heritage practices from the afterlives of regenerated post-industrial places. For instance, tracing how the stories told about a place's past have enacted visions of a sustainable future can also reveal the particular meaning these terms held for those re-writing these narratives. In this way, the rendering and re-use of industrial heritage sites has been employed to overcome inherited socio-economic deprivation through a modern-day celebration of a past inhabited before such conditions were wrought (Dicks, 2000 in Birkeland, 2017). Yet questions remain as to how newly sustainable futures might be differently conceived by the histories we enact in now regenerated post-industrial spaces today. Some attention in this vein has also been paid to the varying temporal experiences that can arise through engagements with specific remnants of former industrial sites. Heatherington et al (2019:31) dub these materials “time edges” whilst Wheeler (2014:23) describes them as “unconserved features.” Both are

referring to material traces of the industrial past that have become imaginatively conceived as existing outwith deliberately engineered heritage narratives – even as they physically lie within places that employ these histories to sustain futures therein. In Chapter 2, I explored how Anna Storm’s (2014:7) ‘undefined post-industrial landscape scars’ capture the unnarrated nature of some post-industrial material afterlives. Yet once they are apprehended— often within a changing heritage context— Storm’s ‘undefined’ scars are “... marked by an integral potential to gravitate towards” other, clearer meanings, becoming recognised as ‘ruined’ or ‘re-used.’ By contrast, Heatherington and Wheeler’s work examines post-industrial deposits that retain a more open-ended sense of interpretative vagueness, even as they become perceived and recognised as originating in the past. They point to the same reason for this divergence – the ‘naturalisation’ of these remnants through time into the landscapes that hold them. This process often prevents recognition of these entities’ former lives, but for those in the know, “alternative, and sometimes unforeseen narratives” can also be revealed (Heatherington et al, 2019:32). Instead of existing ‘frozen in time’, interviews conducted with those who apprehended these traces revealed a recognition of their perpetual transformation through processes such as weathering and vegetation colonisation, and thus the nature of their “ongoing, unfinished stories” (Massey, 2006:21, in Wheeler, 2014:31; Heatherington et al, 2019). Interview participants were able to enrol their own ongoing stories, memories and meanings in these remains, which offered a personal, intimate form of heritage experience. Wheeler examines in particular how industrial waste heaps generated by mining practice can “iterate certain histories and knowledges” in this way, as their legacies are “... not formalised but remain, to some extent at least, ambiguous and open to being assigned multifarious meanings” (Wheeler, 2014:30). The conversation opened up by the relics featured in these authors’ work results in a key question, which can be explored through the particularity of other contexts— how can a recognition of the post-industrial deposit’s capacity to grow into new relations and meanings help us move beyond a philosophy of inheritance predicated upon the need to preserve past remnants into their futures?

This brief review has drawn together strands of thought present in both historical geography and contemporary archaeology regarding the means by which a researcher can act to constitute the past in their present. It has also examined areas of literature where these sub-disciplinary interests have coalesced around exploring the role of heritage practice in assembling futures in and of place. I have surveyed how regenerated post-industrial sites have

employed heritage narratives to sustain particular visions of their futures, and have also highlighted the ‘naturalised’ industrial remain, situated within, and yet also apart from these ‘official’ accounts of a place’s past. The questions posed by these relics— on how best to realise their potential in generating more personal experiences of a place’s heritage— have illuminated in turn the question of how my research practice might perpetuate a different account of the Lochshore’s slag into the future of this site’s heritage narratives. In asking this question, I will contribute to a wider opening-out around how this particular post-industrial site might be understood, but also to a broader enquiry as to how heritage making practices in post-industrial sites might contribute to a new sustainment of these place’s heritage futures, as a means of exploring Anthropocene legacies.

I will next outline how I built an approach to tracing my own role in the process of creating knowledge about the past, and examine how this work intersected with particular conditions posed by my research context, as well as by the slag materialities that I encountered.

3. Evolving archaeological practice in a transforming landscape

Harrison (2013) suggests that the fields of archaeology and heritage have a particularly close relationship, as archaeological methods can be used to produce heritage (through processes such as excavation, retrieval, preservation and display) but can also therefore offer a lens through which to examine the production of heritage itself. I will build upon Harrison’s proposal here by turning this investigative lens to focus upon my own archaeological practice. I will trace how the methods I started with (field walking and stratigraphic analysis – both considered core components of the archaeologist’s toolkit) became necessarily altered when I tried to apply them within the context of an actively transforming landscape.²⁹ I will also track how I consequently adjusted my approach by putting these traditional archaeological methods in interdisciplinary conversation with human geography and geological perspectives. Lorimer (2010:258) captures my resultingly reactive research design process well, observing “amidst any cross-disciplinary traffic of ideas and techniques concerning the fragmentary past, the specifics of methods can still be hard to pre-plan. More likely, they are fallen upon, or opportunistically designed.” Throughout this section then, I

²⁹ Harrison (2011) notes that practitioners of contemporary archaeology often use established archaeological methods in their research, seeking not to completely rework these traditional approaches, but instead to modify them to produce more diverse ways of creating knowledge.

will reflect upon this responsively interdisciplinary approach to archaeological practice, cast in a context where both heritage narratives and the physical landscape around me were being re-shaped in real time. I will also set up a consideration of how these adaptations to established tools of heritage production might open up more multifaceted spaces of engagement with the past in the present.

3.1 Field Waking Surface Archaeologies

In his preface to *Ethnographies of Archaeological Practice*, Edgeworth (2006) admits that an attempt to research archaeologists themselves might be considered an unusual step by those working within this discipline. Yet subsequent chapters in this book reveal a common theme – that there are certain experiences which are tacitly recognised as being central to shaping an archaeological identity, and amongst these, the field school, the excavation, and the communality of archaeological endeavour are considered foundational. Indeed, in early August 2021, I experienced the significance of these practices first hand. I was invited to join the University of Glasgow’s Archaeology Field School, which involved a two week long investigation on and around Cochno Hill, north-west of Glasgow. The field school comprised a key training opportunity for undergraduate archaeology students, and I was welcomed into the fold to learn alongside them. The field school cleaved along two crucial undertakings – our first week was spent deciding where to dig, and the second upon the dig itself. Although I could not attend the week of the excavation, I was able to participate in a number of pre-excavation practices, which emerged as constituting both a means to survey the landscape, but also a way to inform and build collective consensus on which fragment of that whole we would choose to exhume, and thus build new knowledges from.

It had been my initial intention to work with a group of archaeology students and staff to recreate this field experience at Glengarnock. As I had done at Cochno, I envisioned that we would firstly conduct a field walkover survey. Wright (2023:969) observes that “walking around systematically looking at the ground... is the survey equivalent of digging the dirt on an excavation”, as loci of potential value, held within the matrix of a wider area, are discerned. Each member of the team would be successively placed a few metres to the side of the next, to form a transect of archaeologists across the landscape. We would then commence our walk, tracing multiple perpendicular routes away from this baseline, as each of us forged a path forwards from our own starting point. Eyes down, we would survey the ground in front

of us, pausing to place small flags at any potential features to enable us to return later to consider them together. Revisiting these markers, we would then decide where best warranted the sinking of an excavation test pit, to examine the stratigraphy of the slag underfoot. These plans were however not to be. As outlined in Chapter 3, site access became severely restricted as construction work for the regeneration project spread across the landscape. North Ayrshire Council kindly granted me permission to walk over the site if I gave prior notice to the team working on the construction project, but for health and safety reasons, access was largely to be an individual endeavour only. A subsequent conversation with the construction team leader revealed further complications. Intrigued by my interest in the site's industrial waste, he pulled out his phone and showed me a picture of a fractured piece of construction equipment. He recounted how the steel breaker attachment on his team's excavation vehicle shattered when it came into contact with the unyielding slag. My lingering hopes of excavation were dispelled by the material obduracy of the very material I wished to unearth. I therefore found myself having to shape a Lochshore field practice that looked very different to that of my archaeology field school experience. My work would be conducted with the company of a far smaller community of practice, and an archaeological dig—commonly understood as a key practice through which “... individuals are turned into archaeologists” (Jacobs and Van Reybrouck, 2006:33)—would not occur.

Some archaeologists have however voluntarily turned away from excavating the subterranean in their work. Harrison (2011) for instance proposes the surface assemblage could form a key type of deposit for contemporary archaeologists to study, depicting these traces as jumbled together, with items deposited at many different times occupying the same horizontal space. Smykowski and Stobiecka (2022) also pick up on the archaeological value of the surface, arguing that it is where those studying the Anthropocene should turn to see this proposed epoch revealed to us. Using plasticrusts (conglomerates of plastic and natural rock) found on the coast of Lanzarote as an example, they contend that the walkover survey could thus be re-adapted to explore the present and emergent futures of places that exist at the “unruly edges” (Tsing, 2015:20) of conventional heritage practice. These connections, between a contemporary archaeology of the surface, and the readaptation of the walkover survey, were realised in Map Orkney Month, an archaeological project situated within a wider, yearlong endeavour titled ‘Public Archaeology 2015’ (Lee and Thomas, 2015). Map Orkney Month's aim was to “... take the idea of a walkover survey and unfold it” (Lee, 2018:7) by combining data recorded by residents of and visitors to the archipelago, to produce a “counter map... an

unfamiliar Orkney, revealed through the creativity and experience of its inhabitants and contributors from the outside” (ibid:1). By opening up the means of producing archaeological knowledge to the non-archaeologist, the traditional role of the walkover survey— as a tool for authoritative voices to discern and decide what is and is not of archaeological value— was subverted. The project’s foregrounding of alternative knowledges of place instead therefore enabled the walkover survey to be positioned as a means of “... capturing the way that heritage is woven into everyday life” (ibid).

The ideas behind Map Orkney Month were influential in the development of my own Lochshore walkover practice in two main ways. Firstly, the project paid attention to how archaeological fieldwork can produce new representations and understandings of place. This chimes with what cultural-historical geographer Hayden Lorimer (2019:332) identifies as a central concern in human geography, as the idea of place has been continuously “re-visited and re-invented” for several decades. Yet he also observes that despite this work, the facility to articulate a ‘sense of place’ remains one which can be hard to grasp. Residing somewhere in the relationship between locality and emotion, a sense of place can be established through the act of paying attention. It can however become especially illuminated when change occurs therein. Fear can coalesce around this ‘passing’ of a place, as something irreplaceable in its nature is anticipated to be lost, but an alternative feeling of situated immersion in a deeper, ongoing narrative can also arise. Lorimer characterises spaces where this dynamic plays out as ‘passing places’ – sites that orientate us from “the remembered past... [to] a past now being rewritten in the name of the future” (ibid:342). Passing places can be formed in instances of change where the forces that have shaped them instead come to herald their destruction. During Lorimer’s visits to a place that had become deeply meaningful to him, oncoming coastal erosion lapped at the edges of his consciousness, invoking a sensitivity to future grief, and informing his awareness that “... this place seems destined to be consumed by itself, incapable of holding back the tidal forces that have daily been part of its scenic drama” (ibid). DeSilvey (2012) observes that such places can ask big questions of conventional heritage practices, as our instincts to conserve or preserve are confronted with the enormity of change wrought by planetary crises.

I found these confluences of thought echoed in a key instruction provided by the organisers of Map Orkney Month to participants preparing to engage in their own walkover practice: “Your site doesn’t have to be archaeological or heritage related. It will *become* a site through

you recording it” (Lee, 2016:10). By asking participants to pay a particular kind of archaeological attention to sites that held a personal sense of place, locations or entities not formally recognised as constituting ‘heritage’ could nonetheless be put in conversation with these wider questions facing heritage future making practices. I approached my walkover survey of the Lochshore slag peninsula in this spirit, returning again and again to visit the site in all seasons, to try to orientate myself within its transforming nature. I took field notes, video recordings and photographs during each of these trips, and subsequently reviewing these records allowed me to identify a succession of reoccurring points of pause, where elements of this slag landscape, through either their endurance or emergence, had evidently repeatedly caught and held my attention. Starting my walkover from a shifting baseline, where — adapting Lorimer’s phrasing — the ‘remembered past’ of the Glengarnock Steelwork’s slag is fading, and gradually treading my own route through the ways in which this material is being and could be ‘re-written in the name of the future’, I was able to build my own map of personal ‘passing places’, to consider how alternative acts of heritage future making practice could be realised here.

The second way in which the Map Orkney Month project influenced my own methodology here was through the “freeing” influence that interdisciplinarity brought to the organisers’ approach (Lee, 2018:154). Lee in particular credits the influence of experimental geographies in opening up ideas around how contemporary archaeology could be performed as a shared experience. Last (2012) describes experimental geography as a field primarily characterised by its diversity – but does observe that those who call themselves experimental geographers generally tend to be self-reflexive about their role in the research process, often by seeking new ways of doing or relating to conventional methods. Kullman (2013:888) concurs, highlighting that for experimental geographers, “... the a priori shape assumed by any given method becomes less interesting than the actual transformation that it undergoes during the research process.” In this way, methods, whether ‘new’ or ‘old’ can be recognised as ‘experimental’ and be responsive to the situated nature of the places they are employed in. The Map Orkney Month team harnessed this source of inspiration to argue that contemporary archaeology *has* to embrace experiment in this way, in order to realise its potential in exploring different means of producing archaeological knowledge (Lee, 2018). Crucially, the extra-disciplinary influence that gave rise to this commitment also assisted in positioning the integration of diverse forms of knowledge as a central tenet of the team’s approach. Lee (2016:18) observes that the transmission of education around how archaeologists represent

space is often conducted in a ‘top down’ manner, through for instance, the nonetheless “collaborative and relatively egalitarian” environment of the archaeological field school excavation process. Yet by inviting non-archaeologists to conduct their own walkover surveys, informed not by the circulation of formal training, but instead by an encouragement to share their own perspectives, an alternative approach to the co-production of place and heritage was explored.

I was influenced by elements of this approach in turn, as I organised a Lochshore outing which would enable me to capture different perspectives in conversation, whilst tracing the ghostly lines³⁰ of my previous walkovers. As my time visiting and re-visiting the Lochshore progressed, I was able to become better acquainted with the construction work team leader. I am very grateful to him, as his ongoing accommodation of my work enabled me to supplement my primarily individual practice with a larger group visit to the site, in March 2023. I was accompanied on this trip by my three supervisors (Professor Simon Naylor, Dr Kenny Brophy and Dr John MacDonald) as well as Ben, a former steelworker and local charity representative, who I had met through attending a meeting of the Lochshore Development Group in September 2022.³¹ We were also joined by Lizzie Robertson, a PhD student in the School of Archaeology at Glasgow University. Lizzie works to counter prevalent imaginaries of the Scottish Highlands as an unoccupied expanse of wilderness, through employing immersive soundscapes to explore the myriad of past and present, human and non-human lives within particular Highland places.³² Bringing some of the equipment she uses in her research to the Lochshore visit, she recorded our conversations using both a shotgun microphone (to pick up individual voices) and a bi-directional microphone (to capture multidirectional group discussions, and ambient noise). As the microphones followed Lizzie, and thus not where I necessarily walked, I was able to latterly witness conversations which I was not always a part of, as the group continually splintered and re-formed throughout our walkover. I could therefore hear a greater range of interactions than those simply captured through my experience of the trip. The result was a series of transcribed

³⁰ I draw this phrase from Tim Ingold’s (2016:50) book *Lines: A Brief History*. He describes ‘ghostly lines’ as those which can be represented by means of media such as words or maps, but which “... have no physical counterpart in the world.”

³¹ This name has been chosen as a pseudonym. Extracts from a separate interview I conducted with Ben will be featured in the next chapter.

³² Further information about Lizzie’s PhD research can be found at this blog post, which is featured on the Scottish Archaeological Research Framework website: Robertson (2023) [ECR Case Study: Performing Glencoe – Sounding out a Creative practice for Digital Archaeologists in Highland Landscapes | The Scottish Archaeological Research Framework \(scarf.scot\)](https://www.scarf.scot/)

sound files, which offered an insight into the sharing and questioning of received knowledge around me, as we collectively explored our understandings of the Anthropocene and its traces, trying to make sense of the slag surrounding us. I was thus able to present the results of this collective walk as a further layer upon my map of personal ‘passing places’, by tracing how the passage of different voices and perspectives through this landscape wove between and alighted upon these points of pause, sparking off further engagements with this space and revealing its multiple temporalities.

3.2 Stratigraphy and Social Media

One passing place that I re-visited several times was a vertical cut that had been made in the landscape by excavators, to form a drainage ditch. This action had exposed layers of slag that would otherwise have gone unseen, and presented the opportunity to explore this feature more closely, by means of stratigraphic drawing.³³ Hodder and McAnany (2009:2) observe that archaeologists work at many scales, encompassing entire landscapes to the minutiae of individual objects. Stratigraphy however, forms a key “middle ground... where landscape and artefacts meet.” As such, stratigraphic drawing— employed to produce a lasting record of the exposures that the act of excavation simultaneously uncovers and alters— “... forms the jugular vein of archaeological practice” (ibid:41). In his brief history of stratigraphy in Anglophone archaeology, D’Amore (2014) outlines three distinct movements in thought, each shaped in their own way through their relationships with geological science. Indeed, the idea of stratigraphy was first adopted by 19th century European archaeologists, interested in work being undertaken (particularly by geologist Charles Lyell) to formulate geological divisions of time that intersected with human history. Thus, as geologists argued that the fossilised remains of long-dead organisms could be used to determine the relative ages of rock layers in sequence, so archaeologists began to characterise artefacts as types of human fossil, and tie these to successive stages in our own species’ development. Yet as Rudwick (2008) points out, geological stratigraphy was simultaneously developing to examine how and why the stratigraphic record had come to be. It was not until the mid-20th century however that archaeologists also turned their attention to these questions of formation, by considering the matrix materials, such as soil or rock, surrounding artefacts (D’Amore, 2014).

³³ It is worth noting here the overlaps between my adapted walkover practice and how this method is more traditionally applied – these layers of slag were located through my walkover survey, and as a result, they subsequently underwent a further method of archaeological investigation.

This work initially involved applying the geological principle of uniformitarianism— the assumption that natural processes we observe today have always operated in the same manner throughout earth’s history— to enrol physical and chemical processes, such as sedimentation or weathering, in the creation of the archaeological record itself. Yet others (chief among them Mortimer Wheeler and Edward C. Harris) argued that by studying the interfaces between layers, instances of human action, such as construction or waste deposition, could be seen to contribute to, or disrupt this stratigraphy. The development and practice of a uniquely *archaeological* stratigraphy therefore involved a dissolution of the assumed binary between a naturally formed matrix and socially produced artefacts embedded within it (ibid).

Archaeological understandings of strata have thus grown to resemble a ‘palimpsest’ – a term landscape historians have borrowed from descriptions of monastic manuscripts to denote the complex task of interpreting successive layers of landscape, which overwrite each other, yet do not fully erase what came before (Heatherington et al, 2019). This comparison works especially well when considering how archaeologists impose their own readings of this record onto these many layers, in turn becoming “... involved and entangled, intricately interwoven” in these accretions, variously “interrupting and inhabiting each other” (Dillon, 2015:255, in Heatherington, 2019:20). Yet archaeological stratigraphy also reflects critiques levelled at the palimpsest metaphor, by recognising that nonhuman others also hold the power to write landscape histories (ibid). Meanwhile, in their overview of this field’s genealogies and modern day praxis, Mills et al (2005) record how some practitioners have sustained archaeological stratigraphy’s growth away from its shared roots with geology. As each discipline’s focus on differing timescales has translated into divergent approaches towards viewing the stratigraphic record, archaeologists have often paid attention to the information that can be gleaned from localised, site specific stratigraphic sequences, which would be “... subsumed within the characteristics of larger bodies of rock” for geologists (Stein and Holliday, 2017:1). This focus on a section’s distinct context has left archaeologists generally less interested than geologists in developing globally synchronous systems of stratigraphical categorisation (ibid; see also Mills et al, 2005). Yet despite these shifts, D’Amore (ibid:7093) observes that the influence of geological stratigraphy retains a key role in archaeological stratigraphy, driving in particular how archaeologists visualise the past, as “in the daily tasks of archaeological practice, time is naturalised by the temporal metaphor of... stratigraphy: the passage of time is vertical and sequential.”



Figure 5.3: The author in the process of measuring the depth of a stratigraphic layer. This measurement will be recorded on the stratigraphic drawing, seen balanced on the wall in the foreground of the image (photograph courtesy of Kenny Brophy).

My own stratigraphic drawing practice replicated this way of seeing (see **figure 5.3**). To begin, a line of string, 1.8 metres long, was strung taught at the top of the section. Then, at 20 centimetre increments, I took a vertical measurement between the uniformly horizontal line of the string, and the top of each layer in the deposit. I entered each of these measurements as a dot on a transparent piece of paper, laid over a board with a grid inscribed on it. By then joining these dots to sketch a horizontal line, tracing the undulating top of each layer, I produced an annotated stratigraphic drawing, recording the relative dimensions of each layer and their characteristics. Although this result can seem rather abstracted from the earthy materiality of the original exposure, the process of stratigraphic drawing requires

the researcher to intimately engage with a deposit. By running my fingers across the top of each layer to determine the precise point of its interface with the next, or carefully scraping at the exposure's surface with a trowel to make these demarcations clearer, I became physically enrolled in marking the exposure's stratigraphy, to better understand the slag before me. In their re-imagining of traditional archaeological stratigraphy as 'social stratigraphy', Hodder and McAnany (2009:3) pick up on the agency of the stratigraphic *interpreter* in the co-constitution of larger processes that underlie the reception of past actions. In this way, stratigraphy becomes the product of a "web of human interactions", connecting the researcher and the researched in reciprocal processes such as memorialisation, "... history-building, forgetting, renewing, cleansing and destroying" (ibid:1). The addition of an entombment to the stratigraphic record might thus instigate processes of memorialisation, remembering and history-making; the simultaneous lowering or erasure of another feature may well activate processes of forgetting or destruction. Reactions to Hodder and McAnany's paper— collected

in an issue of *Archaeological Dialogues*— indicate that the practice of archaeological stratigraphy had not necessarily received a great deal of re-theorisation until this publication. Indeed, Helwing (2009:25) opens her response by exclaiming “New thoughts about the use of archaeological stratigraphies! Is this so!” Another contributor’s remarks however pick up on Hodder and McAnany’s focus on pre-historic and ancient sites in their work. Mills (2009:40) highlights the alternative potential that contemporary deposits could hold, in contributing insights into “... the ways in which depositional histories are linked through the practices of both memory and materiality.” Following Mills then, I wished to trace the extent to which social relations could grow out from, and feedback into, stratigraphic enquires made with archaeologically contemporary materials. I did this by putting my stratigraphic practice in conversation with social media.

Archaeologists studying the contemporary past are, uniquely compared to practitioners in the rest of the discipline, able to in some instances access those with living memory of that which is under investigation (Harrison and Schofield, 2010). Yet although there has been a recognition of how oral histories can be employed in this way (see for example, Beck and Sommerville, 2005; Moshenska, 2007) this acknowledgement stands in contrast to contemporary archaeology’s relationship with social media. As Richardson (2019:153) observes, “there is little advice available to the archaeologist... on how to approach digital social research questions from a methodological perspective.”³⁴ There have also been calls from within historical geography for more attention to be paid to the rise of digital methods. Offen (2013) notes that the sub-discipline’s engagement with digital data has primarily progressed through the use of GIS. Yet he also highlights the growth of digital indigenous geographies, where community elders and youth can connect through online spaces. In their study of the production of digital archives by Scottish community heritage groups, Beel et al (2015:209) also recognise the use of these sites as a means of inter-generational knowledge exchange. These efforts reflect “... ongoing concerns with regard to a community’s ability to maintain and pass on cultural traditions to future generations.” Little attention has however been paid in this literature to the role of the researcher as the *receiver* of this reciprocal process.

³⁴ This is not to say that there is little evidence of archaeologists engaging in this practice on social media sites themselves. As just one example, the *After the Garden Festival* project uses posts on Twitter/X to source information from the public on the present day locations of material culture from the 1988 Glasgow Garden Festival (After the Garden Festival, 2022).

My own attempt to position myself in this manner began with a lucky break. I found the KB Steelworks Facebook page only after being directed to it by a fellow attendee following a meeting of the Lochshore Development Group, which I attended in September 2022.

Previous searches for social media pages relating to the Glengarnock Steelworks had returned no results, and I doubt I would have thought to adjust my searches by using the name of the town adjoining Glengarnock— Kilbirnie (KB)— without this insider tip. Once I had joined the page as a group member however, I found it was well subscribed to, with over 400 members and fairly regular posts sharing old photographs and memories of the works. My stratigraphic drawing practice had generated a number of questions, which I posted on the group's page (a full list of these questions can be found in Appendix 2). I was then able to put the responses I received in conversation with my stratigraphic interpretation, to explore in particular the power that gaps in this stratigraphic record exerted upon my construction of alternative heritage narratives surrounding the Lochshore slag's legacies.

4. Narrative Essay

Daniels and Lorimer (2012:3) trace a recent “recuperation of narrative in human geography” – where, in some quarters, a shift has been made from an ‘unselfconscious’ employment of this literary form, to a recognition of “... the nature and value of narratives as a form of expression or interpretation.” This realisation has manifested in a “deeply personalised quality of expression” which has inflected voices in the emergence of the ‘new nature writing’ genre both within and beyond academia especially (ibid:4). Yet this particular ‘quality of expression’ can also vary according to the character of the landscape encountered by a narrator. Daniels and Lorimer (ibid) especially highlight accounts which explore sites which variously exist “after nature” (such as post-industrial waste-scapes). Such “mundane, malign (and) messy” places can make for disorienting encounters, and can leave would-be narrators both humbled and confused as to how best to immerse their readers in their experiences (Lorimer and Parr, 2014:544).

I faced my own challenges in this regard. As a result of my fieldwork, I had generated an assorted collection of handwritten notes. Some, in faded pencil upon rain-splotched paper, were quickly jotted down as I crouched behind improvised shelters, seeking respite from the

winds that often bluster around the exposed slag peninsula that juts out into Kilbirnie Loch. Others were neatly penned as I reclined more comfortably upon some of the Lochshore Park's new benches. Returning to these notes back at my desk however, I became aware that my scribbled thoughts, feelings and impressions largely captured my own sense of bewilderment as I repeatedly attempted to interpret the slag landscape features I walked amongst. The act of constructing a narrative from these notes— of deliberately crafting a re-telling of my encounters, paying particular attention to times when I struggled to do so— gave me a scaffolding upon which to make decipherable my experiences to myself, by practising rendering them legible to others. The resulting 'Narrative Essay' presented here is thus named both to acknowledge the affective qualities of the Lochshore slag landscape, but moreover, to highlight the significance of my conscious attempts to *articulate* my responses to it, as a means of generating research data that I felt I could productively explore and convey. Drawing further inspiration from Hill's (2013a:382) efforts to experiment with a non-conventional academic writing style, I will present a temporally non-linear series of vignettes which respond to her call to "think and write landscape anew" *with* the voices of others. Dwelling in and between four 'passing places' that I encountered during my fieldwork, I will explore the multiple temporalities that they held for both me and my companions.

I also generated a number of images during my fieldwork, both hand drawn and photographic. Following Barthes, archaeologists Hamilakis and Ifantidis (2013:764) recognise that visual representations can "embody two times simultaneously", encompassing "the that-has-been of when the [image] was taken, and the here-and-now of its viewing." For those interested in the multitemporal nature of a particular thing, this duality underscores the fact that "... an object embodies not only the time of its first creation, but also subsequent times, when the very same object... was invested with new meanings and mnemonic weight" (ibid). Here then, I embrace the potential of the image to signify this plurality of meaning making, dispersing a selection of images through my text to evoke the Lochshore's slag landscape, representing my own creation of this slag's narrative here, as well as the reciprocal effects this anthropogenic geo-material had upon my telling.³⁵

³⁵ The first of the photographs that feature in the slag stratigraphy sub section was one of a number kindly shared with me by Professor Michael Given, from the University of Glasgow's School of Archaeology. Michael (whose work with ancient Cypriot copper slag is cited a number of times in this thesis) accompanied myself and Kenny Brophy on a trip to the Lochshore in late Autumn 2022. Despite his considerable experience working with slag heaps, Michael expressed clear amazement at the relative novelty of the Glengarnock slag formations.



Passing Place 1 – The Slag Beach

In the past, before the regeneration project gave new pathways to the slag-landform protruding into Kilbirnie Loch, my approach to this place was marked by the choices of antecedent others. A pair of desire lines had been pressed into the earth, leading in different directions – one drove me towards and along the loch shoreline, the other disappeared into the forested area behind. I always opted for the shoreline path, as this is where I had come to learn that the site's visible slag lay. Now, the new paths also diverge, and the route towards the shoreline has become more formally demarcated.

Yet I soon find myself drawn away from the even sound of gravel crunching under my feet, as my attention is lured from the new route by the sight of another, more recent desire line. Subtler than its predecessors, it strikes out from an expanse of bare earth (still re-vegetating after the construction work), tracing a collective impulse to go down to the water itself. I follow, absconding from the regenerated path, which passes on by. Just beyond the truncated stump of a young tree, I glance to my right and find what at first glance looks like a small

collection of rocks, arranged in an incomplete ring on the ground. Closer inspection reveals this stone circle to be made up of an assortment of natural and anthropogenic materials, including bricks, slate and a piece of broken-up clay pipework. The most likely explanation for its presence is that of an interrupted hearth building project – I have seen other rudimentary fire pits of this kind dotted about, easily distinguished from their surroundings by their charred, blackened centres. Their presence persists, despite the best efforts of newly installed signs, which forbid this activity due to concerns that the fires may get out of hand. Anticipating what lies beyond the end of this desire line however, I cannot help but picture this unfinished circle forming the early life of another feature. In my mind's eye, I envision others treading this informal path in the future, pausing to place another item on this pile of found things, to hint at, and to pay homage to the place they are returning from. Stepping beyond my imagined proto-cairn, I drop down onto the slag beach.

The slag beach is a place that gets stranger the more you look. It is a place where every encounter starts with a question – ‘what is that?’ When I first found the beach, it appeared to be a short stretch of shingle, harbouring clusters of larger rocks, and dotted with the occasional boulder. Yet as I walked across the beach, eyes down, I noticed something unexpected – STE . Taken aback by the sudden presence of letters, I looked closer, and found that they were carved into a squarish looking rock. Crouching down, closer to the ground's surface now, I cast about, soon spotting more letters, and even entire words – DAL – BONNYBRIDGE – CALDE – SBC – STEIN . In a moment, everything resolved, as I realised that these ‘rocks’ were in fact partial or whole bricks, which had been stamped with the name of their manufacturer. The STEIN maker's mark, for example, denoted a key supplier of refractory bricks, used in the construction and lining of industrial furnaces (Scottish Brick History, n.d.). Now I could see that the boulders I had perceived earlier were large wedges of rusted metal, which rang slightly if I kicked them with my boot. I could also see that the vast majority of the beach's substrate was composed of slag. The slag's diversity was striking – I'd pick up one piece, black and surprisingly heavy, and find globules of solid iron incorporated into its (now plausibly weighty) mass. Another sample would resemble a pumice stone, lighter both in colour and weight, with a strand of lichen growing from within one of the many holes that perforated its surface. Some days the slag beach was painted in shades of brown, as dead leaves accumulated amongst the corroded tones of disused tools, and floated upon the rusty hue of loch water pooling in surface depressions. On other days, it was carpeted in green, as invasive Canadian pond weed washed up out of the loch during

winter storms, and mosses colonised the rock and slag faces. Later in the year, when the sun had bleached this vegetal residue to straw, the light glinted off vitrified, metallic and crystalline materials. As natural and unnatural things intermingled, they sometimes became indistinguishable, inviting me to look closer, to touch, and to explore, to try to discern their provenance.



The microphone bearer, Lizzie, was trying to get her eye in.

“So, is the slag the bubbly stuff?” she asks. I agree, but then pause, considering how best to account for this aspect of the slag’s appearance. One of the ways I often try to describe the Lochshore slag landscape to myself and to others is through reaching for geological metaphors. For instance, I often compare the slag beach to volcanic counterparts I have seen on holiday. I pick up two pieces of slag, deliberately selecting dissimilar looking samples, then turn to John, wondering if he could demonstrate that a geological understanding of this place can go beyond the figurative. “So say if I’m holding these two pieces” I begin “See how this one’s very bubbly, and this one’s less bubbly... why is that?” “It depends how its

cooled” John explains. “Think of these as both molten when they come out of the furnace and then they’re just suddenly in contact with the air. This one—” he gestures to the piece of slag weighing less heavily in my hand— “has cooled more quickly, there’ll be a lot more air getting into it, so there’s more bubbles in it. That’s opposed to that one, which cooled more slowly, so it’s denser, with less bubbles in it.” I realise that my volcanic beach metaphor has some basis in reality after all, as I picture white hot slag, spilling from the furnace mouth. John describes how this molten material would have been poured into wheeled wagons, transported by train to the tops of the slag heaps, and then tipped out to flow downslope. I remember one of the oral history accounts captured by the Glengarnock Steelworks Conservation Project, where this activity was likened to tipping fresh buckets of material onto elevated accumulations of waste “... just like a sandcastle” (Mr [redacted] Interviewed 11th January 1980:8). “So if that one got stuck” John continues, pointing to the heavier slag sample, “there’d be less churning motion to introduce air... whereas that other one very possibly went a lot further.”

As we walk on, the microphone picks up an intra-disciplinary conversation between archaeologists Kenny and Lizzie, as the rest of us progress slightly ahead. “It’s definitely the meeting of many materials” Lizzie observes, as we leave the slag beach behind. “Yeah, it’s weird” Kenny agrees, “and it does need a bit of archaeology and a bit of geology to make sense of it all.” He pauses, thinking this statement through, then asks “... because the industrial processes are anthropomorphic processes... why is it the domain of a geologist? When actually it’s the product of human activity? Why is it the domain of John?”

“Sorry?” John doubles back, hearing his name.

“Why are you interested in anthropomorphic material?” Kenny asks him “because geology is all about rocks, and natural – ”

“Tell me why that’s not a rock” John interrupts, holding up a piece of slag. “It’s made of minerals.”

“You’re playing on the edge of boundaries here!” Kenny jokes. “Well, we’re all made of atoms, let’s go down to that level, why not get the quantum physicists in!”

“That’s true, but in terms of its crystallographic structure, that’s a rock, made of minerals”

John explains. “Don’t see why not” he continues “it’s just an anthropogenic one.”

“Do you get push back ever, from other geologists?” I ask, re-joining the conversation.

“Not really, I think they’re just bemused by it” John replies.

Di Paola and Ciccarelli (2022:88) have coined the phrase ‘Mashed Up Anthropocene Environments’ to describe places that have been shaped through the emergence of a state of symbiosis between human influence and natural process. These environments owe their “very existence” to “the dynamic entanglements and agglutinations of the human and non-human, local and planetary... forces and processes that are characteristic of the Anthropocene.” The authors observe that such places can generate a fundamental sense of disorientation within us. Our aesthetic expectations become confounded in these settings, which at first sight seem to conform to received notions of ‘natural’ beauty. Upon closer inspection however, the presence of anthropogenic forces at work is revealed. The ways in which our landscape forming legacies thus become ‘mashed up’ with the flora, fauna and physical processes that constitute a place— in ways that we cannot predict or necessarily control — leads us to question ourselves, and how we see the world. Di Paola and Ciccarelli catalogue three particular ways in which this disorientation can manifest. The first is through what they term ‘phenomenological disorientation.’ They explain:

“Because what a thing is (taken to be) guides the ways in which it is experienced and appreciated, a fundamental source of aesthetic disorientation in the face of a phenomenon or object is not knowing what that phenomenon or object is, or – to put it less grandly and more precisely – not having a clear notion of where and how to place it within the larger context of our experience and systems of significance” (ibid:91).

Hughes (2021) observes that disorientation is not typically treated empirically. Yet during my fieldwalking practice, the experience of phenomenological disorientation was intrinsic to my developing appreciation that each of my passing places held the ability to continuously re-establish what I thought slag was. I routinely registered a sense of discomfort when walking along the slag beach, a sensation that I came in time to recognise as a meeting with the limits of my own comprehension when trying to make sense of this place (Bissel and Gorman-Murray, 2019). This dynamic was particularly evident during attempts at mental organisation through the use of neat categories. For instance, the division between what is natural and what is anthropogenic was disrupted on the slag beach, as I witnessed slag, bricks and scrap

metal masquerading as shingle, rocks and boulders, and later, pioneer species growing on a slag substrate. The conversation that took place between Kenny and John also demonstrates a struggle with established binaries, as the question of where to place slag in an archaeology/geology dualism was raised. Kenny's conflation of archaeology with anthropogenic materials, and geology with natural rocks was challenged by John's reading of the geological in an industrial process. Although John was more comfortable with the notion of an 'anthropogenic rock', he still enrolled slag within his own disciplinary systems of understanding – slag was a rock because it was made of minerals. His colleagues were also "bemused" by his small but significant step away from the materials customarily studied by geologists. Di Paola and Ciccarelli observe that as Mashed Up Anthropocene Environments render the familiar unfamiliar, they can feel "unhomely" (ibid:92). It is perhaps not surprising then that the status of the discipline—the domestic setting in which everyday academic work is generally done—became so quickly destabilised during our group walk on the slag beach.

The discomfiting experience of phenomenological disorientation was captured by Kenny as he described the slag beach as "weird." The word 'weird', Turnbull et al (2022:1207) contend, conveys well "both anthropogenically changed worlds, and the experience of living within them." The authors acknowledge that there are shameful legacies of demarcating and denigrating difference wrapped up in the history of this word. In particular, they point to H.P. Lovecraft's notion of 'Weird fiction', where, informed by his eugenicist convictions, he positions difference as a source of fear. Simultaneously however, the relationship between the use of 'weird' as a descriptor, and the encountering of difference, can be re-claimed in a manner oppositional to this vexed inheritance, as the potential of the unfamiliar to challenge us is approached carefully, and in community. The recognition of weirdness is a social phenomenon, an undertaking that is "... made through relations" and which "... thus differs from subject to subject from group to group" (ibid:1215). As our time spent in the Lochshore landscape lengthened, our own relationships with the weirdness of the slag shifted. My walking companions and I continued to be disorientated by the particular Mashed Up Anthropocene Environment this material produced, yet as we passed through more slag-formed places, we also began to (often belatedly) recognise the role of our own pre-held assumptions in this process.

Later in our walk, Kenny was talking through his changed perceptions surrounding the connections between slag, archaeology and geology. “So this is simultaneously a geological sample and an archaeological find” he observed, gesturing to another piece of slag lying at the side of the path. “Because if you found this in an excavation you’d stick it in a bag and give it a number and record it.” John agreed that he would do the same, and observed that both geologists and archaeologists would subsequently also look at the slag under a microscope when they returned from the field.

“Ultimately it transcends both categories” Kenny concluded.

“Ultimately both would end up in the Molema Building” Lizzie joked, referring to the university building shared by the School of Archaeology and the School of Geographical and Earth Sciences.

The ability of different spaces to foster interdisciplinary community came up again in conversation later, as Lizzie and Kenny hung back to investigate another deposit. “It’s something I’ve never thought about before” Kenny admits, “because... I mean, you find things like fossils on archaeological sites and modified minerals and all that kind of stuff, but it’s never really struck me in the past that geology could be interesting. And so, at first I just took it for granted that... a geologist would look at rocks, and natural stuff, so it’s been quite useful to question disciplinary assumptions.”

“And this kind of material, and this kind of landscape” he went on, “you couldn’t understand one without the other, to try to make sense of it. Although I’m not too sure how often geologists and archaeologists talk about these issues.”

“Even though we’re in the same building” Lizzie again observed.

“That’s how academic disciplinary siloes work” Kenny reflected, “they sort of discourage these kind of connections, that are often made when we do work in landscapes that bring together people with different interests and different skills. It’s a fascinating landscape...” he trailed off, before continuing “but I’m not quite sure what to make of it, or what to do with it.”



Passing Place 2 – The Slag Platform

The resumption of my walks along the regenerated path often did not last long. My eye caught by more ephemeral traces of people's presence— a rusted beer can, tattered plastic bag or an upended, inside-out camping chair, all recent deposits, but indeterminately so— I invariably strayed back to the slag shoreline, where, like with like, this rubbish had been dumped. Further along this margin, the slag becomes more consolidated. The shingly surface of the slag beach is substituted for an expanse of solid material, forming a kind of platform running parallel to the water's edge. This sight is made all the more arresting however by the things that are embedded within this fused mass. A foot of steel girder stands proud of the surface, the rest of its length sunken rigidly into the slag beneath. A bent rail, curving out of its subterranean entrapment, threatens to trip up the unwary, and what appears to be a stone carving of a strip of wire rope, frayed ends splayed realistically, is revealed to be the real thing, petrified hard onto the slag platform's surface. All of this makes the moment of the slag's deposition feel immediate and visceral. Standing here, it is easy to imagine being in the path of another swathe of molten material, rushing down the grassy bank towards the loch,

scrap metal and other miscellaneous works waste held buoyant in its churning flow. Easy to picture too, as John had described, these lava like outpourings being successively released from the steel works and spreading across the landscape, cooling to form its composite layers. My imagination lent the slag an impression of endurance, as I came to see it forming an unchanging base layer, tethering the place transforming around me to its industrial, almost geological, origins.



The microphone picks up a conversation between John and I, as we walk along the slag platform. We are discussing his theory that this place was in fact formed in the period *after* the slag flows cooled. Making sure I've got this right, I ask him if the slag platform is a depositional or post-depositional feature. "So based on some recent analysis I've done" he replies, "I think it's the latter. The reason I say this is that you can break through this—" he indicates the surface beneath our feet—"and I have done at one point, and then you get into just the loose stuff underneath." The slag platform was not then, an uppermost layer overlying decades of solidified slag flows, but in fact a surface crust, which had formed long after the steelworks had stopped operating. John explained that the platform was composed of calcite, which had gradually grown between individual pieces of slag, eventually fusing them

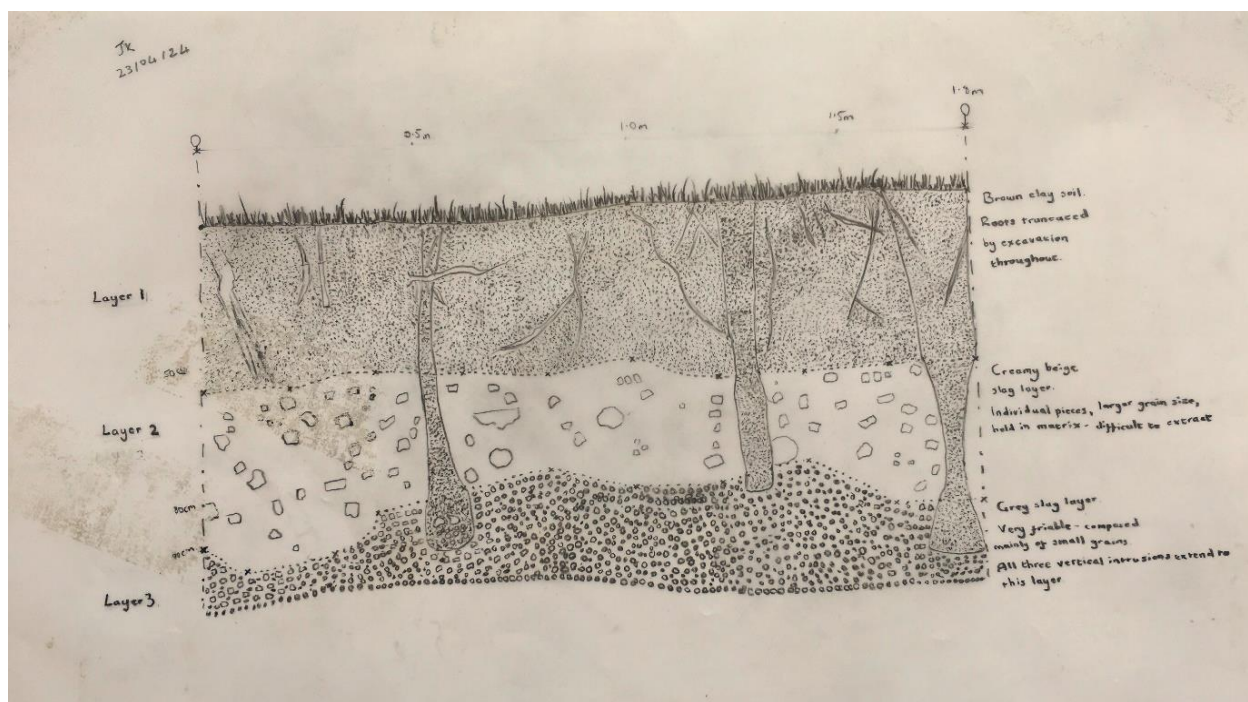
(and other debris items lying in the same place) together. “If you cut a fresh surface of this” said John, indicating the platform, “you’ll see there’s lots of slag, but with a mineralisation between them. That mineralisation is the calcite.” He described how the calcite had formed through the coming together of three elements – the slag itself, water, and air. As the water of Kilbirnie Loch washed over the deposits on its shoreline, it percolated amongst the slag clasts. In these in-between spaces, the water was changed in the presence of the slag’s chemistry, becoming more alkaline. The higher pH of this water in turn drew atmospheric carbon dioxide into this interstitial mixture, resulting in the precipitation of calcite. “So this new mineral has formed after the slag has been deposited” he concluded, “because you need time for that calcium to have leached out of the slag.”

By imbuing the slag platform with a notion of permanence, I had again employed a particular kind of geological metaphor. Yet rather than using comparison to try to convey a description of the unfamiliar, I was conflating the physical landscape with a particular set of values, declaring the preservation of the past captured in the frozen moment where the slag cooled and solidified. In this case however my metaphor did not translate, and the potential for transformation held in the slag’s afterlife took me by surprise. Despite, or perhaps because of my confidence in my initial interpretation of the slag platform’s origins, I had, in the face of John’s revelation, once again become unsettled by this place. In their characterisation of ‘epistemological disorientation’ Di Paola and Ciccarelli advise that my experience is not necessarily an unusual one in the context of Mashed Up Anthropocene Environments. In tracing how a particular place came to be, we position the practice of genealogy as a central means of appreciating our surroundings. In Mashed Up Anthropocene Environments however, the tracing of these histories becomes complicated, as the precise point at which the human begins and the natural ends, or vice versa, cannot be disentangled. I had not made room for the unexpected agency of the non-human in my reading of the slag platform’s origins, and as a result, I laid down my own incomplete knowledge of the liveliness of geological process as the basis upon which I built this false genealogy. In this passing place, my exposure to interdisciplinary conversation had the effect of rewriting this personal history.

Passing Place 3 – Slag Stratigraphy



Running parallel to the length of the path, a narrow gully had gradually taken shape. It was for the most part fairly shallow, and its excavation thus generally revealed only topsoil. At certain points however, more substantial drainage efforts had been realised. The construction of sumps, intended to conduit water outflow under the path and down into the loch, required the construction workers to dig deeper, and so here, more extensive sections of previously subterranean landscape had been uncovered. The time I spent in one such place was mediated through the practice of stratigraphic drawing. By affording what initially looked merely like a pile of earth this particular form of methodological attention, this deposit was visually re-assembled into distinct layers. Working on different occasions with both Kenny and John, I established that the first layer— just over 50 cm deep— consisted of dark brown clay topsoil, punctuated by the roots of trees and earthworm burrows. The next layer fluctuated between 30 to 40 cm in depth, and was formed of slag. It had a much harder, rocky texture, and was a creamy colour, similar to that of the slag platform on the loch shoreline. The final layer, extending to the base of the approximately 1.1 metre deep section, was also slag, yet this looked and felt very different from the material directly above it. It was light grey in colour, and its texture was much more friable, so it was difficult to extract and hold a discrete piece



from the section without it falling into smaller fragments. These horizontal layers were disturbed in three places by vertical intrusions, where something had, at some point in the past, been driven into the ground. Sunk in each case to the depth of the third stratigraphic layer, the subsequent removal of these objects left lacunae, each then infilled by topsoil. I completed my drawing as the section ended at an arbitrary point, extending as far down as the construction workers needed. Its base did not therefore culminate in the choice of a definitive point, such as the top of a new layer. Unable to excavate any further, I stopped by necessity where it stopped, left with no knowledge of what lay beneath.

My attempt to interpret this stratigraphy was predicated upon presence, as the embodied labour of preparing, comparing, measuring and representing the section layers generated a myriad of in-field questions. Yet it was also an experience haunted by my own absence from this landscape in times past. For instance, the question of how each of the stratigraphic layers I discerned had come to be, and why they were so different from each other, would potentially be far more easily answered if I had been here when the slag was tipped. Then again, if, like the slag platform, these layers had changed compared to their initial post deposition form, I could never have been present to track this evolution, progressing as it did over many years, and at least for some of that time, underground. The vertical intrusions that cut into these layers further reminded me that I had not encountered the afterlife of this stratigraphic section until the moment I had drawn it. Knowledge of events that had taken place after the closure of the steelworks, which might have affected the section's present

state, were out of my experiential reach.³⁶ The final facet of disorientation that Di Paola and Ciccarelli (2022:96) identify as symptomatic of encounters with Mashed Up Anthropocene Environments is that of ‘narrative disorientation.’ When constructing a narrative of a place, we attempt to tell “... a story that makes sense of (gives structure and coherence to) a sequence of episodes, and intelligibly assemble them as one unit, and as that unit and not another.” Through working with the stratigraphic section, I had effectively encountered the middle of one such story. Perhaps it was for this reason that I felt the absence of the origins of the stratigraphy’s narrative so strongly – I had arrived too late, and missed the beginning of its tale. Instead, I was now faced with a brief sequence of layers, each an episode in the story of this landscape. Untethered from their wider context however, my only conclusion for this stratigraphy seemed to be the questions I asked of it. During her work in an archive, Steedman (2001:1179) recalls experiencing a false conviction – that the dust rising from the successive pages she leafed through was in fact the final material remnants of the past she sought, previously encased in, and now released from the repository of sources she consulted. Of course in reality, this dust only evidenced the gradual decay of these documents over time, revealing that “the search for the historian’s nostalgia for origins and original referents cannot be performed, because there is actually *nothing there*: only absence, what once was: dust.” As I surveyed the layers of soil and flaky slag before me — which on the hot, dry day that I plotted the section’s basic measurements, did take on a rather dusty texture— I reflected on how these layers of landscape resembled the fragmentary, partial and always somewhat unknowable nature of a documentary archive. Neither space would permit me to remedy the difficulties presented in attempting a second hand reading of past events – yet I could glean fresh insights into the formation of this particular deposit through the sharing of experience, by someone who had personally known some of its recent history.

In order to construct my stratigraphic drawing, I had to come and then go from the section. Once its dimensions were pencilled in, I returned to my desk, and, with the aid of a

³⁶ I did develop various theories around the answers to these questions, speculating that the differences between the layers of slag could be due to how they were deposited, or the chemistry of the steel making furnaces they derived from. The vertical intrusions could have been associated with former processing of slag to produce road aggregate; a result of past environmental sampling work; or simply traces of wooden posts hammered into the ground to mark out the route of the new path. I channelled some of these hypotheses into the questions that I posted on the KL Steelworks page.

photograph, I worked out how to represent what I had seen in the field. In a similar way, the questions I generated in the field subsequently occupied a space that extended beyond the immediate context of my drawing practice, by being granted access to a particular virtual place. My post on the KL Steelworks Facebook page was answered by the group's administrator, Hugh McMillan.³⁷ Hugh had worked at the steelworks for 10 years, until its closure in December 1978. He wrote:

"If you scroll down the pics a fair way there's a pic of the Slag being tipped, an Engine (Pug), a Ladle tipping molten Slag etc, Slag usually broke up sliding down the bank, that was visible as a red glow at night, occasionally the crust on the outside would hold and allow a ball to reach the Loch, that would result sometimes in a fair old bang as the molten slag hit the water!"



I found the picture Hugh described, and was immediately struck by how different its slag looked when compared in particular to the first slag layer I had observed in the stratigraphic section. The colours did not match – the just-tipped slag was charcoal black, and as Hugh described, it also broke up as it was deposited. It in no way resembled the section's cream

³⁷ I am extremely thankful to Hugh for his permission to use his words here, and also for allowing me to reproduce a photograph that was taken by a late friend, and passed on to him.

coloured slag, where individual pieces were difficult to extract from the matrix that held them. By juxtaposing images from the past and present, and through conversations with John, I realised that this difference actually held a story already familiar to me. The cream coloured slag had reminded me of the slag platform on the loch shoreline for good reason – the same process was occurring in both. Here however, the slag lay under half a metre of soil cover, and so the water and air ingress needed to form calcite was limited. The calcite that did spread into the spaces between the slag, binding them together, thus only extended so far down from the top of the stratigraphic section. It was then succeeded by the preceding layer, which had not been affected by this process.

The other part of Hugh's reply referenced a story that I had thought I knew. The part played by slag in this tale was however completely new to me:³⁸

"The Slag Hill was removed over years to be used to build the Lagoons at Hunterston, it was meant to be an integrated Steelworks in a plan by Monty Finnieston the then BSC Chairman, that was scuppered by the Government and it ultimately became the Ore Terminal, now the Peelports site, the movement was carried out by WHMalcolm, Yuill and Dodds, and Brogan by road, no doubt they could tell the tonnage moved, there was also some slag waste from old ironworks in Kilwinning used, hope this helps."

In 1967, the Glengarnock Steelworks was amalgamated into the British Steel Corporation (BSC), which came under the chairmanship of Monty Finnieston in 1974. The editor of the Manpower Report (Charman, 1981:29) observes that "it had always been intended that, following nationalisation, the operations of the Corporation should be rationalised and modernised" and as part of these efforts, the furnace technology employed at Glengarnock was deemed outdated. Meanwhile, renewed industrial activity was commencing a few miles

³⁸ The observant reader may recall that the partial removal of Slag Hill is mentioned in an extract from an oral history interview featured in Chapter 4 of this thesis, as Glengarnock's local GP was recorded remarking upon this fact. I will admit here that my memory is in comparison far less sharp, and so I had forgotten this particular detail by the time I was in contact with Hugh. For this reason, his account of the movement of slag from the former steelworks site was indeed a surprise, but it is worth noting that the information regarding its destination was completely new to me.

to the west of the Garnock Valley, on the coast at Hunterston.³⁹ Between 1974 and 1979, a new deep water terminal was constructed here, to receive imported shipments of iron ore (Hunterston Coal Terminal, 2019) The initial intention was that metal working would take place at this location itself, but this ambition was never realised (ibid). Instead, the iron ore was transported to the Ravenscraig Steelworks in Scotland's central belt, where modern Basic Oxygen Steelmaking furnaces had been installed in 1964 (Payne, 1979). The Hunterston terminal came under the ownership of Peel Ports in 2003, and ceased operating in 2016.

Two of the oral history interviews collected by the Manpower Project make mention of these events. Opportunities arising from the new terminal's presence are discussed during a conversation with the manager of both the Glengarnock Mill and the Hunterston Iron Ore Terminal. He describes how workers recruited from the Glengarnock Steelworks to the terminal adapted to this change in their workplace:

“Manager: They’ve done extremely well. And I’m delighted with the ones that we have got from here. As I said I would have liked to get more from here – you know, built up the entire force from Glengarnock.

Interviewer: Yes, it would have been some way of making up to the people of Glengarnock—you know, a bit—for the closure of the Melting Shop.

Manager: It would have been; and that is what the Corporation had in mind – that even although we were closing down the Melting Shop, jobs were available at Hunterston” (Mr [Redacted] Interviewed 4th August 1980:6).

As selected extracts from an interview with the Scottish Divisional Officer to the Iron and Steel Trade Confederation illustrate however, the connection between Glengarnock and Hunterston had originally been hoped to perpetuate the survival of the works itself:

³⁹ I have already mentioned Hunterston in this thesis, in the context of its recently previously operational nuclear power station. The station derives its name from the Hunterston Estate, large areas of which were subject to compulsory purchase orders to accommodate various industrial activities in the latter half of the previous century (Virtual Hunterston, 2021). Nuclear power generation has been present here since the 1960s— there is also another nuclear power station at this site, Hunterston A, which entered decommissioning in the 1990s— and the Hunterston Port described in this chapter, which lies slightly further up the coast, also takes its name from this original estate.

“To me Glengarnock was a first class works. It wis a very economical works – very viable, very economical. Unfortunately, the people who owned it— Colvilles— wouldnae spend any money and now the chickens have come home to roost. That’s how it closed... The closure [interviewer’s note: ‘of Glengarnock’] – certainly we fought the closure. And we had a tough campaign because the B.S.C. just— not because they didn’t want this place— but that was part of the programme... The closure of the Melting Shop, we accepted... the methods of making steel by the open hearth process were outdated, were technologically too expensive... But Ah wanted Hunterston developed... So that despite the fact that we had closed the Melting Shop, then we had an opportunity which— Hunterston’s only eight, nine miles away from here— we could talk about the Hunterston/Glengarnock complex” (Mr [Redacted] Interviewed 10th July 1980:3-4).

The Trade Union Officer’s interview reveals that some expectation had been invested in the future of a Hunterston/Glengarnock joint venture in the early days of the terminal’s construction, as its presence grew upon land reclaimed from the sea.⁴⁰ Hugh’s revelation that material from Slag Hill had been used in the creation of the Hunterston Lagoon thus enrolled Glengarnock slag in the anticipated realisation of this hope. The terminal’s land reclamation process badly disturbed local wildlife, and so it was agreed that for this project to go ahead, an artificial lagoon would be crafted. Here, it was hoped in turn, a new habitat would form. The partnership between the ore terminal and its local steelworks would not come to pass. Yet the Hunterston Lagoon remains, now cared for by the RSBP. The Glengarnock slag that built it also endures, though some miles removed from the deposit I drew at the Lochshore. Hugh’s response had contributed a new, invisible layer to this stratigraphy however. As slag was removed from Slag Hill— the local name for the landform where I conducted my walkover practice— this material was potentially missing from the succession I recorded. Geologists have a particular term that they use to refer to this im(materiality) of missing time. I realised that my stratigraphic section might contain an anthropogenic *unconformity*, a “surface of

⁴⁰ Writing in 1979, Payne recounts how the Hunterston plan “planted a seed which, despite every discouragement, has taken firm root in Scotland’s industrial strategy” (Payne, 1979:417). In the 1960s, British Steel was reorganised to encompass several regional groups, in the hope of encouraging healthy competition between these geographical divisions. The Scottish and North Western group however “interpreted this... all too literally” (ibid) and publicly proposed their plans for new steel plant on the Ayrshire coast without first consulting with BSC management. Soon, these aspirations had become enrolled in conversations around Scottish nationalism, and “the industrial renewal of central Scotland” (ibid:421). Despite Monty Finniston’s decision to do away with BSC’s geographical divisions in 1970— due to several instances of regional budgetary “exuberance” (ibid:423)— the archival voices recorded here demonstrate that the ‘seed’ Payne describes had remained rooted in the thoughts of Glengarnock workers in the final years of this decade and on into the 1980s.

contact between two groups of unconformable strata, which represents a hiatus in the geologic record due to a combination of erosion and a cessation of sedimentation” (Allaby, 2008:600-601).

Accounts of ‘hiatuses’ or ‘interruptions’ have previously featured in archaeological stratigraphic interpretations. King (2023:3) for instance details how the presence of “physical gaps of material attributable to human activity” in a stratigraphic section can indicate the historic movement or expulsion of people from a particular place. Tysczuk (2016:435) however argues that unconformities in Anthropocene deposits can put the idea of ‘missing time’ in direct conversation with future imaginaries. She envisages geologists yet-to-come discovering gaps in Anthropocene stratigraphies through successions of buried rubble, and interpreting these cycles of devastation and reconstruction as the results of increasingly prevalent destructive weather events. Archaeologists of the far future might also examine these deposits, and infer the eventual interruption of these anthropogenic remains as evidence of forced abandonment. Absence in this record would extend to the non-human too, with Anthropocene unconformities also marking the “shifts, distribution and extinction of species.” When faced with the prospect of our own descendant’s possible non-appearance in future stratigraphies, the Anthropocene unconformity can, Tysczuk contends, function for us as a kind of “aporia” (ibid) – a rhetorical device used to express doubt or disorientation. The introduction of the Anthropocene as a means of storying our own pasts and futures has dropped us into the middle of an ongoing narrative, whose implications can make it difficult to know how to begin to continue. Stories of Anthropocene unconformities can reveal our multitemporal capacity to cause and suffer harm, as well as our abilities to forget and be forgotten. The act of speculatively weaving the consequences of our actions into a future that stretches far beyond an individual lifetime can leave us feeling unsettled and uncertain. Tysczuk imagines her instances of missing time at the moment of their future discovery. Her Anthropocene unconformities draw their power to unnerve as they project a setting where major events in human history are compressed into what might only be a few metres of stratigraphic section.

My own possible Anthropocene unconformity however was interpreted in the present, and formed in the recent past. It tells a smaller story, its gap in time created by the removal of slag, in the hope that this waste material’s destination might secure the steelwork’s future. The absence of these strata could signify the eventual loss of that optimism too. Yet my

unconformity also functions as an aporia. In *The Book of Unconformities: Speculations on Lost Time*, Raffles (2020:6) observes that these absences “... reveal holes in time that are also fissures in understanding; holes that relentlessly draw in human investigation and imagination yet refuse to conform, heal or submit to explanations in ways we might desire or think we need.” At first sight, I could not see the absent presence of the unconformity in my stratigraphic drawing. This was only revealed to me by means of an intergenerational exchange. Yet I do not know exactly where Slag Hill was mined for its material, and so I cannot say for certain if the 1.8 metre span encompassed by my section holds the invisible gap between layers that I project onto it. Many of my questions surrounding the section remain unanswered, and when I look upon it, I still feel uncertain. Where I once perceived straightforward succession, I now see how the gaps in my own knowledge represent the ephemerality of this slag’s story, and how this both constitutes and limits my understanding of this passing place. My stratigraphic-social media practice revealed both the potential to learn more about the slag’s past, and that my desire to know all of its history would not be accommodated.

Passing Place 4 – Slag Stalactites

Each time I approach the point where the peninsular slag landscape begins to curve back round upon itself, I start to feel apprehensive. My final passing place appeared suddenly during the confusion of the construction work, and as I draw nearer to where I think it lies — amidst my anxiety to find it again, I always forget precisely where it is— I am never fully convinced that it won’t be missing. Superstitiously, I worry that it will somehow have been withdrawn from the regenerated landscape by the cessation of the activity that revealed it. To rediscover it is thus an experience mingling surprise and the pleasure of recognition. Initially, it is not much to look at. Across another drainage ditch by the side of the path, a cluster of boulders sit, piled in the scrubby undergrowth. Amongst the mosses growing on their surface, orangey splotches of rust bloom, suggesting the presence of another not-wholly-natural deposit. The first time I came here however, it was another colour that caught my eye. I was walking on the verge beside the route of the new path, which at that point formed an elongated hollow, gouged out of the ground. The going on this incipient trail was uneven to say the least – mounds of excavated earth, metres high, were interspersed with stretches of sodden mud, rapidly transitioning to muddy water in the late Autumn rain. Were it not for my raised position, I doubt I would have glimpsed the tiny pillars of creamy white. As it was, I

stopped in my tracks, taken completely unawares by the sudden sight of several miniature, centimetre high stalagmites, seemingly growing out of the flat tops of the rusted, mossy boulders.

“I think that’s some of those stalagmites” Ben calls out. The first time I came across these structures was whilst interviewing Ben as we walked through the Lochshore landscape, and he is evidently as enthused as I am to see them again. We beckon John over to hear his opinion on how they formed.

“So, let’s say this one is growing up like that – “ I begin.

“Growing up?” John queries.

“Oh.” I pause as I mentally flip the boulder over into what must have been its former position. My stalagmites were in fact stalactites. “So they were growing down.”

“A drip feature I think” John confirms.

“So is this calcite again then?”

“Same idea” John agrees, “ exactly the same process as that on the shore, but at a much smaller scale.” He explains how the boulder— an amalgamated mass of scrap metal and slag— would have been exposed to a fine film of rainwater trickling down its surface. This water would have again become alkaline in the chemical presence of the slag, and would have again attracted atmospheric carbon dioxide to dissolve in the water. “Slowly you’ll get a drip forming” he finishes, “and that will just precipitate. But also, the action of dripping gives you that surface area as well for carbon dioxide to come out of solution, to outgas, and that goes into that kind of crystal form.”

The existence of the slag stalactites felt fragile compared to the other features I had encountered. In part, this was because the conditions that lead to their formation had been truncated, turned the wrong way up. The stalactites were also, in and of themselves, highly delicate – one broke off in my hand when I reached out to touch it. As soon as I perceived this threat to the slag stalactites’ ongoing-ness, I felt an urge to, literally, right this wrong, by rolling over the boulder, and preserving their perpetuation into the future. Of course, I could not manage this— the boulder was very heavy, and I am very weak— but this sudden

impulse made me curious. Why I had been struck by the desire to carry out this act of maintenance, when each of the passing places I had come to know—including the slag stalactites themselves—demonstrated that the remains of the past can be subject to afterlives beyond our control?

I worked through a tentative answer to this question during my last visit to this final passing place. Almost a year after our interdisciplinary walkover, I returned again alone to find the slag stalactites. As I was gratefully noting that they were, for the most part, still intact, a voice suddenly called out – “Can I ask what you’re doing?” I turned to see a dogwalker on the path behind me. “I’m just looking at this big rock” I explained, “because it’s kind of weird...” I trailed off, trying to think of how to describe the existence of the slag stalactites in what was clearly only a passing encounter, but the dogwalker, leash straining, had already been pulled past me. “Aww cool!” he shouted cheerfully over his shoulder by way of farewell, “I thought you were looking for fossils or something!” Looking back at the slag stalactites, I realised that they were fossils of a sort, preserving a trace of a moment in the course of human history. Formed from the byproducts of our industrious activity, they grew out of a coalescence of wastes, as local slag met constituents of a global excess of greenhouse gases. The existential threat and already realised harms of the climate crisis were thus captured in these small instances of beauty.

If we continuously pass through and pay attention to Mashed Up Anthropocene Environments, Di Paola and Ciccarelli (2022:100) observe, we can become better acquainted with their unfamiliarity. In time, we might even start to feel like we have gotten to know them. As a result, we will in turn become mashed up within, and affected by these places. We will also become vulnerable to them – susceptible to anticipating their loss, and exposed to the uncertainty and lack of closure in their ongoing stories. We will struggle to find “ontological reassurance” in these places, as our lack of control over our own legacies brush up against the unpredictable agencies of the non-human. We may develop an appreciation of difference here, but apprehending that which has become aesthetic will remain an uncomfortable experience. Looking upon a beautiful outcrop⁴¹ of our complicity in planetary-scale change will always be a guilty pleasure. Yet Di Paola and Ciccarelli argue that we

⁴¹ This choice of word is inspired by Lorimer’s (2010:269) observation that “... in minutia it is possible to find small kingdoms of worldliness, and to craft small stories as outcrops of global history.”

should continue to consciously explore and inhabit these places. As they will “... increasingly be the landscapes of our lives” (ibid:98) we should become more attuned to the complex ways in which our notions of self and inheritance are opened up within them.

“I hope they leave these kind of fascinating odd things” John remarks, as we left the slag stalactites and the rest of the regenerating landscape behind.

“Yeah, they will” Ben answers confidently.

I hope he is right, and that the anthropogenic boulder hosting these tiny, beautiful formations will remain where it is, even if this is more by necessity by choice. If, much like the rest of the slag in this landscape, the stalactites are kept here simply because they are deemed too cumbersome to be moved further, I will continue to cherish this particular pocket of perpetuated neglect.



5. Conclusion

Simon joined Kenny and Lizzie as we took our leave of the Lochshore's slag landscape. Kenny had been picking up and pocketing fragments of found pottery throughout our walk, and Simon asked why an archaeologist might similarly want to keep a piece of slag. Kenny and Lizzie replied that whilst a slag sample might be taken from a site for chemical analysis, in order to help determine the kind of metallurgy that might have been practiced there in ancient times, generally this material would be left where it was. "Slag is just another human created object, a bit like pottery" Kenny observed "... an amalgam of natural materials that have been fired to create something, but it's not quite the same as it's a by-product." "Slag is not necessarily what you would say is a personalised object" he went on, drawing this in contrast to a pair of toy marbles from the recent past that had been found during an archaeological survey of the Cochno Stone, a rock lying to the north west of Glasgow that is extensively decorated with prehistoric carvings (see Brophy, 2018). The discovery of the marbles gave an immediate and visceral window to a former time – it was easy to imagine children using the rock's flat surface as the setting for their game. By contrast, it is difficult to imagine this kind of intimate human-object relationship with a heap of industrial waste. Yet whilst Kenny had retrieved pocketful's of pottery from our trip, I too had collected armfuls of slag. This gave him pause – maybe people did form unexpected connections with slag in the past, just as children had rolled marbles across the Cochno Stone's ancient engravings, and I now had enough pieces of slag to create a rockery in my garden. Simon joked that my back yard might even someday become an archaeological site itself, this small domestic deposit of metallurgical discards confounding investigators with its presence in the distant future.

This chapter has explored how Glengarnock's slag legacies might be encountered differently in the Lochshore landscape. It has posited that a personal, close-up engagement with this material could complement the more distant perspective currently employed by a newly installed interpretation board which describes the Lochshore Park's slag. I developed an approach that positioned heritage practice as a contemporary, creative act, which can be explored and shaped by archaeologists and non-archaeologists alike in conversation. I then threaded this ethos through the interchange of ideas that informed my use of surface walkover

surveys, stratigraphic section drawing and social media exchanges. In employing these methods, I have engaged with two themes that Lisa Hill— a scholar whose disciplinary identity encompasses both archaeology and geography— identifies as key points of possible confluence between these subject areas (Hill, 2011; 2015). In the chapter’s narrative essay, I utilise Hill’s first suggested interdisciplinary theme— that of the non-linearity of time— through my adaptation of Lorimer’s (2019) notion of ‘passing places’, presenting a multitemporal account of four sites in the Lochshore slag landscape that loops between my own recursive passages and one particular trip, where conversations between different disciplinary companions were recorded. In crafting this narrative, I have also responded to DeSilvey’s (2012:50) call to experiment with modes of storying landscape that reveal “the untidiness and contradictoriness” of our engagements with place, time and disciplinary boundaries. Throughout my narrative, I found that Hill’s (2011:1) second theme, the affective potential of materiality, and specifically her contention that “... barely perceptible echoes from the past have the power to move us in unexpected ways” manifested through my work, as I variously experienced encounters with difference, doubt and dynamism. The slag beach’s jumbled deposits, and the unexpectedly recent anthropogenic geology of the slag platform repeatedly undid the expectations of both myself and my companions, as we grappled with both how to— and who should— interpret these features. Gradually, by acknowledging and then embracing the various disorientations offered up by this Mashed up Anthropocene Environment (Di Paola and Ciccarelli, 2022) I learnt to walk alongside the difference between these places’ realities, and what I had initially assumed of them. Yet these excursions were always necessarily accompanied by feelings of doubt, as I was continually challenged to reconceive what slag is, where it comes from, and where its trajectories are going. Whilst sketching my stratigraphic section, I had to hold space for the uncertainties elicited by absence, particularly those formed by emerging gaps in collective memory. However, a chance conversation on social media filled in and simultaneously transformed my partial understanding of this strata, as a literal gap in time— an unconformity— was suddenly rendered present through a shared story of slag relocation. In both material and immaterial ways then, the Lochshore slag landscape emerged as one marked by dynamism. This was especially encapsulated by a reoccurring ‘recombinant geology’ (Paton and DeSilvey, 2016) formed as deposits of calcite mineralised at the watery interface between slag and atmospheric CO₂ (MacDonald et al, 2023a). I found it difficult however, to reconcile my embrace of and resistance to this dynamism. When the slag stalactites— a particular

intersection of ongoing process and my present moment— were recognised to be at risk, I found myself again rethinking the relationship between inheritance, value and transformation.

As Kenny and Simon had perhaps intuited, on that day that we walked through the Lochshore's slag landscape together, this anthropomorphic geomaterial had become a 'personalised object' for me, as valued as the two toy marbles might have been to the children who lost them, playing at the Cochno Stone. The qualities I admired in this slag— its juxtapositions, the ways in which it invited curiosity, even its strange beauty— had all been formed by its ongoing-ness, but they were also rendered precious to me by being captured in my present moment. We practice care, even for objects that seem to capture transformation and flow in their very materiality, at the scale of our own everyday (Fincher et al, 2014). This is a paradox that could usefully contribute to conversations around the new ways that heritage might be enacted in Anthropocene futures, finding as it does an emotionally complex middle ground between the twin poles of traditional conservation and an alternative embrace of transience in heritage practice.

As I became familiar with the Lochshore slag landscape, I became 'mashed up' within it (Di Paola and Ciccarelli, 2022). As I grew to care for it, I also became 'affectively entangled' within it (Ureta, 2016a). Yet as Puig de la Bellacasa (2011) reminds us, the generation of care should also entail imagining what a cared for entity might become if others were to be similarly affected by it. This chapter has dwelt predominantly in exchanges between the past and its constitution in the present, and has concluded with the open question of how we might reconcile the limited extent to which the material effects of this reciprocity might be perpetuated. In the final chapter of this thesis, I will turn to a particular, speculative Lochshore slag future, to consider one vision of how others might come to care about this material, and to explore how this imaginary might be put in conversation with other temporalities at work in this landscape.

Chapter 6: Future Speculations

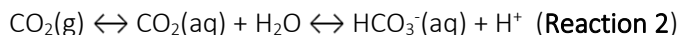
1. Introduction

The previous empirical chapter introduced the ‘recombinant geologies’ (Paton and DeSilvey, 2016) formed as calcite has mineralised on the Glengarnock slag’s surfaces. Not long after my discovery that this PhD project’s original focus— on the toxicity of the Glengarnock slag— had been superseded by the Lochshore regeneration project’s work, I met with my supervisors. As we brainstormed new ways to think and work with slag, discussion turned to scientific work that has engaged with this material, beyond its capacity to contaminate. Dr John MacDonald, my supervisor based within the geosciences, introduced us to an entirely different kind of potential – that of slag’s ability to draw down and sequester atmospheric carbon dioxide (CO₂). My great surprise upon receiving this information was only heightened as myself, John, and our companions witnessed the varied effects of this process in the Lochshore landscape. This sense of revelation was also reflected in everyone I spoke to – including contacts I made through my exploration of the Lochshore regeneration project itself. For instance, during a meeting of the Lochshore Development Group, which I attended in early September 2022, the chair spoke for all attendees when he expressed his astonishment upon hearing the news that their slag could serve as anything other than a bit of a nuisance.

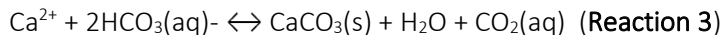
Although I have described the CO₂ mineralisation process in Chapter 5, it is worth revisiting this explanation here, and elaborating upon it in more scientific terms (see **figure 6.1**, overleaf). In essence, like a natural rock, steel slag is composed of many different minerals, of varying chemical compositions. A large proportion of these minerals are forms of calcium silicate, produced as the slag materialises in the steelmaking furnace. When calcium silicates in slag come into contact with water, a dissolution reaction can occur. In this new chemical solution, some of the calcium silicate compounds are broken down, and form new compounds in turn. Calcium however remains chemically unbonded. The alkaline hydroxide is also formed during this reaction, and so this new solution also has a high pH (see **reaction number 1, figure 6.1**). Carbon dioxide gas in the atmosphere is drawn into this alkaline solution, in a process known as ‘in-gassing.’ Thereafter, another chemical reaction occurs, as the CO₂ reacts with water to produce a compound called bicarbonate (see **reaction number**



Calcium Silicate + Water \rightarrow Calcium + Silicic Acid + Hydroxide



Carbon Dioxide (gas) \leftrightarrow Carbon Dioxide (aqueous) + Water \leftrightarrow Bicarbonate + Hydrogen



Calcium + Bicarbonate \leftrightarrow Calcium Carbonate (solid) + Water + Carbon Dioxide (aqueous)



Figure 6.1: The CO₂ mineralisation reaction (adapted from MacDonald et al, 2023a) and its result in the Lochshore landscape.

2, figure 6.1). The bicarbonate then reacts with the unbonded calcium to produce a substance called calcium carbonate, or calcite. This is deposited (or precipitated) onto the slag as a solid substance, thus capturing the in-gassed CO₂ in mineralised form (see **reaction number 3, figure 6.1** – all information cited on these reactions is drawn from MacDonald et al, 2023a). It is clear that sources of CO₂ gas, water and slag are all required for this reaction. The air in our atmosphere is of course overburdened with CO₂, and the lithified slag platform we walked across in the previous chapter is routinely inundated by both Kilbirnie Loch's water and by rainfall (see also Hilderman et al, 2024 for an account of this process in a coastal

setting). The resulting hard, cream-coloured calcite crust has built up on the slag surface, and extends along the loch shoreline.

Despite the fairly striking nature of this feature, it appeared that the suite of reactions that formed it had been ongoing for years, without attracting the obvious notice of anyone I had spoken to about the Lochshore landscape, besides John himself. Part of the reason for this may have been the previously rather remote location of this slag. Yet as these access restraints were removed, as the Lochshore regeneration project's new 5km path began to weave its way through this area of the site, I wondered how this unexpected slag legacy might also be projected into the future of this place. What new meanings might become attached to the Glengarnock slag as a result of its capacity to mineralise carbon dioxide, and could these new meanings engender further material changes to this landscape? In order to explore a speculative Lochshore future, where the Glengarnock slag's carbon capture potential becomes a less surprising legacy, I will utilise approaches from both human geography and the geosciences in this chapter. I will first briefly review literatures on carbon dioxide removal by means of anthropogenic geomaterials, reading within and between natural and social scientific perspectives, to formulate how this process may be further investigated through the specificities of place-based study. I will then describe how I used methods from differing disciplinary origins to generate results that, when put in interdisciplinary conversation, allowed me to both envision and critically evaluate the meanings of a future Lochshore slag landscape that prioritises CO₂ mineralisation.

2. Putting legacy slags in conversation with place based enquiries

Interest in the environmental benefits that steel slag could effect has been growing in recent years. In a 2015 review, Piatak et al evaluated over 150 articles on ferrous and non-ferrous slags, to present a detailed account of their chemical characteristics, as well as their environmental applications. The authors identified several ways in which ferrous⁴² slags in particular could be utilised in environmental remediation, including as a means of chemically

⁴²As I use a number of terms in this chapter to describe different categories of waste, these labels require some elucidation. 'Ferrous slags' refers to slags which contain iron, and therefore encompass both iron and steel slags. When I use the term 'steel slag' I am differentiating between iron and steel slags, referring only to the latter. References in the chapter to 'slag' always refer to steel slag, the focus of this thesis. Meanwhile, 'alkaline wastes' is a general term used to describe any anthropogenic geomaterial that has a high pH. As well as ferrous slags, these materials include red muds produced from the manufacture of aluminium, some mine tailings, and debris from the demolition of buildings (Khudhur et al, 2022a).

removing undesirable elements from water sources, as a source of alkalinity to counter acid mine drainage, and as an additive to improve soil structure and fertility. They do not however mention the use of ferrous slags to mineralise atmospheric carbon dioxide. This is likely because CO₂ mineralisation in steel slags is a relatively recent addition to the literature surrounding the environmental valorisation of these materials (Khudhur et al, 2022a). Indeed, in their 2009 study of carbonate precipitation in artificial soils which contained slag, Renforth et al noted their belief that their work was “... the first reported case that demonstrates how artificial soil (i.e. made ground) can act as C sinks by accumulating CaCO₃” (Renforth et al, 2009:1762). In light of this discovery, the authors called for the development of methods to quantify the carbon capture potential of these mixtures of natural and anthropogenic deposits. They also highlighted the need for further research to be directed towards how carbonate formation is mineralogically facilitated in legacy steel manufacture wastes, hypothesising that the weathering of silicate minerals could play a role in this process.

The prescience of Renforth et al’s suggestions regarding the future direction of this work can be traced in later publications, including those of Mayes et al (2018), Chukwuma et al (2021) and Riley et al (2020), which demonstrate efforts to quantify the carbon capture potential of ferrous slag deposits at local, regional and national scales respectively. Meanwhile, in a review of the use of ferrous slags (amongst other alkaline wastes) in carbon capture applications, Khudhur et al (2022a) note the mechanism for carbonate precipitation in these materials – the weathering of silicate minerals, as Renforth et al suspected. However, Khudhur et al also highlight the manner in which this process has caught the attention of researchers. The CO₂ mineralisation observed in alkaline anthropogenic waste materials mimics natural processes that contribute to planetary atmospheric CO₂ regulation. In the context of the climate crisis, enthusiasm has thus grown for the development of new techniques which can *enhance* the carbon capture potential of alkaline wastes, including steel slags. Whilst laboratory-based research has demonstrated the efficacy of these industrial wastes in promoting carbonation reactions, Power et al (2014) have stressed the additional need for the value of these uses to be realised in operational industrial settings. This emphasis is reflected in further strands of research, which have generated proposals for slag management strategies that can be accomplished by steel producers prior to waste deposition, such as using still-hot slags (Santos et al, 2012) pre-treated with alkaline solutions (Chen et al, 2019) which have been shown to increase carbonate formation rates. Large-scale carbon capture methods have also been suggested for immediate post-deposition contexts, whereby

supplies of air and water (both essential to the carbonation process) are engineered to come into contact with alkaline waste deposits by means of specially designed structures (Abanades et al, 2020; Chen et al, 2019), pumping systems (Nowamooz et al, 2018), or the deposition of wastes over large surface areas (McQueen et al, 2020; Wilson et al, 2014).⁴³

The steel slag at Glengarnock however is contained within already long-established deposits, so the management options here differ from the various potentialities outlined above. A closer match to the Glengarnock context can be found in Pullin et al's (2019) study of a slag heap at the site of the former Consett Iron and Steel works in the North of England. Both the Consett and Glengarnock slags reside in legacy deposits, where CO₂ mineralisation has proceeded by means of the "lowest cost approach" (ibid:9503) – that is, through passive, in-situ weathering and carbonation. Pullin et al assessed the carbonation potential of the Consett slag management strategy by analysing recovered slag samples from three boreholes, drilled in a 60m transect across the heap. Measurements of water levels, water pH, and gas CO₂ concentrations were also taken for each of the boreholes. The authors found that the slag samples had undergone relatively minimal carbonation; meanwhile, gas CO₂ concentrations in the boreholes were well below surface levels. Whilst the water recovered from the boreholes was found to be very alkaline, water levels were low in two of the boreholes, whilst no water presence at all was recorded in the third. The authors connect these findings to the particular "slag emplacement conditions" found in this setting (ibid:9507), hypothesising that the decision (following the cessation of industrial activity at the site) to cap the Consett slag material with a layer of clayey topsoil restricted the ingress of air, carrying CO₂ gas, and water into the heap, resulting in a consequent limiting of carbonation. Drawing from these results, Pullin et al suggest various modifications that could be made to the legacy slag management strategy applied at Consett, including removing topsoil cover and shaping slag heaps to be shallower, so that CO₂ mineralisation rates could be improved through greater natural water and air ingress.

Pullin et al's study raises questions regarding the relative levels of CO₂ mineralisation between different slag emplacement conditions. These questions also highlight a gap in the literature surrounding the CO₂ mineralisation observed in the Glengarnock slag to date.

⁴³ All citations referenced here regarding immediate pre- and post-depositional slag treatments were found in Khudhur et al (2022a).

Previous studies (see MacDonald et al, 2023a; MacDonald et al, 2023b) have identified evidence of CO₂ mineralisation occurring in slag samples collected from exposed locations on the south-west shoreline of Kilbirnie Loch. No investigations have however been made into the carbonation levels of slag samples collected from beneath the topsoil layer, which (like Consett) is deposited over much of the slag at the Glengarnock site. A comparative analysis of exposed and buried slag sample carbonation levels may therefore hold implications for how the Glengarnock slag could be managed in the future to enhance in-situ, passive weathering of this material, and thus carbon capture potential at this site.

Pullin et al do however recognise potential difficulties that could arise if changes to slag landscape management practices were to be pursued, highlighting public dissent towards alterations to existing landscape uses and aesthetics as a particular issue that must be considered. Riley et al (2020) concur – in their UK wide study of legacy iron and steel wastes, they note further challenges to slag landscape management modifications, such as conservation designations that may have been applied to former industrial sites. They also draw attention to matters of cost, legislation and governmental support as necessary to reflect upon when conceptualising revised slag management activities, including the valorisation of carbon capture potential. Khudhur et al (2022a) also emphasise the need for economic analyses of alkaline waste carbon capture strategies, to facilitate the uptake of investment in this area.

Each of the points raised by these authors intersect with areas of concern within the social sciences – and the application of social scientific perspectives to carbon capture proposals has also seen recent engagement. In the introduction to a special themed issue of the *Journal of the Royal Society Interface*, titled ‘Going negative: An interdisciplinary, holistic approach to carbon dioxide removal’ Zelikova (2020:2) argues that as the exploration of carbon dioxide removal (CDR) methods will involve “... coordinated efforts from decision makers and stakeholders from every sector of society”, the research community that coalesces around CDR efforts should therefore also reflect this multiplicity. She goes on to point out that as research into the employment of CDR techniques is still a relatively nascent field of literature, the opportunity to embed diverse perspectives and approaches is perhaps more easily afforded at this early stage. Dowell et al (2020) agree, noting that work on CDR should prioritise interdisciplinarity at the primary stages of research design. They observe that strands of research on CDR have developed independently in the sciences and social

sciences, with the former generally concerned with the technological viability of proposed technologies, and the latter focussed upon the consequences of implementation and reception at different scales. Research that remains within disciplinary siloes will not, Dowell et al argue, be adequate to address CDR futures, not least because social science perspectives are often employed to review the impacts of a given technology post-implementation. In order to provide forethought, rather than acting solely in hindsight, the authors suggest that those working within the social sciences must pay attention to science-based carbon capture plans, to grasp the intricacies of what is being proposed. Those working on carbon capture systems within the sciences in turn need to open up to conversations with their social science colleagues, to gain a more nuanced consideration of CDR viability.

An example of how this can be achieved in practice is provided by Mabon (2012). Writing within the fields of human geography and environmental ethics, he argues that important insights can be generated through socially and spatially informed enquires, directed towards communities where CDR systems could be sited. Evaluating various public engagement ‘toolkits’—produced to assist the communication skills of those working on carbon capture technology implementation—Mabon contends that the generalised nature of these resources can lead to a failure to anticipate the diversity of attitudes towards different CDR methods that can be held within and between communities. He proposes a number of alternative approaches which can instead seek to understand these multifaceted responses. For example, by drawing out the deeper values that underpin an individual’s viewpoints, it can be appreciated that perceptions of local environments can be deeply personal, emotional and grounded in everyday lived realities. Furthermore, these values can be put in conversation with the narrative trajectory, or story, of a particular place, so that “... by looking at all the different narratives that have gone before in a place, and weighing up what is the most appropriate outcome that will continue this narrative trajectory” a researcher can consider if a particular CDR technology should— or importantly, should not— be employed in a particular setting (ibid:335). To provide a highly simplified example, a community that has long valued its local environment as a provider of jobs and resources may be more likely to welcome CDR implementation than one which has experienced environmental exploitation or degradation at the hands of state or techno-scientific actors. Yet Mabon also highlights the likelihood of conflicting values and narrative strands becoming exposed within a community. Human geographers are, he argues, equipped with the necessary training to explore these questions, and to contend with the messy, complex and sometimes contradictory answers they

pose. A context specific, qualitative perspective offers the explanatory power to guide tentative understandings of how attitudes towards CDR have come to be in a particular place, and how they may therefore play out in that setting in the future. Moreover, he stresses the importance of these kinds of enquiries to work on carbon capture projects, as poor engagement strategies can create a self-fulfilling cycle. Negative community perceptions of these technologies can be instigated or reinforced by outreach practices which in turn prompt or strengthen researcher assumptions of complete foreknowledge of community concerns, leaving no room for uncertainty, or an openness to complexity.

In this brief review, I have situated Glengarnock's steel slag within wider conversations around passive CO₂ mineralisation in alkaline wastes, identifying its legacy emplacement conditions as a key factor potentially limiting its capacity to passively weather in-situ. I have also considered the value of interdisciplinary engagements with carbon dioxide removal strategies, and explored the potential of place-based enquiries to better understand how these technologies might be received. I will now go on to describe how I designed a small-scale study to comparatively analyse the extent and nature of carbonation in exposed and buried samples of Glengarnock steel slag, in order to ascertain what a re-imagined slag landscape—managed to maximise slag carbon capture— might look like. I will also outline how I assessed the implications of this speculative future in the context of the present, through analysis of interviews conducted with individuals involved in the Lochshore regeneration project.

3. Building a speculative future for an anthropogenic geomaterial

This study engages with a landscape that has been produced by human industry, but shaped through natural process – with results that were unanticipated, and until recently, unappreciated. The Anthropocene is therefore an appropriate framework to inform the methodology of this small-scale study, as human activity is the force which has created the terrain under investigation, but also as this 'made ground' forms the basis of a speculative enquiry into how it could be enrolled in a vision of living within this new geological epoch. Yet when conducting a bibliometric survey of the Web of Science database, searching for Anthropocene related academic articles published between 2002 and 2019, Biermann et al (2021:808) found that the majority of results worked with the Anthropocene in a conceptual

manner, grappling with how to theoretically engage with this proposal. In addition, of the minority of papers which employed an empirical approach to study the Anthropocene, less than a quarter were found to have employed interdisciplinarity “at even a cursory level” (ibid). The authors, working within the field of critical physical geography, argue that as the Anthropocene concept proposes that the social and biophysical worlds have become inexorably linked, the way in which we study Anthropocene environments should therefore become similarly “ecosocial.” They therefore suggest that efforts to study the Anthropocene, and its manifestations in landscape should both employ and go beyond a mixed methods approach. They propose that research engaging with the Anthropocene should also consider the politics of knowledge production within, and the dissemination and reception of this knowledge outwith, academic contexts. Here, I will demonstrate how this chapter has tried to heed Biermann et al’s recommendations. I will outline how I have used techniques from both the natural and social sciences to generate results that, when put in conversation with each other, have helped me to envision and critically assess a future Glengarnock slag landscape, as well as the potential knowledge politics underpinning this proposal.

At this juncture, it is also worth stating my awareness of the fact that the mixed methods employed in this chapter may cause it to be accessed by future readers from a wide variety of disciplinary backgrounds, spanning the sciences and social sciences. To account for this diversity, I have therefore taken an approach whereby I assume that the reader has no prior knowledge of the methods under discussion. This will necessitate a more detailed level of methodological explanation than may be usual – particularly when contrasted with analogous sections of scientific papers. My tone here will also be in a less passive style than that which is typically demonstrated in scientific writing, as I foreground a slightly more experiential perspective, which follows my own actions and impressions more closely. I intend to also draw attention to the community of technicians who assisted me in the scientific elements of the work outlined here, whose precise roles might otherwise have been omitted from a less personal account. I am also aware however that I must balance the inclusion of appropriate scientific rigour in particular with my assumption that a reader has no prior knowledge of what is being described. Thus, whilst I will prioritise the needs of those who are new to the techniques discussed here, I will also embed technical details that will satisfy the interests and requirements of those who are more familiar with the scientific methods used.

3.1 Site Visit and Sample Collection

As mentioned a number of times in this thesis thus far, the landform which grew from the south western shore of Kilbirnie Loch, as steelworks slag was tipped into this waterbody, has only come into being within the last 80 or so years. This is also the area from which my slag samples were gathered. A review of historic maps demonstrates that slag tipping was mainly concentrated at the southern shore of Kilbirnie Loch in 1916 (Ordnance Survey, 1916). In 1918 however, and as detailed in Chapter 4, the new ‘Scheme B’ melting shop started operations, as a result of the call for increased domestic steel production during the First World War (Charman, 1981). Now located to the south-west of Kilbirnie Loch, the new basic open-hearth furnaces produced slag which was in turn deposited in a new direction, spreading gradually north-east from the ‘Scheme B’ site. No further historic maps are available until 1958, where it can be cartographically observed for the first time that an entirely new area of land had emerged, jutting into Kilbirnie Loch (Ordnance Survey, 1958). An aerial photograph taken in 1946 does however show that this artificial peninsula was already extensively formed more than a decade earlier (Ordnance Survey, Royal Air Force, 1946). There is evidence that by the 1960s and 70s, the area was in use as a slag works, producing road aggregate (Road Research Laboratory and Institute of Geological Sciences, 1968). Following the final closure of the Glengarnock melting shop in December 1978, this former slag works site became subject to a land renewal project, spearheaded by the Garnock Valley Task Force (formed of representatives from the Scottish Development Agency, British Steel, and the local authority, then called Cunninghame District Council). Encompassing plans to revitalise industrial and recreational uses of the former steelworks site, the project was launched in January 1979, and ran for four years. In that time, the project aimed to establish and enhance a growing medium on the previously exposed slag works substrate, to support the development of vegetation cover, consisting of lime tolerant grasses, scrub and trees (Carter, 1984). Meanwhile, the slag to the south of Kilbirnie Loch was overlaid with “... an advanced sand/peat construction and an elaborate drainage system” to enable the creation of sports pitches (ibid:52).⁴⁴

⁴⁴ The report from which I drew this information did not mention any slag removal as part of these landscaping efforts. The extraction of slag from Slag Hill detailed in the previous chapter must therefore have occurred at a different time.

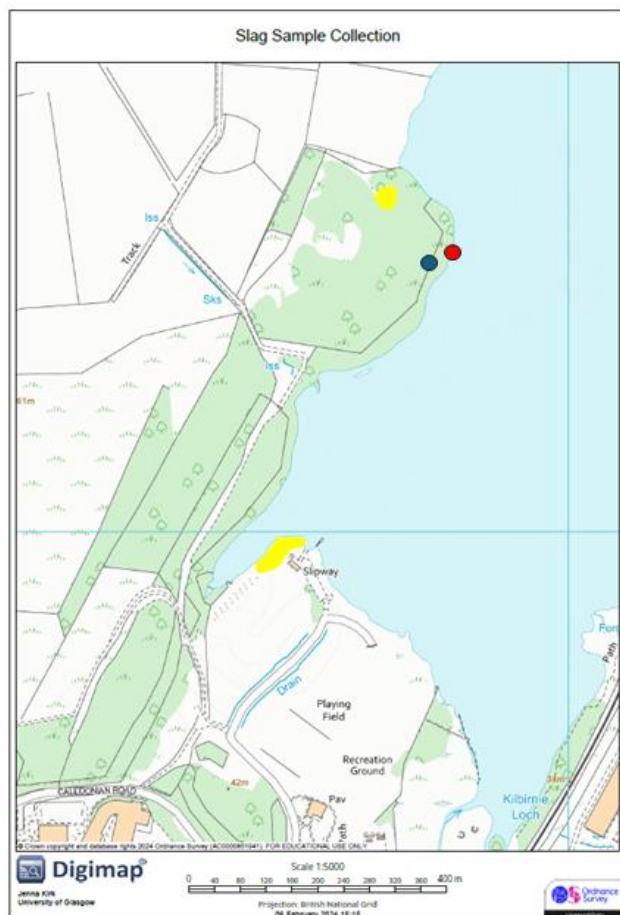


Figure 6.2: The areas marked in yellow demarcate the parts of the site where we were permitted to dig for slag samples. As the area at the south of Kilbirnie Loch bordered ground used by the local model airplane club, it was decided that we would concentrate our initial sample collection efforts in the second area available to us, to the west of the loch. The blue and red circles show where the buried and exposed samples were respectively collected. Adapted from Digimap Ordnance Survey Collection, <https://digimap.edina.ac.uk/>.

There have also been a number of investigative groundworks conducted across the former steelworks site since the melting shop ceased production, and records of these surveys bear out the site history detailed above (see for example, Ove Arup and Partners, 2000; AECOM, 2017, in RPS, 2019b). Most recently, RPS Ireland Ltd and Causeway Geotech Ltd worked with North Ayrshire Council on site environmental assessments preceding the commencement of the Lochshore regeneration project. Logs from trial pits and boreholes dug closest to where I collected my samples record a thin layer of topsoil underlain by a thicker section of clay, embedded with gravel sized pieces of slag, as well as other anthropogenic deposits, such as bricks and cement clinker. Each of these vertical excavations terminated on a solid layer of slag (RPS, 2019a).⁴⁵

By the time of my visit (accompanied by my supervisor, Dr John MacDonald) in August 2022 to collect slag samples for scientific analysis, vegetation cover occupied most of the fieldwork area, save for the shoreline of Kilbirnie Loch, where slag deposits remained exposed. Specifications for access to the site were fairly restrictive due to health and safety concerns, as the regeneration project's new 5km path construction work had recently commenced. For this reason, it was agreed with North Ayrshire Council (NAC) that our work digging for buried slag samples would be kept to a very small area (see **figure 6.2**). In addition, this situation left a very small window of

⁴⁵ I am grateful to North Ayrshire Council, who made the RPS Ireland Ltd reports available to me, as well as many other useful documents pertaining to the Lochshore regeneration project.

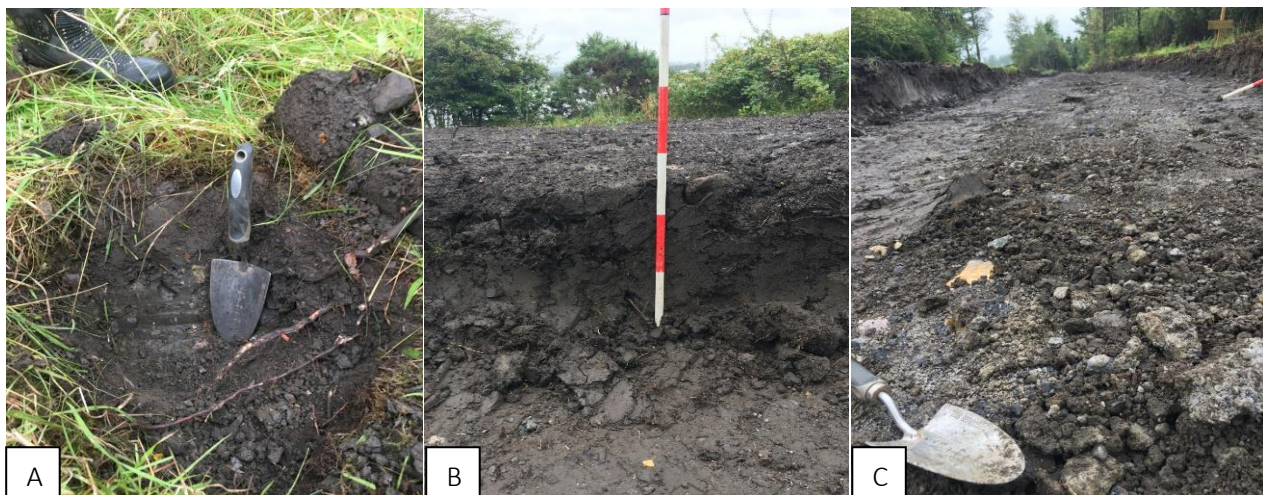


Figure 6.3: Our attempts to collect buried slag samples. Figure 3A shows our initial dig site, where we could only excavate c. 20cm of topsoil. Figure 3B shows the c. 70cm trench excavated by mechanical diggers working on the 5km path, and Figure 3C shows previously buried slag samples from the base of the excavated trench, which we were easily able to collect.

time (a matter of days) to obtain these samples, as the construction work was soon due to move into the space that had been demarcated for our slag collection. Conditions on the day that we collected the buried slag samples were initially unpromising, and then serendipitous. Digging in the small area we had pre-arranged with NAC was very difficult, due to the unyielding nature of the hard slag layer we encountered. Only a very shallow pit could be excavated before the pressure on my spade caused it to come close to fracturing (indeed, later conversations with the path construction workers revealed that the ground conditions had caused breakages to their heavy equipment). Further digging with a trowel did not allow us to reach the depths at which discrete hand samples of buried slag might be accessed, so we abandoned the attempt. We soon noticed however that deep trenches had been excavated nearby by the construction machinery, in preparation for laying the new path infill. This allowed us to easily pick up slag samples that had recently been uncovered by this work (see **figure 6.3**). The exposed slag samples were collected from the carbonated area of slag exposed on the loch shore, as previously depicted in figure 1. This required work with a hammer and chisel to separate samples from the solid platform of fused material formed by the mineralisation process. Due to the time-consuming nature of this work, and the aforementioned time constraints limiting our time spent on sample collection, it was decided that samples pre-collected at an earlier date by my supervisor would instead be used. Three samples were collected from each location, and for identification purposes, the buried slag samples were named JK1, JK2 and JK3, and the exposed samples called GG4, RC18-01 and RC18-02.

3.2 Slag Sample Processing and Data Analysis

3.2.1 X-Ray diffraction (XRD)

I firstly used a technique called X-Ray Diffraction (XRD) to examine the mineralogy of my samples. By detecting the presence of the mineral calcite (CaCO_3)— which precipitates onto the slag as a result of the mineralisation process— I could establish at the outset that CO_2 mineralisation had taken place within my samples. During the XRD process, a sample is placed within a chamber (called the experimental area), between a source of x-rays (called an x-ray tube) and an instrument which receives the signals produced as a result of the diffraction process (called a detector). The X-Ray diffraction process— as the name suggests— relies upon the diffraction, or scattering, of incoming x-rays by the atomic structures of the crystals which make up a sample. Slag samples are made up of a number of different minerals. Minerals have a very regular, crystalline atomic structure. These structures diffract incoming x-ray beams and these interact to give ‘peaks’ or ‘reflections’ in a particular pattern for a given crystal structure. These diffraction patterns can then be used to identify the minerals present in a sample by comparing known diffraction patterns for a given mineral to the experimentally measured diffraction pattern. The experimentally measured diffraction pattern will contain signals from all the crystalline materials in the sample. This can present challenges in identifying particular minerals or phases.⁴⁶

To prepare my samples to undergo this process, I first had to reduce them to powder form. I therefore contacted Dr Mark Wildman, an Analytical Technician in the School of Geographical and Earth Sciences (GES) at Glasgow University, who operated a piece of machinery called a Retsch BB100 Mangan Jaw Crusher (which operates by exerting

⁴⁶ The information in this description of XRD analysis (as well as in subsequent opening paragraphs on TGA and SEM analysis) was gained from a few different kinds of source. I found that academic textbooks were generally written at a level that I struggled to understand, as even those aimed at undergraduate students assumed a fairly comprehensive grounding in scientific disciplines such as physics, which I did not possess. I initially therefore used web-based resources to gain a basic understanding of the processes I was aiming to describe. I found introductory videos aimed at beginners, prepared by academic or industry professionals, and posted on platforms such as YouTube, particularly helpful (videos from Putrika, 2021 for XRD; The Madison Group, 2020 for TGA; and Coffey, 2017, for SEM were the primary sources I used). Initial drafts of my descriptions of these processes were then sent to Dr Claire Wilson, Andrew Monaghan, Dr Connor Brolly and Dr Liene Spruzeniece, and resulting conversations around edits to these drafts thereafter shaped what is written in these paragraphs.

compressive force upon samples) to perform the initial pulverisation⁴⁷. After this process, the samples were reduced to less than 1 millimetres (mm) in grain size, but as XRD analysis works best with a maximum grain size of less than 90 micrometres (μm), further work was required. Assisted by Dr Charlotte Slaymark, an Environmental Biogeochemistry Technician in Glasgow University's School of Geographical and Earth Sciences (GES), I proceeded to further grind my samples using an instrument called a Retsch MM400 Ball Mill, which operates through subjecting steel jars, each containing a portion of powdered sample and a small tungsten carbide ball, to a rapid sideways shaking motion. The repetitive impact of the ball upon the sample reduced the grain size to the desired level. Finally, I passed my powdered samples (using a Endecotts Minor Shaker) through a sieve with a $90\mu\text{m}$ sized mesh, to fully ensure that only sample particles of less than $90\mu\text{m}$ would be used for the XRD analysis.

My samples were now ready to pass to Dr Claire Wilson, from Glasgow University's School of Chemistry, who conducted the XRD analysis, using a Malvern Panalytical Empyrean multi-purpose platform. The results were delivered to me in two file formats, one which would allow me to graph the results in Excel, and the other which would allow me to interpret the results using a piece of software called HighScore Plus. Both programmes display the XRD analysis results in the form of a line graph, which features several 'peaks' corresponding to signals from particular diffraction angles, picked up by the XRD detector. The HighScore Plus software could then compare the peak patterns that made up the results for my samples, to a substantial collection of reference peak patterns for different mineral phases, in order to determine which mineral phases were present in the sample.⁴⁸ Piatak et al (2015:241) cite "... numerous challenges associated with characterising the mineralogy of slag" especially affecting efforts to precisely *quantify* the relative proportions of minerals present. For this reason, I conducted a qualitative analysis, simply seeking to ascertain which minerals were present in my samples. Yildirim and Prezzi (2011:1) however highlight the

⁴⁷ It is worth noting here that some sample preparation and analysis procedures were carried out by me, but others were conducted by technicians. In these latter cases, training me to operate machinery or equipment to process only a small number of samples was agreed to constitute an unnecessary health and safety risk, and pressure on technicians' time. In each of these cases I was however invited to meet with the technicians, to receive a full explanation of how the procedures they were carrying out for me worked in practice.

⁴⁸ I use the terms 'mineral' and 'phase' interchangeably here, but it is necessary to explain their relationship. Minerals are entities that together aggregate to form rocks. They are substances that generally have a crystalline atomic structure, and characteristic chemical composition. Minerals can exist in different phases, which are structures that can be distinguished by their physical, rather than chemical differences (Allaby, 2020). XRD analysis can identify the different phases that make up a mineral, as well as the mineral itself.

complexities that can also affect qualitative XRD interpretation of slag samples, due to the presence of “several overlapping peaks resulting from the many minerals present in the samples.” The HighScore Plus software interpretation was impacted by this dynamic, as although the programme highlighted that some of its peak pattern matches strongly reflected the reference data, other matches were flagged as being more tenuous. For these latter matches, I therefore used an online repository of reference peak patterns (Laetsch and Downs, 2006) as well as articles which listed common slag minerals (Chukwuma et al, 2018; Yildirim and Prezzi, 2011) to visually compare the peak patterns for selected minerals with those of my results. If I felt these matches were more accurate than those suggested by the software, I changed the mineral identified accordingly. I was struck by the subjective nature of this exercise, which could represent a limitation in terms of the reliability of my results. However, as my main objective in using XRD analysis was to establish the presence of calcite in my samples, and as the HighScore Plus software highlighted the calcite matches to be amongst the strongest identifications in each of the samples, I was content that the detected presence of calcite in my samples was accurate. Uncertainties regarding other mineral pattern interpretations were therefore less important than they might otherwise have been.

3.2.2 Thermogravimetric Analysis (TGA)

As XRD analysis could not reliably quantify the amount of calcite in my samples, I next used a process called Thermogravimetric Analysis (TGA) to determine how much calcite (and therefore CO₂) was present in each. This would give me a clear indication of whether the exposed slag samples mineralised more CO₂ than the buried slag samples.

Thermogravimetric Analysis utilises the process of chemical decomposition, where a chemical entity is broken down into two or more products. This is achieved by the application of thermal energy, or put more simply, by heating a sample. As the sample is heated, the chemical bonds which hold its constituent chemicals together break, causing decomposition. The decomposition process instigates a change in the weight of the sample (the term ‘gravimetric’ refers to the measurement of weight). Different chemical substances decompose within known temperature ranges. A sample’s weight change can thus be measured over a particular temperature range to indicate how much of a particular chemical substance was in the original sample. The TGA process requires a sample to be placed upon a balance

mechanism within the thermogravimetric analyser, to enable its weight change to be measured. An instrument called a thermocouple is also present, to measure temperature. A furnace heats a supply of gas, which flows over the sample. During the experiment, the temperature increases at a set rate (known as a heating ramp), whilst temperature and sample weight readings are taken at regular intervals. I prepared my samples for Thermogravimetric Analysis following the same procedure as that for XRD analysis, ensuring the powdered grain size was less than 90µm. I then passed my samples to Andrew Monaghan within the Glasgow University School of Chemistry, who conducted the TGA analysis using an SDT-Q600 (V8.3 Build 101) instrument. The samples were heated at 10 degrees Celsius per minute, up to a top temperature of 1000 degrees Celsius. Temperature and weight readings were taken every 0.0083334 seconds. The experiments were conducted within a controlled atmosphere of inert Argon gas, chosen as it would not distort the experiment results by chemically reacting with the samples.

The results were delivered to me in a file format that allowed me (with the assistance of fellow PhD student Faisal Khudhur) to graph the TGA results in Excel. A TGA graph features two curves. The TGA (or weight %) curve shows the change in sample weight with respect to time or temperature, with the weight generally expressed as the percentage of sample remaining against the initial sample weight, at a given time or temperature. The derivative weight curve shows the derivative of mass change over time as a function of time or temperature. At a given time or temperature therefore, the derivative weight curve expresses the rate of weight change. The derivative weight curve is particularly useful to highlight different decomposition events that occur during an experiment, as by expressing the fluctuations in the rate of sample weight change, this curve shows distinct peaks, demarcating the conditions under which each decomposition event commences and finishes. As mentioned earlier, different chemical substances decompose within known temperature ranges. As slag samples are made up of many different minerals, the derivative weight curve can highlight the temperatures at which the decompositions of these different minerals begin and end. Calcite (CaCO_3) decomposes between 500 and 900 degrees Celsius. As calcite decomposes, CO_2 is released. To calculate the amount of CO_2 lost from a particular sample, firstly the weight of the sample at 500 degrees Celsius is subtracted from the weight of the sample at 900 degrees Celsius. This determines how much weight was lost from the sample during the calcite decomposition event. Next, this figure is divided by the weight of the sample at 105

degrees Celsius. This figure represents the overall weight of the sample when it is fully dry i.e., when any water that may have been on the surface of the sample has been expelled. Finally, the resulting figure is multiplied by 100, to give the weight percentage of CO₂ lost, and therefore originally mineralised, within the sample's calcite (this method is adapted from Pan et al, 2016, and Chiang and Pan, 2017).⁴⁹

Pan et al (2016) have however highlighted some limitations regarding the use of TGA to calculate the weight of CO₂ in a sample. They point out that the specified temperature range given for the decomposition of calcite actually varies quite widely between studies. This claim is indeed borne out in the literature – between a sample selection of six articles, I found six different temperature ranges cited for the decomposition of calcite (Chang et al, 2011; Chang et al, 2012; Huijgen et al, 2005; Lekakh et al, 2008; Pan et al, 2016 and Santos et al, 2013). All of these temperature ranges did however fall between a minimum of 500 degrees Celsius and a maximum of 1000 degrees Celsius. Pan et al contend that this diversity in the 'known' decomposition temperature range for calcite is due to a level of subjectivity in the interpretation of TGA graphs, as researchers use the ranges suggested by the derivative weight curves of their own experiment results, rather than a universally agreed figure. Although the main purpose of using Thermogravimetric Analysis in this study was to ascertain the amount of CO₂ within my samples, this was ultimately to gain a comparative perspective of this figure between exposed and buried samples, rather than a precise quantification. I therefore chose to employ a calcite decomposition temperature range of 500 degrees Celsius to 900 degrees Celsius, as 900 degrees Celsius was the highest temperature—rounded to the nearest hundred—that the TGA experiments ran to for my samples.⁵⁰ In addition, Pan et al note that the decomposition of various hydrated compounds (such as α dicalciumsilicate hydrate) can occur within the same temperature range as calcite, therefore making the CO₂ weight % calculation less reliable. Santos et al (2013) however point out that if XRD analysis is conducted alongside TGA, and the XRD results do now show the presence

⁴⁹ There are two different methods conventionally used to calculate CO₂ weight percentage loss. The 'delta y' method calculates the weight loss of CO₂ between two specified temperatures, whilst the 'on-set' method uses the difference between the points at which the baseline and the slope of the TGA curve intersect to calculate this weight loss (Pan et al, 2016). Here, I have used the delta-y method.

⁵⁰ Although the TGA experiments for my samples ran to a top temperature of 1000 degrees Celsius, the final temperature and weight readings were in actuality recorded at a range of different temperatures just below this. To keep my CO₂ weight loss calculation consistent between samples, I therefore chose to employ a calcite decomposition temperature range of between 500 and 900 degrees Celsius.

of these hydrated compounds (as was the case for my samples) then this potential overlap in decomposition ranges should not present a concern.

3.2.3 Scanning Electron Microscopy (SEM)

Whilst a conventional optical microscope can show the presence of calcite within slag (see **figure 6.4**) a scanning electron microscope (SEM) can produce images at far greater magnifications and higher resolutions. I therefore used Scanning Electron Microscopy as my final analytical method, to compare the microstructures of the slag samples, and to establish the extent and nature of the CO₂ mineralisation in each.



Figure 6.4: A view of one of my slag samples through an optical microscope, during sample preparation for the SEM. White deposits of calcite can be seen precipitated into pore spaces (photograph courtesy of Connor Brolly).

A SEM operates by directing a beam of electrons onto the surface of a sample. It runs under a vacuum to facilitate this process. As air molecules would interfere with the electron beam, the imposition of a vacuum is crucial for ensuring that the beam is well focused when it reaches the sample, to ensure the best image and data quality. As the incoming electrons interact with the atomic structure of the sample, several different kinds of signals, which are emitted from varying depths within the sample, can be picked up by the SEM detectors, each providing a different piece of information about the material. The most commonly used signals in the SEM are secondary electrons, backscattered electrons, and characteristic X-rays. Secondary electrons are emitted when the incoming electrons excite the electrons in the sample. This means that the sample electrons gain energy, but as a consequence the incoming electrons lose energy.

While the excited sample electrons can emit their own ‘secondary’ electrons as a result of this process, the energies of these secondary electrons are very small, so they cannot travel very far. Thus, only secondary electrons that are generated near the surface of the sample can

journey far enough to be picked up by the SEM detectors. Secondary electrons can therefore provide information regarding the surface topography of the sample. Backscatter electrons are emitted when incoming electrons reflect off the centre (or nucleus) of the atoms which make up the sample. This process does not cause the incoming electrons to lose any energy. As these 'backscattered' electrons therefore have higher energies than secondary electrons, they can travel further from the interior of the sample to be picked up by the SEM detectors. Backscattered electrons can also provide topographic information, as well as data regarding the composition of the sample, as they produce a stronger signal when interacting with heavier atoms compared to lighter atoms. Finally, X-rays are emitted when the ordering of electrons in an atom is altered by incoming electrons. As X-rays have higher energies than electrons, they can travel from the greatest depths within the sample. Each chemical element has its own unique ordering of electrons in its atoms. When these electron orders are disrupted, a chemical element will emit its own characteristic x-ray pattern. X-rays also therefore carry information regarding the composition of the sample. These various signals are then processed by computer software into images. The strength of the signals received from across the sample correspond to the levels of brightness or darkness displayed on the images. SEM images are therefore produced in greyscale, but colour can be artificially added to the images, to highlight certain features. In this study I used the SEM to capture images corresponding to the three kinds of signal outlined above. Secondary electrons (SE) and backscattered electrons (BSE) thus produced SE and BSE images, whilst x-rays produced energy dispersive x-ray spectroscopy (EDS) images.

To undergo SEM analysis, my samples had to be sliced into thin sections, 30 micrometres (μm) thick. This work was conducted by Dr Connor Brolly, a technician in Glasgow University's School of Geographical and Earth Sciences (GES). The samples were firstly cut into small blocks using a diamond saw to reduce their size, so that they could be mounted on a glass slide. They were then each bonded to a frosted glass slide using an epoxy resin/hardener. A Petrothin machine was then used to reduce the thickness of the slag block mounted on the glass slide, so that only a thin section (of $80\mu\text{m}$) remained. The samples then underwent a process called lapping, where they were abraded by a grinding solution. This was done using a Logitech LP30 Lapping Machine, using a glycol and aluminium oxide solution, to achieve a thickness of $36\mu\text{m}$. The samples were further ground using silicon carbide papers and polished using aluminium oxide, reducing the thickness to $30\mu\text{m}$. The thin

sections were then coated with a 22-nanometre thick carbon coating, to prevent the sample becoming electrically charged during the SEM operation. This ‘charging’ of the sample negatively affects the quality of the images produced.

I produced SEM images of my samples over a number of sessions, assisted by Dr Liene Spruzeniece, GES Microanalysis Experimental Officer, and my supervisor, Dr John MacDonald. This work was carried out in Glasgow University’s Geoanalytical Electron Microscopy and Spectroscopy (GEMS) facility, using a Zeiss Sigma variable pressure field emission gun scanning electron microscope (VP-FEG SEM), with an Oxford Instrument X-Max 80 mm² Silicon Drift Detector Energy Dispersive Detector. The conditions under which the SEM operated are listed in **table 6.1**.

SEM Operating Condition	Value
Vacuum	High
Current	High
Accelerating voltage	20kV
Working distance	8mm
Aperture	60µm

Table 6.1: Details of the conditions under which the SEM operated during my sessions.

Using the SEM involved manipulating a joystick to navigate around the magnified image of the sample, which appeared on a computer screen. At first, I found it difficult to interpret the varying shades of grey that formed the images produced, but with John and Liene’s assistance, I was eventually able to recognise the microstructures in each sample which indicated that calcite precipitation had occurred. I could then compare and contrast the scale of these areas of calcite to determine if a greater extent had precipitated in the exposed or buried slag samples. Liene and John also assisted me to additionally capture large area x-ray images for selected samples. The large area ‘mapping’ process (which takes several hours to complete) produces SE, BSE and EDS images based upon merging several fields of view into one image, allowing for far larger sections of a sample to be captured to provide a statistically representative area for evaluating the extent of variation in CO₂ mineralisation for each sample.

In order to further process the EDS images and large area EDS maps, I used Oxford Instruments AZtec software to produce ‘element maps’, so that the distribution of different elements in each sample could be observed through a colour coding scheme. This additionally allowed me to observe the relationship between areas of calcite precipitation and areas of slag affected by this process. Each of these element maps were processed using the AZtec ‘trmap’ function, which removes both background noise in the data as well as potential overlaps of element X-ray peaks in the obtained spectra, resulting in more reliable results.

3.3 Evaluating a speculative future: Interview compilation and analysis

Scientific analyses of my slag samples would allow me to imagine how the Lochshore’s physical landscape might change if slag CO₂ mineralisation was prioritised here. Yet I also wanted to find a way to put this particular speculative future in conversation with those who knew the past and present-day Lochshore landscape. Initially, I had sought to recruit interview participants through email, targeting individuals who I knew worked with organisations that were currently, or previously had been involved in the management of the former steelworks site, in order to build up a picture of slag management practices through time. The resulting pool of potential participants was however quite small, and ultimately garnered very few responses. My interview recruitment strategy thereafter switched to one which relied on snowballing (where an interview is secured with one participant, who then recommends other individuals for subsequent interviews). This resulted in interview conversations with contributors who were connected through their engagement with the Lochshore regeneration project in various ways (see **table 6.2**). My original focus on slag management thus necessarily broadened to encompass the contemporary changes taking place at the former steelworks site. This approach was more successful, and I was able to conduct four 1-to-2-hour interviews, either in person or through video call, between July and December 2022.

Participant Pseudonym	Description of job role
Ben ⁵¹	Local Charity Representative
Katie	Local Authority Regeneration Officer
Poppy	Community Engagement Officer
Rosemary	Local Authority Locality Officer

Table 6.2: All participants were assigned pseudonyms to protect their anonymity – in addition, their job titles have been generalised.

An initial interview question was devised to specifically assess the participants' awareness of the Glengarnock slag (the full list of questions posed to participants can be found in Appendix 3). Although all interview participants were aware of the presence of slag on the site, their direct interactions with it were generally very limited. In addition, although all of the contributors showed interest in the idea that slag can capture CO₂, they had no prior knowledge of this fact. Given the generally obscure status of the Glengarnock slag, these responses were not unanticipated. Yet in the broader context of CDR project implementation, they are also, according to Mabon (2012), not altogether unsurprising. As carbon capture schemes are a relatively recent technological development, we do not often have readily available examples of CDR technologies to call upon when considering our own perceptions. In addition, these technologies can often be quite unobtrusive, and therefore escape attention. For these reasons, and as the interview participants were not aware of the passive, in-situ mineralisation that was taking place through the Glengarnock slag until this fact was raised in our discussions, it was difficult to sustain conversation on this point. I therefore instead began to ask questions around broader topics, such as place, community, heritage and landscape aspirations. These queries prompted discussions surrounding the wider Lochshore landscape that the Glengarnock slag underlies and partially constitutes, as well as the participants' experiences of and hopes for this place, particularly in light of the regeneration project underway there. Later, as I listened back to these interviews, I realised that this mode of questioning allowed me to gauge how each interviewee personally envisioned Glengarnock's narrative trajectory, and how these stories interacted with the values held by the contributors towards this place and its future. I could then assess how envisioned changes to the management of the Glengarnock slag (arising from the scientific slag sample analysis results) could potentially reflect more general participant aspirations for the redevelopment project. Transcripts of each interview were written up, and subsequently thematically coded. This is a process whereby each transcript is analysed to identify topics that persistently arose within

⁵¹ Ben also featured in the narrative essay presented in Chapter 5.

each, or between all of the interviews. In this way, I was able to deduce various ‘themes’ that emerged as important to my participants, through noting their recurring presence in our conversations.

Whilst my interviews would allow me to draw out areas of synergy between the results of my scientific analysis and participant visions of the Lochshore’s future, I also wanted to critically explore the implications of prioritising CO₂ mineralisation in a slag landscape. I drew guidance on this matter from writing upon the practice of ‘speculating’, which Wilkie (2020:347) defines in *The Routledge Handbook of Interdisciplinary Research Methods* as the act of finding ways to “explore possible latent futures that matter.” Williams and Keating (2022:1) argue that speculative thinking can generate “plural rather than singular narratives” and thus “... recuperate multiple rather than complete forms of knowledge.” Tyszcuk (2021:1) also investigates the meaning of taking a speculative approach, tying this to the practice of scenario building through her *Collective Scenarios* project. The Anthropocene concept, Tyszcuk argues, itself employs the word scenario’s etymological connection between storytelling and setting, to draw us on an “excursion” into a future where the earth’s strata is characterised by “human-induced geological unconformity.” As the Anthropocene simulates a view from an imagined future, projected from current circumstances, the act of asking “what if?” can cause the temporal distance between ‘now’ and ‘then’ to collapse (ibid:2). Tyszcuk contends that working with speculative scenarios can therefore offer us a means of “rehearsing the future” (ibid). Spaces of rehearsal, she stresses, are different from spaces of performance, as they are characterised both by uncertainty, and by negotiations around who gets to participate, in which role. I found this dynamic to be strongly reflected and grounded in Olden’s (2016:201) work at the regenerating post-industrial Govan Graving Docks site in Glasgow. Her research was shaped in response to an environment where “the site’s imaginary— that realm of future imaginings, long the privileged sphere for the musing of the developer and his investors— begin to splinter in surprising ways soon after land clearance.” The beginning of the end of the Graving Docks’ prolonged period of ruination caused established imagined futures for this site to become less certain, and “alternative ideas and visions... [to thus] spark in the public imagination” (ibid). Olden herself worked on a ‘counterplan’ for the regeneration of the Graving Docks, in opposition to that proposed by the high-end developers who owned the site at the time of her fieldwork. She then pitched her counterplan to a group of locals, fellow geographers, artists and scientists. She was left with a series of questions from this engagement, including reflections upon who (or what) her

scheme privileged; facets of the site that her counterplan might unwittingly destroy; and an over-riding concern – how to live better in the Anthropocene, and how best to conjure this future. Olden and Tyszczuk conducted their speculative work in collaboration, with participants who could probe and challenge their proposals. Mindful of the absence of such voices to critique my re-imagined slag landscape in this way, I therefore drew inspiration from the kinds of questions that these researchers had experienced— encompassing issues of accountability, uncertainty and the politics of knowledge production— to more critically consider the speculative Lochshore future my interdisciplinary conversations had generated.

4. Results and Discussion 1 – Comparing legacy slag emplacement conditions

4.1 XRD

The results of the XRD analysis firstly allowed me to gain a sense of the general mineralogy of each sample (see **table 6.3** and **figure 6.5**). The results show the presence of calcium silicate and calcium oxide minerals across all of the samples. Certain samples also contained iron oxide (JK1 and RC18-02), and magnesium oxide (JK2, JK3 and RC18-01). In addition, all samples except RC18-02 also included magnesium iron oxide in their results. These classifications of minerals have previously been recorded in studies of steel slag mineralogy (see Chukwuma, 2021; Herbelin et al, 2020; Yildirim and Prezzi, 2011). Herbelin et al (2020) note that the mineral phases found in steel slag will be determined by processes both during and immediately after the steelmaking process. Materials added to the molten steel, the type of steel under production, furnace conditions and the cooling conditions that the slag is subjected to will all contribute to the mineralogy of a sample. Some mineral phases (such as brownmillerite, larnite and wuestite) will be present when the slag has formed (ibid). Others, such as quartz, may appear in XRD results due to contamination of the slag samples, either by anthropogenic materials (such as sand or bricks) or the natural geology in which it is deposited (ibid; Chukwuma et al, 2021). Other mineral phases form through secondary processes. One example is portlandite, which forms when lime (CaO) in slag comes into contact with water (Yildirim and Prezzi, 2011). The formation of calcite is also a secondary process (Chukwuma et al, 2021; Herbelin et al, 2020). Calcite was recorded in each of my

Name of mineral phase	Chemical Formula	Mineral Group Classification	In JK1	In JK2	In JK3	In GG4	In RC18-01	In RC18-02
Alite	CaSiO ₅	Calcium Silicate	✓	x	x	x	x	x
Brownmillerite	Ca ₂ (Al,Fe ³⁺) ₂ O ₅	Calcium Oxide	✓	✓	✓	✓	✓	✓
Calcite	CaCO ₃	Calcium Carbonate	✓	✓	✓	✓	✓	✓
Larnite	CaSiO ₄	Calcium Silicate	✓	✓	✓	✓	✓	✓
Magnesioferrite	Mg(Fe ³⁺) ₂ O ₄	Magnesium Iron Oxide	✓	x	✓	✓	✓	x
Periclase	MgO	Magnesium Oxide	x	✓	✓	x	✓	x
Portlandite	Ca(OH) ₂	Calcium Oxide	✓	x	x	x	✓	✓
Quartz	SiO ₂	Silicate	✓	✓	x	✓	✓	x
Wuestite	FeO	Iron Oxide	✓	x	x	x	x	✓

Table 6.3: A summary of the mineral phases identified by XRD, and their incidence in each of my samples.

samples, and these incidences of calcite therefore indicate that post-depositional CO₂ mineralisation has occurred in all of the samples.

It is possible to form a qualitative first impression of the quantity of mineral phases present in a sample, by noting the relative intensities of the peaks that appear on the XRD graph (Yildirim and Prezzi, 2011). In all of the samples, the calcite peaks recorded at 29 degrees hold the highest intensities, suggesting that this forms a major phase in each. The relative intensities of the calcite peaks also vary when a comparison is made between the buried samples (JK1, JK2 and JK3) and the exposed samples (GG4, RC18-01 and RC18-02). The peak intensities (rounded to the nearest thousand) for the buried samples range from 10,000 to 20,000 counts. For the exposed samples, two of the XRD graphs (GG4 and RC18-01) record intensity counts of 27,000 and 28,000 respectively. These figures provide a rough initial indication that two of the three exposed samples collected have therefore undergone more CO₂ mineralisation. However, the RC18-02 sample is anomalous to this trend, with a 29-degree calcite peak registering only 7000 counts (rounded to the nearest thousand). This figure represents the lowest calcite peak intensity of all the samples. It is not possible to

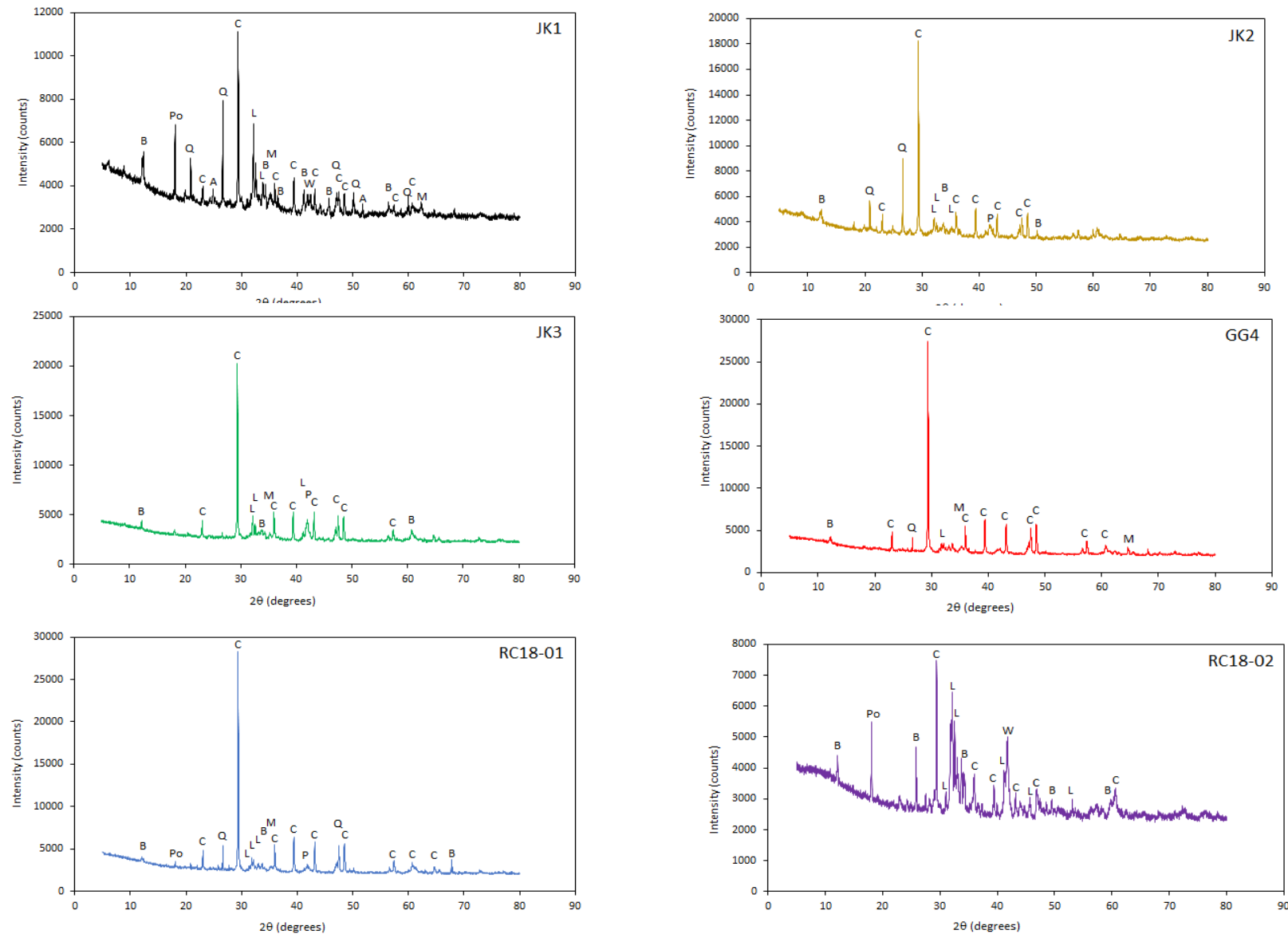


Figure 6.5: XRD graphs for each of my samples. The letter above each peak corresponds to an identified mineral phase as follows: A- Alite; B- Brownmillerite; C- Calcite; L- Larnite; M- Magnesioferrite; P- Periclase; Po- Portlandite; Q- Quartz; W- Wuestite

definitively say why this may be the case, but one possibility is the mineralogical heterogeneity of the sample. When compared to the other samples, intensities for other major peaks in RC18-02 are notably closer in value to that of the 29-degree calcite count. These higher relative quantities of other mineral phases may be why this calcite peak overall registers as proportionally less intense for this sample.

4.2 TGA

The TGA results allowed me to quantify the CO₂ content of each sample, as a proportion of the weight of the original experimental sample (see **figure 6.6**, overleaf). When comparing the results between exposed and buried slag samples, generally higher weight percentages of CO₂ were recorded for the exposed samples. This suggests that higher levels of CaCO₃ decomposition, and therefore more CO₂ mineralisation, had occurred for these samples.

However, there was also variation seen between the samples within the exposed and buried sample sub-groupings. For example, there is a range of 4.86% for the CO₂ weight loss values between the buried samples. This speaks to the uncertainties that can underpin work with legacy slag deposits, as generally it is very difficult to know the life history of a particular slag sample. There were no surviving records regarding the chronology of the Glengarnock slag deposition (if indeed these records existed in the first place), and there is also the possibility that some of the slag may have been moved around the site (due to by-product processing of the slag for road aggregate for example). An individual piece of slag may therefore have undergone intervals of burial and exposition, for unknown periods of time. A high level of uncertainty, and a series of often unanswered questions thus accompanies attempts to account for legacy slag emplacement histories. For this study's buried samples, it is not known how long they might have lain exposed prior to the work of the Garnock Task Force to renew the soil and vegetation cover on the site.⁵² For the exposed samples meanwhile, it is not known whether they had lain exposed since their deposition, or if they were later uncovered. An interview I conducted with a representative from the Scottish Enterprise (who owned the Lochshore site until its sale to North Ayrshire Council in 2021) may however cast some light on this. Discussing previous management of the slag landscape

⁵² Indeed, Carter (1984:53) records evidence of "... reforming skeletal soils and vegetation" found on the former steelworks site by contractors hired by the Garnock Task Force, so some initial slag coverage by soil may have taken place even before the 1980s landscape renewal efforts.

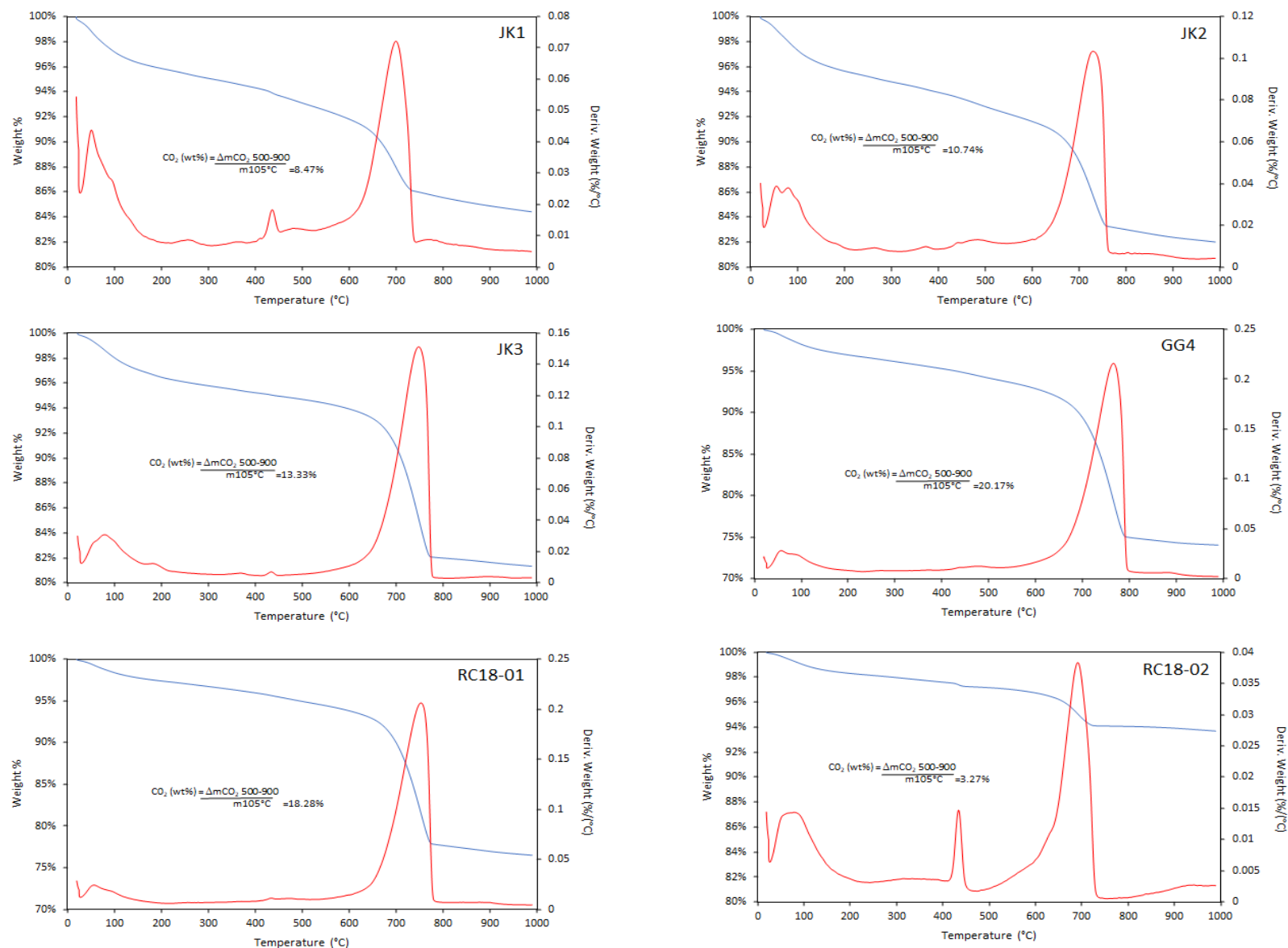


Figure 6.6: TGA graphs for my samples, with the CO₂ weight loss percentage for each noted. The rise and fall seen in the red derivative curve line between 500 and 900 degrees Celsius in each graph shows the decomposition event for calcium carbonate (CaCO₃).

at Glengarnock, the Scottish Enterprise representative commented that the exposed slag on the loch shoreline "... remained untouched throughout SE's ownership of the site." This suggests that this slag had at least been exposed since the Scottish Development Agency (renamed Scottish Enterprise in 1991) took over management of the site following the steelworks closure. Although the TGA results can reveal how much CO₂ is contained within each sample, and therefore indicate the extent of CO₂ mineralisation that has occurred, it is very difficult to produce detailed explanations for why smaller variations between samples may exist.

It is also important to note that again, the RC18-02 sample did not follow the trend of exposed samples showing higher CO₂ weight loss percentages compared to buried samples, as it instead recorded the lowest CO₂ weight loss percentage across all of the samples. This sample's mineralogical heterogeneity, discussed in the previous sub-section, may again account for this otherwise unexpected figure. As the TGA results record CO₂ lost in relation to the original dry weight of the sample, a lower proportion of calcite relative to the presence of other mineral phases may therefore explain the RC18-02 result.

4.3 SEM

Whilst XRD and TGA methods are examples of destructive sampling (where preparation for the analytical procedure causes an irreversible change to be made to the sample) use of the SEM allowed me to view intact sections of the collected slag. Through observing the microstructures that constituted the interior and outer rims of this slag, I was able to gain a deeper insight into how CO₂ mineralisation had taken place, and to what extent this process had occurred. Evidence of CO₂ mineralisation can be recognised in SEM images through the interrelation of distinct zones. These zones occur successively, as areas of fresh slag lie adjacent to areas of weathered slag, which in turn border regions of precipitated calcite (MacDonald, 2023a). The 'element mapping' function, which can be featured in EDS images, demarcates these zones particularly well (see **figures 6.7 & 6.8** overleaf). As its name suggests, the element mapping process can identify the presence and distribution of individual chemical elements only. It therefore cannot recognise the combination of chemical elements that constitute particular mineral phases. Knowledge of the chemical reactions that underpin the CO₂ mineralisation process can however be used to inform interpretations of these images. As we have seen from this study's XRD data, fresh slag is composed of many

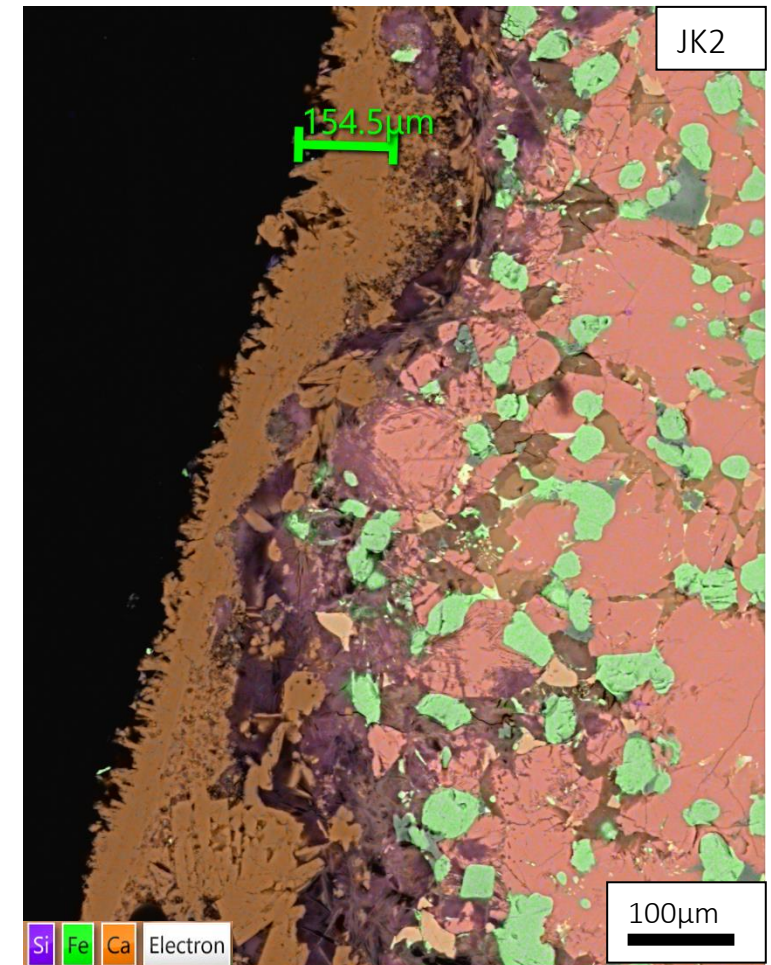
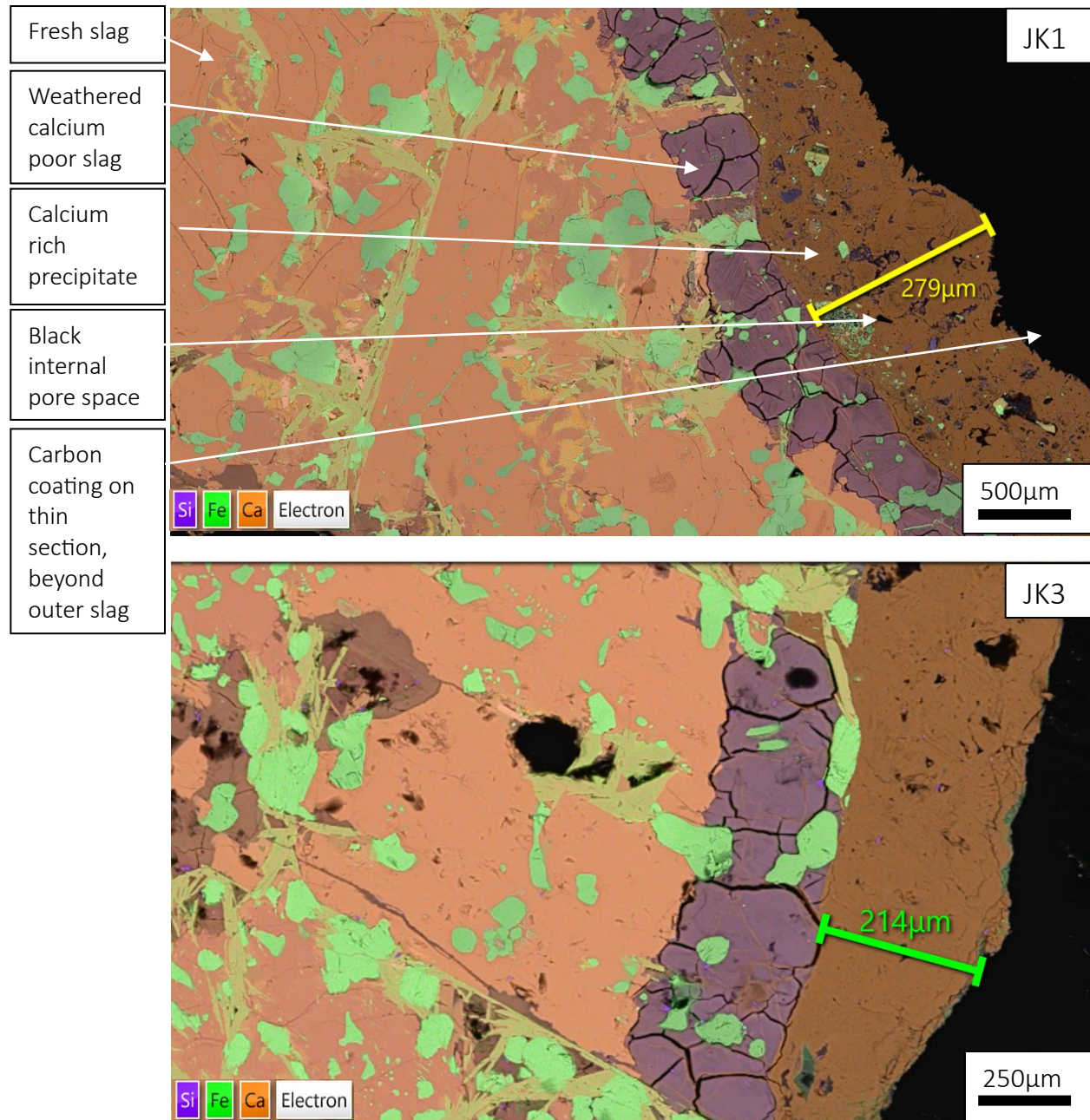


Figure 6.7: SEM EDS images for the buried slag samples. Annotations identifying relevant features are included for the first JK1 image to aid the reader. Images at a 500μm scale were not captured for the JK2 and JK3 samples, so instead these images are displayed at a 100μm and 250 μm scale respectively. The JK2 and JK3 calcite precipitate measurements have therefore been converted to a 500 μm scale, to aid comparison between the SEM images. The converted measurements have been noted in green, to highlight the difference in procedure taken for these sample images.

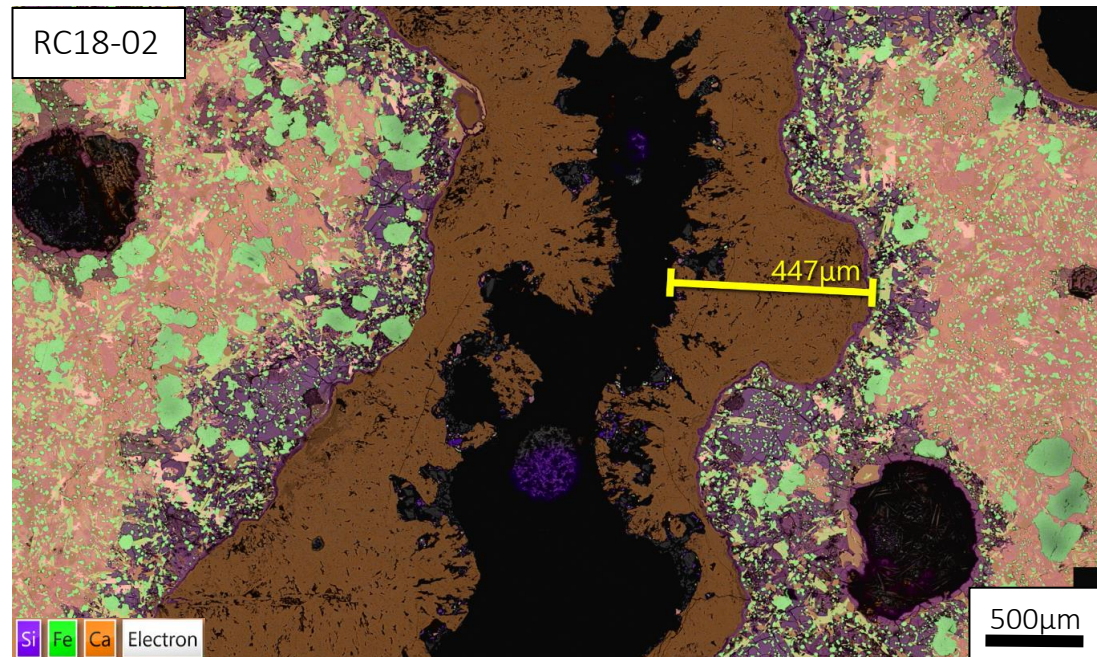
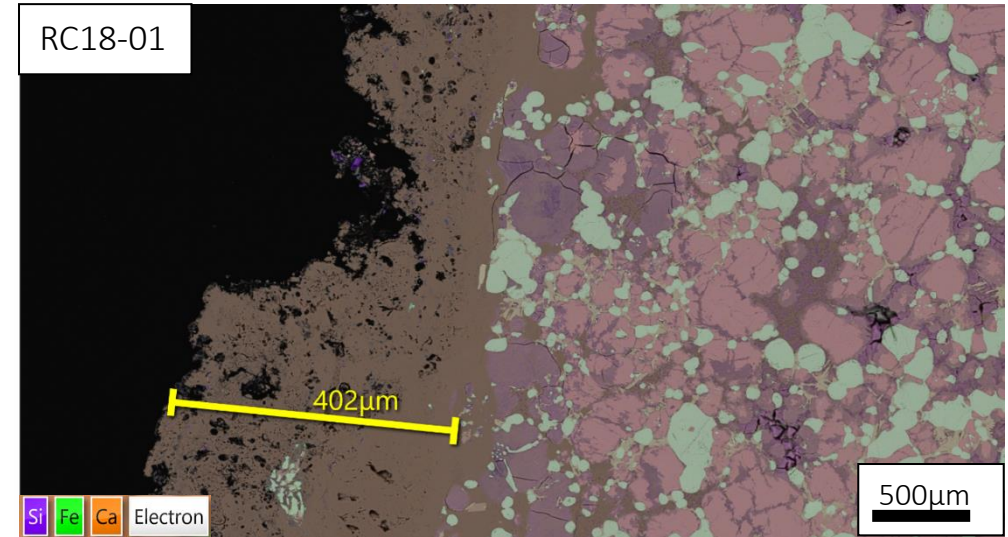
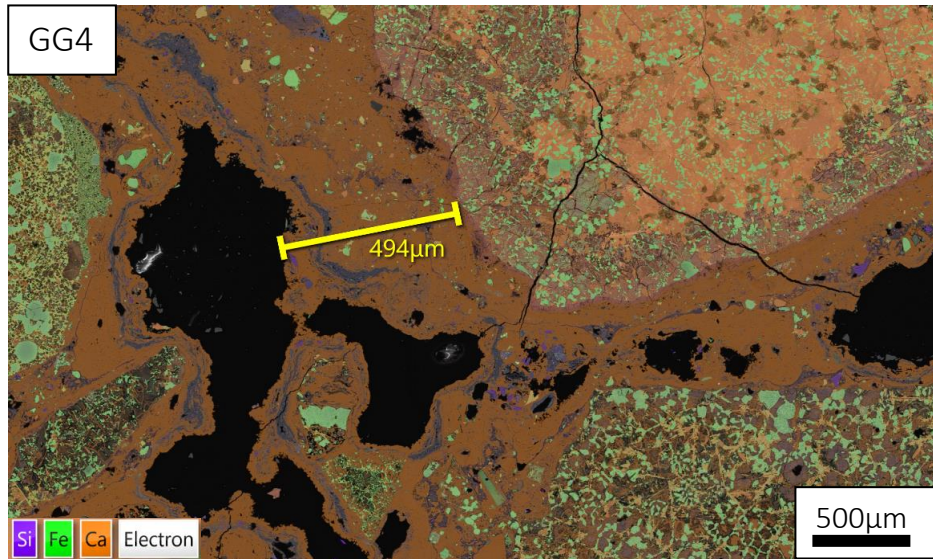


Figure 6.8: SEM EDS images for the exposed slag samples. Here, the calcite precipitated is noticeably more extensive compared to the buried samples.

mineral phases, including calcium silicates, such as larnite. Previous studies (such as Khudhur et al, 2023) have identified larnite in particular as a calcium silicate phase which, relative to other slag silicate minerals such as åkermanite or gehlenite, weathers quickly to produce a calcite precipitate. Crucially, when the calcium silicate present in fresh slag comes into contact with water, it has been found that the calcium therein becomes soluble, and is leached, or washed out, of the slag (Khudhur et al, 2022b; Khudhur et al, 2023; Mayes et al, 2018; MacDonald et al, 2023a; MacDonald et al, 2023b; Pullin et al, 2019). Thereafter, the leached calcium reacts with CO₂ to form a secondary CaCO₃ (calcite) precipitate (ibid). This process has been observed in SEM EDS images, through paying particular attention to the chemical elements calcium and silicon (Khudhur et al, 2022b; Khudhur et al, 2023; MacDonald et al 2023a; MacDonald et al 2023b). In my images, the calcium and silicon are colour-coded orange and purple respectively. Each image shows a zone of fresh slag, that can be recognised by the coincidence of these two elements, forming an area of coral pink colouration. As the slag is weathered, and the calcium is leached from it, a calcium depleted, purple zone occurs. Finally, the calcium rich precipitated calcite forms an orange region. My images are also colour coded to show the presence of iron (in green). Iron is present in the fresh and weathered slag, but not in the precipitated calcite. This indicates that iron does not take part in the CO₂ mineralisation chemical reactions, but also demonstrates that the calcite precipitate is a secondary deposit, distinct from the slag itself (MacDonald et al, 2023a; MacDonald et al, 2023b). In order to compare the extent of the CO₂ mineralisation between my exposed and buried slag samples, I used the Oxford Instruments AZtec software calliper tool, which measures and reports the distance between two chosen points on an image. Each image was captured at a scale of 250µm, and I measured the extent of the precipitated calcite zone in each image perpendicular to the edge of the weathered slag zone (two images could not be measured at a 250µm scale, and so calcite measurements in these instances were converted from their original scale to the 250µm scale to allow for easier comparison). Using this method, it can clearly be seen that the exposed slag samples show more extensive calcite precipitation— and thus more CO₂ mineralisation— than the buried slag samples. An important caveat to note here is that these two-dimensional images may not have been captured perpendicular to the slag surface, and might thus instead be at an oblique angle – resulting in the calliper tool measurements being exaggerated. This issue is countered to an extent however by conducting these measurements with three samples from the exposed and buried sample groups respectively. This means that a general comparative trend can be established from this larger data set.

The differences in the types of SEM imaging captured for the exposed and buried samples also reflects these results. For the exposed samples, large area mapping images were captured at a scale of 1mm, as there was generally more calcite precipitation in evidence across the thin sections of these samples. By contrast, for the buried samples, areas of calcite precipitation had to be more actively sought out across the thin sections, so single frame images were instead generally used to capture these more sparsely distributed sites of interest. One large area map BSE image was however captured for buried sample JK2, and the difference in the extent of calcite precipitation distribution described above can be seen when it is compared to large area map BSE images of exposed samples GG4 and RC18-01 (see **figure 6.9**, overleaf). In addition, and contrary to the XRD and TGA results, the RC18-02 sample also follows this trend, and indeed records the second widest extent of calcite precipitate of the samples. This demonstrates that although this sample has a smaller quantity of calcite in proportion to its overall mineralogy, the calcite that *is* present has precipitated in larger amounts compared to the buried samples.

These results indicate that the emplacement conditions of the GG4, RC18-01 and RC18-02 slag samples meant they were able to mineralise more CO₂, due to their relatively greater exposure to air and water. The exposed samples were more open to CO₂ in-gassing compared to the buried samples, and they were also proximate to Kilbirnie Loch, allowing its waters to periodically cover this area of shoreline slag, as the loch levels rise and fall depending on rainfall levels.⁵³ MacDonald et al (2023b) note that the extent of calcite precipitation has been observed to vary depending on water source, with more precipitation observed in slag samples weathered by larger bodies of water, compared to through rainfall. Yet as calcite precipitation (and thus CO₂ mineralisation) depends on a highly alkaline source of water, too great a volume of water will cause its pH to dilute and lower. The *intermittent* nature of Kilbirnie Loch's contact with the exposed slag is therefore important, as this forms small pools of water upon the slag surface. This enables the regulation of both water volume and pH to facilitate the weathering and mineralisation processes (ibid). The SEM images—and in particular the large area maps—do however exhibit variations in the extent of calcite

⁵³ I saw evidence of these fairly significant changes in loch level during various fieldtrips to the Lochshore site. After a particularly dry spell in April 2021, a large extent of the slag on the loch shoreline was exposed – yet during a trip to the same stretch of shoreline after a period of heavy rainfall in October 2022, the slag was completely underwater.

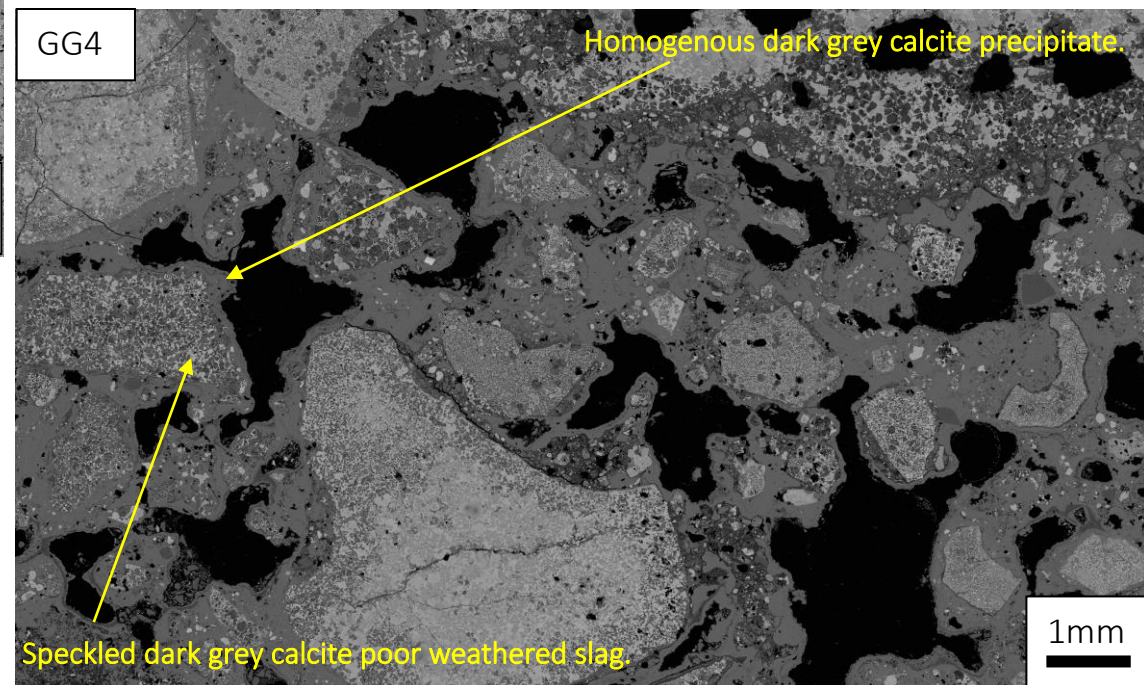
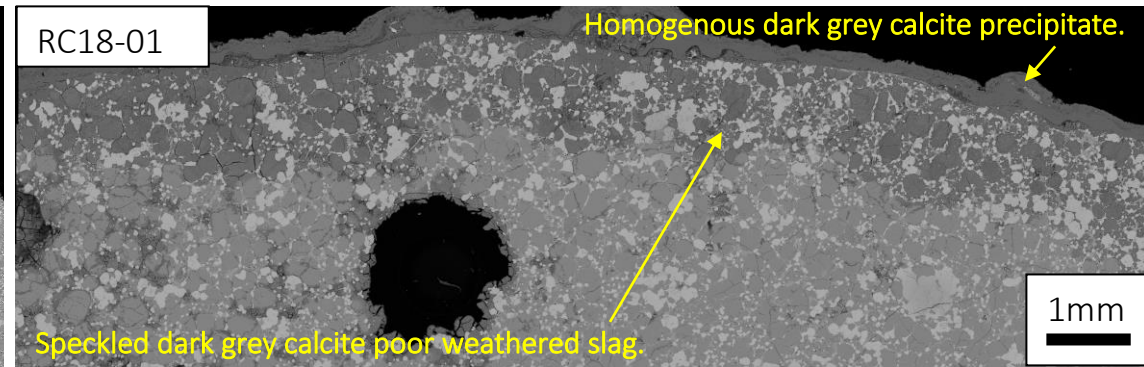
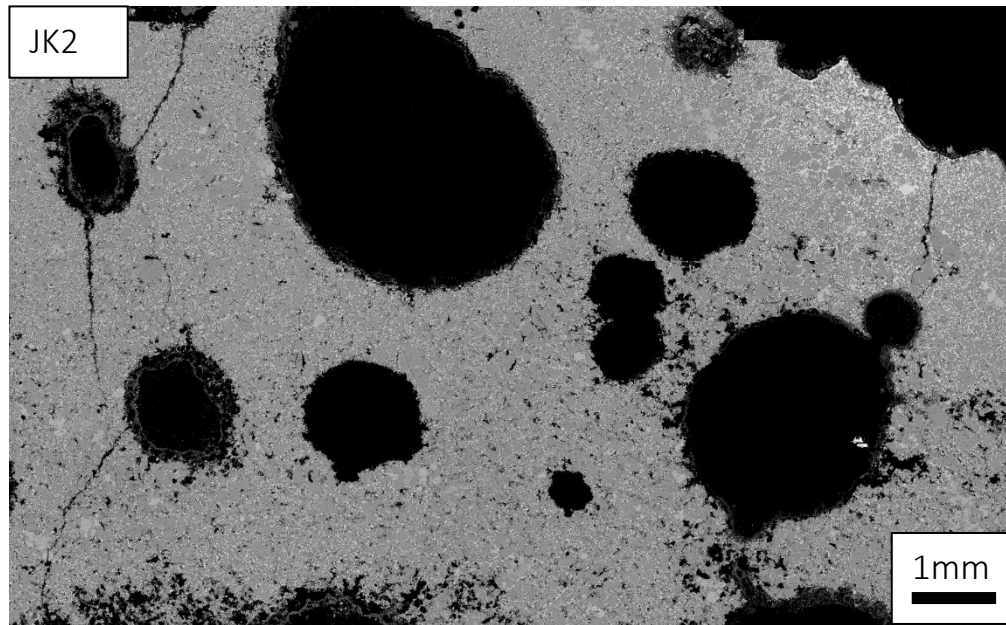


Figure 6.9: BSE images comparing a buried (JK2) sample with exposed (GG4 & RC18-01) samples. In the RC18-01 image, a homogenous, dark grey zone indicates calcite precipitate on the outer rim of the sample, which is visually distinct to the adjoining zone of speckled dark grey, indicating weathered, calcium poor slag. This same zonation can be seen in the GG4 image, where black internal pore spaces are partially filled with calcite precipitate. By contrast, the internal pores and outer rim of the JK2 image shows little evidence of these features.

precipitation observed within a sample. Each of my samples show some pore and outer rim areas with relatively extensive zones of calcite precipitation, and others with relatively little. Individual areas of calcite precipitation also show variation in the extent of their width. These disparities have also been noted by MacDonald et al (2023a), who put forward a number of explanations as to why they might occur. One suggestion concerns pores contained within a sample. As some of these void spaces may have no connection to external surfaces, it is hypothesised that these isolated pores will show no calcite precipitation, as they have no access to air or water, which facilitate this process. Yet as the authors point out, the outer rims of samples, which are exposed to the external environment, also show variations in calcite precipitation. This implies, they propose, that there are factors internal to the slag itself, such as chemical or physical characteristics, which control the extent of calcite precipitation, as well as external factors. Khudhur et al (2023) also note that the precipitation of calcite itself (or other precipitates, such as those rich in silicon and oxygen) can limit or obstruct the access of air and water to a sample, therefore reducing the potential of further mineralisation sites arising. From these discussions, it can be appreciated that CO₂ mineralisation in steel slag is an active area of research, with further work required to determine all of the factors that enable or limit this process. For the purposes of this comparative study however, the SEM images captured demonstrate that where calcite has precipitated, the buried slag samples generally show less evidence of this compared to the exposed slag samples.

4.4 Summary

From a carbon dioxide removal (CDR) perspective, the means by which the Glengarnock slag has been managed to date has limited the carbon capture potential of this site. The decision to cover the majority of the slag with soil and vegetation cover reduces air and water ingress, and thus diminishes the amount of CO₂ mineralisation that can occur in buried slag. By contrast, the slag which lies exposed on the shoreline of Kilbirnie Loch occupies a relatively small area of the overall site. The management of Glengarnock's slag landscape could therefore be re-envisioned to enhance passive carbon capture in these legacy materials. Following Pullin et al's (2019) proposals for this undertaking, soil and vegetation cover could be removed from areas of the site to expose the underlying slag, which could then be arranged in shallow heaps to facilitate water and air ingress. As the shoreline of Kilbirnie Loch is the only area of the site where exposed slag is already in-situ, these new areas of re-

exposed slag would also benefit from a system which replicates the natural intermittent flooding of the slag by the loch water.

However, whilst this re-imagining of Glengarnock's slag landscape has been generated through scientific enquiry, it does remain largely ungrounded in the specific social context of this place itself. Fincher et al (2014:201) posit that in the face of environmental change, "... futures are imagined with reference to pasts and presents, remembered and lived." The authors name the resulting narratives 'time stories.' Much like Mabon's (2012) 'narrative trajectories of place', these time stories are used by individuals "... to make sense of the time trajectories in which they are involved" (ibid) and, I suggest, can be used to imagine how other, speculative futures might be received. I will therefore next draw upon interviews with community representatives, to draw out each of their time stories, and explore how the Lochshore's own narrative has evolved through time. At a juncture where this landscape and its narrative are being actively re-shaped, I will consider how these individuals project their own visions and aspirations into the future of their local environment, and reflect upon how these insights can be put in conversation with the bones of the re-imagined slag future sketched out above.

5. Results and Discussion 2 – Telling time stories and exploring envisioned futures

When coding my interview transcripts, I found that common themes emerged across all conversations. I also noticed however that each interview participant spoke of their own distinct experiences, which were strongly reflected both in their narratives of the Lochshore, and in how they individually had come to value this place. I will begin here then, by sharing each interviewee's story, in order to draw out this connection between personal experience and how landscape futures are enacted. I will then go on to outline how commonalities observed across the interviews contribute to a collective vision for this site, which I will use to inform my own re-imagination of the Lochshore's slag landscape.

5.1 Ben's Story

I met Ben on a fairly grey October day, outside the newly opened Lochshore Community Hub building. He suggested we take a walk around the former steelworks site, to assist us in picturing the scenes of his memories. Ben had worked in the steelworks for a few summers in his late teens, which involved a number of miscellaneous tasks "... labouring type jobs, just go fetch this, go fetch that, clean this, clean that and whatever, across the site." He recalled a particularly unpleasant, labour-intensive duty he was assigned to— "... for my sins!"— which involved cleaning the steel making furnaces when they were shut down for maintenance. His general impression of the melting shop was "... a fiery dark, Hades type atmosphere, very smoky, dust everywhere." This industrial miasma also percolated into his memories of growing up in the Garnock Valley: "I personally as a kid, I remember being off school for months at a time, with bronchitis, and that was directly inspired by the environment. Because not only did every residential house in the valley here burn coal for heating purposes – the steelworks was just belching it out, in phenomenal quantities!"

After his summer stints in the steelworks, Ben left the valley— first moving to Glasgow, and then abroad— to pursue other opportunities. He would periodically return to see his family, and on one such visit, he found that the steelworks was gone. I assumed this sudden visual absence must have been quite a striking experience for him, and asked for more details. He paused, and then said, "I don't know if it had any impact on me... a young person in their 20s..." As he built a life elsewhere, and returned to the Garnock valley only a few times a year, at the time, Ben viewed this landscape change quite straightforwardly – where there was something, there was now just nothing. Reflecting further however, he did remember noticing the indirect effects of the steelworks closure: "... I suppose under pressure from the unions, which were strong then, they had to give fairly substantial redundancy payments. So the people who got their redundancies, there was a massive flurry of new cars being bought! So there were hundreds of brand-new motors flashing about Kilbirnie and Beith and Dalry..." This was of course he pointed out, a momentary bubble of prosperity, which quickly burst. Thereafter, Ben explained, the economic impact was long-lasting and "devastating."

Later in life, Ben moved back to the valley, and saw the effects of this decline first hand. This contributed to his motivation to work with a charity which seeks to change the local socio-economic conditions, through investment in community-owned renewable electricity

generation schemes. He linked plans for a hydro scheme in particular with the water powered industrial technologies used in the area in the past. Explaining how this hydro scheme had come about, he also emphasised the importance of learning about local physical geography and landscape history, especially that which is overlooked or underappreciated. In this way, he and his colleagues had discovered a former hydro scheme and associated infrastructure from the last century on the hillside above the valley, which there were now plans to revive. It was his hope that his charity's projects, alongside the Lochshore regeneration project, would generate more money for the area, which could then be re-invested into future projects that would create more jobs, whilst also generating positivity in the local community, and the attention of visitors from further afield.

Towards the end of our conversation, Ben returned again to his reaction to the loss of the steelworks from the landscape: "... when you asked me earlier about what did it mean to me when I was in my twenties... did you notice the steelworks weren't there, um... aye, not so much. Now I'm getting on, whether it's time to reflect on things, I certainly have a greater respect I think, for the area..." For Ben, this sense of respect connected this place's past and future, as the natural resources provided by the valley were once, and are now again, used for local benefit. Yet this feeling was also tempered by an acknowledgment of the environmental degradation caused by the area's industrial history. By contrast, and in what Ben described as a "post-industrial awakening", he hoped that "... where the environment has recovered a bit... with that sort of recovery, there might be greater economic stimulus and recovery." Through tapping the innovations of a specifically local past, as well as its environmental legacies, Ben could see "... that things will get better – hopefully! Fingers crossed. It'll not be for the want of trying anyway."

5.2 Katie's Story

In contrast to my rather dreich autumnal walk with Ben, my site exploration with Katie took place on a very warm day in July. Despite this, she had warned me to cover up well, as the typically high water table of the site attracted all sorts of biting insects. As we made our way along the outlines of new paths, skirting mounds of earth churned up by construction vehicles, Katie told me a little of her background. She had prior experience working in other landscape regeneration projects, but she felt her work at the Lochshore in particular had taken

on a new significance in the aftermath of the Covid pandemic, where the importance of access to local green spaces had become very evident. This had further convinced her of the many different forms of social value that these environments can deliver. As we approached the part of the site where I had gathered my slag samples for scientific analysis, she described how the material landscape itself had offered up inspiration as to how the new park could be shaped, so that these benefits could be experienced by those using it. The landform which emerged as slag encroached into Kilbirnie Loch over the course of almost half a century was now proposed to provide the setting, Katie explained, for a mindfulness route. As she continued to outline these plans, I looked around, and connected the material imprint of the industrial and post-industrial past to this latest vision. I saw that the slag's incursion into the loch would enable visitors to this part of the site to be closer to the wildlife that inhabited this waterbody. The vegetation cover that had been planted to conceal the slag now provided the opportunity for *Shinrin-yoku*, the Japanese practice of forest bathing. Large rocks— I was not sure if these were natural or anthropogenic— had been reclaimed, to offer places to sit and be. “We’re just going to make use of what we can find” Katie affirmed, “so we don’t need to order anything in, because they’re here.”

The link between past and future land use was also evident in the plans made for heritage interpretation. It had been suggested that the northernmost section of the new park would represent the pre-industrial age, inspired by archaeological artefacts from the site, such as an Iron Age crannog that briefly erupted from the loch as a result of slag deposition in the 1860s. Further south, the area which held the steelworks would inform visitors about the area's industrial past, whilst the Community Hub Building and sports club facilities would reflect modern day uses of the site. Katie stressed the importance of researching the site's history through repeatedly consulting with its local community. In this way, the new park planners could “... integrate the stories into their designs” so that memory could be captured in the physical structure of the site. She also reflected that accountability for the success of the project ultimately lay however with those tasked to deliver it. As we continued our walk, and Katie pointed out different landscape features that were of significance to her, I observed that in practice, the realisation of the park's future partially lay in the accommodation and regulation of past human, and non-human uses of the site. For instance, as we passed an area of cleared vegetation, Katie recalled that the timetable for work was determined in part by the need to be mindful of breeding and nesting season. Further along, she paused, and pointed out a pile of charred tires and copper wire. She explained that in the past, the secluded nature of

the site had led to various antisocial activities, including burning metal to sell on as scrap. She gestured to a blackened tree trunk: "... you can see how it's charred the tree there, and there's a really big risk of wildfires at the moment... so we've cleared it, and they've lost this haul, so we're hoping that will discourage them... we've also put bollards in... just so that there's not vehicle access anymore." I could appreciate that finding a balance between the desires of multiple site users would be an ongoing concern, as Katie described plans for future phases of regeneration. The work underway as we walked through the landscape was deliberately chosen to be of immediate benefit to the local community. It was hoped however that future site development would also attract visitors from further afield, as well as eventually, new residents.

We ended our walk with a view overlooking Kilbirnie Loch. We could observe the full extent of the work underway, and I commented that it must be very satisfying to take in. Katie agreed, but added that whilst watching the landscape being regenerated was exciting, it was seeing people *in it* that ultimately made the work worthwhile.

5.3 Rosemary's Story

My interview with Rosemary took place over an online video call, and she began our conversation by outlining her team's contribution to the Lochshore project. Their particular focus was local community involvement in both the redevelopment process and its future outcomes. She had been in her post for a number of years, which meant that her knowledge of the Lochshore landscape preceded the current regenerative impacts that were being seen. I asked her what the site had been like during the earlier years of her work. She remembered regular visitors, such as dog walkers and those involved with the local rugby club, but also more antisocial uses of the site:

"... there was certainly a bit of youth disorder, you know, people going down there and using it as a drinking den, setting fires and things like that. I think a lot of quadbikes had been using the site... there would be a lot of people down there with quadbikes, drumming up pitches and things like that... also, I think people had used it kind of as a camping area, like maybe going down with their pals, pitching a tent... people going down and spending a night."

Despite the negative reputation that had become attached to the place that once held the steelworks, Rosemary also noted that generally, the memory of the works itself held positive associations and often generated interest. Our conversation moved onto the slag, as I asked her if she had come across its presence on the site through her work. "... I mean, I couldn't even tell you what parts round the loch are the kind of, slag areas" she confessed, but then went on "... you'd probably be aware that the Garnock Rugby Club's previous facilities actually sunk into the slag?" I immediately asked her to share the story, and she recounted how several decades previously, the club's old changing rooms had suffered from extreme subsidence, so much so that the building had actually broken in two. "... everyone wanted the new Community Hub to be at the water's edge" she continued, "and actually it was really difficult to do it there, or really expensive to do it there, because of the slag." Although overall awareness of Glengarnock's slag was not much in evidence, a latent memory of its more destructive effects had, it seemed, been retained in the community.

Rosemary also however identified the impact of the physical geography of the Lochshore site, and its surrounding landscape, in her work. Local awareness of environmental issues and interventions had been raised through the recent implementation of flood mitigation schemes in the wider area, whilst her own team's community learning and development activities took place in the outdoors far more commonly than other localities. Rosemary could envision the Lochshore landscape itself continuing these engagements, particularly through young people becoming involved with future site uses. Whilst on the topic of the Lochshore's future, I asked Rosemary about aspirations for the regeneration efforts, and she summarised what she had heard from the local community regarding this question. The main feedback seemed to encompass a need for site accessibility, as well as a desire for the Lochshore to become a destination, with attractions that could help to put the local area on the map. I then asked Rosemary what she personally would like to see in the future. Her answer focussed upon the interconnections between the community and their landscape: "... I really hope that it's a place the community feels is theirs and not just somewhere they go to visit, that just happens to be on their doorstep." Expanding further, she explained "I suppose it's just in terms of the regeneration, that the community are part of it I suppose. Because you're talking about the physical regeneration of the slag site, but there is also the community regeneration... [to] regenerate people's perceptions of the Garnock Valley." Rosemary had witnessed the effects of the meanings that had become attached to both the former steelworks site, and the Garnock Valley more generally over the years. In recognising, as she had, that "... it is such a beautiful

place... it's actually fantastic in the Garnock Valley", both local and non-local people's *mental* landscapes of this place could also be renewed.

5.4 Poppy's Story

My conversation with Poppy also took place over a video call. As a relatively newly hired community engagement officer, she appreciated that she had joined the regeneration project at a time of "significant change" for the landscape that she worked in. "There's more and more people coming" she enthused, "and I think that's exciting because you can really see the growth in it. It's just a really exciting thing to be a part of, to see it change, and to see people getting excited to come back." While describing her role, she brought up the job application process, recalling "... they were looking for someone who was... wanting to find out exactly what the community wanted... it's more about consultation at the end of the day." Poppy explained that she worked day to day on facilitating community use of the site, both through listening to local opinions on what kinds of activities would be welcomed, and then by putting those suggestions into practice. By the time of our conversation, there were already newly founded practical conservation, wellbeing walking and nature arts and crafts groups regularly using the site, as well as plans for a future 'Friends of the Park' organisation to form in addition. Through her work, Poppy had seen firsthand how members of the local community had reacted to the site's regeneration, receiving expressions of enthusiasm, but also a little dubiety, informed by the Lochshore's reputation for antisocial behaviour. Recounting a recent discussion with one of the groups she facilitates, she reflected "... they can be a little unoptimistic – you know, they say 'if we create a fire pit, you know what's going to happen Poppy, the place is going to get burnt down.' But I'm like, we have to give it a try, we have to try things."

This tension between past and future uses of the site was subtly evident during a community open day, which had taken place a few months previously to mark the opening of the new Hub Building. The event saw a considerable turnout, with over 1000 people in attendance. I told Poppy that I had also visited the site on that day, and as we discussed our experiences, she asked if I had seen a small group of protesters at the entrance to the site. By the time I arrived, the protesters had left, but their signs remained, with phrases such as 'WHAT ABOUT US?' and 'HISTORY DO YOUR HOMEWORK' written on them. I asked what the protest had been about, and Poppy explained that local quad bikers, who before the

regeneration project, had the full run of the site, were now unhappy about the change in their circumstances. I realised that the previous post-industrial iteration of the Lochshore had by no means been empty of people. Yet it had been less occupied compared to the present environment, and with an influx of new users, I could see that this change could be difficult for some. Efforts were under way, Poppy went on however, to “... try to harmonise and work together, so its everyone’s park.”

As our conversation progressed, I asked Poppy about how members of her community groups perceived the site’s heritage. She had noticed a general sense of pride in the steelworks, and a desire for this to be reflected in both the park and Community Hub. During wanders around the site with her walking group, people were always keen to point out remnants of the industrial past in the landscape to her. Objects or structures whose origins or purposes were unknown however, generated particular interest and curious debate. Poppy wondered if future regeneration work on the site might expose previously buried slag, and if the public might become more aware of its presence as a result: “Well there’s going to be excavation all over the park – I don’t know if you’ve seen the plans, but... there’s going to be a lot of ground taken up for certain foundations... in certain parts it might be that there’s some [slag] found, and what do you do with that, do you take it in or leave it out?” These kinds of conversations, which arise as a number of people walk through a landscape together are, Poppy identified, what helps new groups to evolve and cohere. The importance of sharing stories in and about a particular place is central to this process, especially as landscape futures continue to be actively re-imagined. This Poppy stressed, is why creating opportunities for community engagement at the early stages of the regeneration project is vital – committing to this work in the present can “... make them feel part of that future.”

5.5 Re-imagining Glengarnock’s slag landscape

A distinct narrative trajectory of the Lochshore emerged across these interviews, as each individual’s story intersected with, but also contributed to the chronology of this place. Some participants, such as Ben and Rosemary, had been embedded within the local community over a longer period which preceded the current redevelopment efforts, whilst it was the regeneration project itself that had introduced Katie and Poppy to this landscape. Ben was the only interview participant who had experienced the steelworks in the Lochshore landscape while it was still operational. These memories had left a dual impression, as he recalled the

Garnock Valley as a place of industry and prosperity, but also as a highly polluted environment with significant effects on his own childhood health. He initially witnessed the loss of the steelworks, and the associated socio-economic decline of his community from a distance, before becoming embedded in efforts to reverse these circumstances following his return to the valley. His personal narrative trajectory deeply interwove the influence of the past upon his visions for the future, as he made explicit connections between historical local innovations, informed by intimate knowledge of the area's now sometimes forgotten geographies, and his charity work to bring community-owned renewable energy to this landscape. Of all the interview participants, he was most personally aware of the passage of time in this place, attributing the gradual process of environmental recovery he had observed to a new, post-industrial sense of hope and inspiration for the future. Meanwhile, Rosemary's experiences of the Lochshore landscape began later, with the long aftermath of the steelwork's loss forming the baseline of her own narrative trajectory of this place. She saw how deindustrialisation had negatively affected perceptions of the Garnock Valley, both in the minds of residents and those who lived elsewhere. For others still, the valley simply existed as a kind of "forgotten land" in North Ayrshire, and the West of Scotland more broadly. These views were in constant contrast to Rosemary's own feelings about this landscape, which were projected into her imaged future of the regeneration project. She saw redevelopment efforts as a means for people to relearn the inherent value of this place, enabling them to see what she could already perceive. Katie's narrative trajectory was also mindful of the more recent history of the Lochshore, especially as she encountered material evidence of how this landscape had come to be used. Relics of illicit activities and structures of non-human habitation were presences to be navigated as she sought to actively re-imagine future connections between landscape and land use. The seclusion of a landform created by the excesses of industry had been co-opted by people and animals who wished to go unseen, but in the future, it was envisioned to serve a more diverse population of visitors as a place of mindful contemplation, simultaneously representing the area's past. Finally, Poppy had been in this landscape for the shortest time of all of my interview participants, and her sense of its past came to her second-hand, through conversations she had whilst exploring the Lochshore site with her community groups. These stories of the area's history— and their recognised, as well as more mysterious signatures in the landscape— brought the members of these groups closer to each other, and to their sense of place. Poppy was also keen to challenge aspects of the more recent past, whilst also acknowledging and understanding the dubiety of some members of the community towards the possibility this transformation. Nevertheless, she

encouraged her group members to try to embrace new landscape practices, to help them realise the sense of a different future in their present.

An overarching theme that emerged from all of these participants' interviews was a desire for change – both in the Lochshore's aesthetic and utilisation, but also in terms of its meaning. Yet each of these individual's visions also hold the potential in turn to bring new meaning to the CO₂ mineralisation taking place through the Lochshore's slag. In this way, the slag could form another example of Ben's forgotten local geographies, rediscovered through applying place specific historical knowledge. It could provide hopeful evidence of post-industrial environmental recovery, connecting the carboniferous pollution of the valley's past with the slag's ability to extract CO₂ from an atmosphere overburdened with fossil fuel emissions.⁵⁴ The slag's overlooked nature could find symbolic analogy in Rosemary's depiction of the Garnock Valley as a "forgotten land", whilst a Lochshore future that prioritises ongoing CO₂ mineralisation in its slag could reflect her aspiration that this place's intrinsic value will be rediscovered through the regeneration process. Katie's work, connecting the materiality of the past, found in the Lochshore's physical landscape, to future uses and interpretations, could be further realised through encouraging visitors to contemplate a landscape that enhances the CO₂ mineralisation process in its slag. This re-imagined slag landscape could also provide Poppy and her group members with a new story of the Lochshore's past to discover together, as well as a means to collapse the promise of the future into the present. By absorbing new meaning through a myriad of possible associations, the Glengarnock slag's future potential might also come to resonate more fully with those who can shape its own narrative and material trajectories.

Questions remain however, as to how this re-imagined slag landscape might speak to other cross-cutting themes that emerged from my interviews, as well as issues of uncertainty, accountability, and the politics of knowledge production raised through my engagement with Olden (2019) and Tyszczyk's (2021) efforts to envision speculative Anthropocene futures. A consideration which arose in many of my interviews was the question of who the new

⁵⁴ It is interesting however to consider how some of these meanings dovetail with the significance Dr Lorna J. Waite found in the Glengarnock slag during her research. The connection to the industrial past provided by 'Slag Hill' mirrors Ben's historical readings of his local landscape, whilst the process of healing renewal Lorna evoked— symbolised by the unexpected beauty of her scavenged piece of slag glass— reflects the aspirations held by each of my interview participants for the new Lochshore park.

Lochshore park belonged to. This issue was also continuously raised in my own consciousness as I encountered traces of the landscape's current users amongst the more obvious evidence of regenerative intentions. Piles of charred wood, bricks, discarded tents and empty bottles clustered on the loch shoreline, whilst glimpses of nests and tracks accompanied occasional sightings of retreating wildlife. These were Lochshore inhabitants whose use of this place was facilitated by its seclusion. As the landscape opened up to increased numbers of people, their majority occupancy of the site came under risk – an outcome that those redeveloping the site sought to mitigate for its wildlife, but encourage in terms of its antisocial uses. Witnessing this negotiation led me to wonder what might additionally be lost from this landscape if a move away from the current state of affairs in slag management was to be pursued. It is challenging however to assess the loss of that which prefers to remain unseen. Attempts could be made to ascertain the impact of a re-imagined slag landscape through consulting with ecologists, who could give a sense of the impacts of soil and vegetation cover removal upon the site's non-human community. Conversations could also be extended within the local human community, to determine if more meanings had become attached to the Lochshore than those which I had uncovered in my limited number of interviews. Another source of potential loss would be the benefits previously sought by the decision to pursue a regime of slag burial. The re-imagined slag landscape would certainly cause parts of the Lochshore to look quite different to the "... attractive and healthy" (Carter, 1984:54) aesthetic that the more 'natural' vegetation cover was intended to afford.⁵⁵ The question of how much of the regenerated site should be given over to the CO₂ mineralisation process should thus be open to wider debate. These efforts to anticipate loss should be tempered however by the knowledge that the effects of some absences may remain unknown, or indeed unknowable. Writing upon the process of seeking change in waste management systems, Liboiron and Lepawsky (2022:138) recognise "an ethic of incommensurability" – that is, that "... there may be no single and universal 'good' that can be or ought to be achieved through change, no totally completed and finished project that addresses everything." Using Liboiron and Lepawsky's framing, the 'good' of CO₂ mineralisation in slag may in some cases be irreconcilable with other 'goods' brought about by slag burial. There are no easy answers in terms of how to proceed within this 'ethic of

⁵⁵ The reference to 'health' by Carter seems to refer to the unhealthy environment of the operational steelworks, rather than any ongoing concerns as to toxicity in the landscape following its closure. The Garnock Task Force did hire environmental scientists to assess any contamination risks present as a result of the industrial waste on the former steelworks site, but the resulting report found "... no evidence of serious toxic or phytotoxic contamination problems in the waste materials sampled" (Carter, 1984:53).

incommensurability', but Liboiron and Lepawsky urge those seeking change to not simply "abandon" the difficulties presented by these differences. Instead, they suggest that we consider how we hold ourselves accountable to the implications of the changes we propose (ibid:151).

This question of accountability applies not only to what may be lost as a result of pursuing a Lochshore slag landscape that prioritises CO₂ mineralisation, but also to what may (or may not) be gained. What would 'success' look like for this new environment, and who is enabled to decide this? 'Success' might simply imply maximising slag valorisation for carbon capture, yet other values could also become attached to this process. For instance, a theme which strongly emerged from my interviews was the participants' desire to see 'ripple effects' of socio-economic benefit emanate from the regeneration of the Lochshore. A re-imagined slag landscape would require financial investment to facilitate its exposure and maintenance. Would these new landforms provide any kind of 'ripple effects' themselves, such as forms of monetary return, or skills acquisition for local people, so as to align with the wider aspirations for the future of their setting? A further reaching question still is whether this re-imagined slag landscape can truly realise the promise of CDR technologies contributing to a decarbonised future. Buck (2020:2) notes that those working in both industrial and policy making contexts are progressively coming to view CDR as a process of waste management. She points out that as "many forms of carbon removal are literally integrated with other forms of waste management", these systems have thus become recognised as providing a "central mechanism" of CDR. Yet as Hird (2015:202) identifies, a key facet of waste is that of its relative mundanity. The matter of waste does not catch the public imagination, or generate the same level of communal anxiety as, for example, the climate and biodiversity crises. This, Hird argues, has implications for how waste is managed, as it is routinely dealt with in a manner that does not problematise the handing down of its legacies to future generations. She deems such management strategies as instances of "political sedimentation", where the interests of corporate and political actors to uphold the status quo are prioritised. Seeing this situation being potentially repeated in the emerging entanglements between CDR strategies and waste management practices, Buck (2020:8) highlights wider concerns that CDR techniques (and in particular, proposals for carbon capture, *utilisation* and storage) could enable the perpetuation of petro-capitalist disposal systems, rather than their eventual elimination. Suggestions that the drawdown of atmospheric CO₂ by industrial wastes could "... partially close the loop on the [carbon] footprint from steel production" (Renforth et al,

2009:1763) may serve to support the case for continued greenhouse gas emissions, rather than their at-source elimination. These concerns give rise to the question of how a landscape which holds the localised effects of this atmospheric remediation could actively challenge the harnessing of meaning making depicting CO₂ mineralisation in industrial waste as a justification for the continued industrial use of fossil fuels.

Returning to the question of *who* might define the success of a re-imagined Lochshore slag landscape, a final theme which strongly emerged from my interviews was the participants' desire to see the involvement of the local community in the regeneration project. As it stands however, knowledge surrounding the potential for slag carbon capture at this site has not been democratised in this way. I certainly cannot claim that this small scale study has achieved this goal. Despite its many advantages, as outlined in Chapter 3, the interdisciplinary nature of my PhD project has naturally limited the time I was able to spend working within any one approach. Consequently, both the scientific work and interviews conducted for this chapter are limited by relatively small sample sizes. The process of learning to work within a disciplinary area unfamiliar to me also took time, trial and error, and this largely prevented the dissemination of my new-found knowledge with the local community. Yet the many questions that this chapter has unearthed here— emerging from a confluence between the sciences, social sciences and the potential of slag carbon capture— could emerge as avenues of new opportunity to co-produce future work. Mabon (2012:336) observes that "... public perceptions are formed, reinforced and negotiated as people go about their daily lives." A pair of fundamental questions thus face carbon capture schemes – the extent to which they "... permeate people's lives" and the manner in which attitudes towards them can be shaped by people's practices with them. Despite this, "Publics are highly unlikely to 'do' CCS themselves" (ibid). Based on the findings of this chapter, this last assertion of Mabon's could be challenged, by assembling a diverse community of co-learners, to further pursue answers to the questions raised here. This could represent a first step in building the re-imagined Lochshore slag landscape envisioned here.

6. Conclusion

In this chapter, I have uncovered initial evidence that emplacement conditions which promote slag exposure, rather than burial, can enhance the CO₂ mineralisation process in this

anthropogenic geomaterial. I have used this information to re-imagine a Lochshore slag landscape that prioritises carbon capture, and have populated this landscape with possible new meanings for Glengarnock's slag, drawn from the 'time stories' (Fincher et al, 2014) of those who aspire to shape a different Lochshore future. Finally, I have examined what the implications of seeking changes to slag management at this site could and should entail. A number of key findings have emerged from this process, as well as several questions requiring further research. The importance of community engagement with any landscape regeneration process, including the implementation of CDR technologies, emerged strongly. For broader community engagement with the prospect of CDR at Glengarnock to be encouraged, local people therefore need to become more aware of the presence of CO₂ mineralisation in the Lochshore slag. This awareness building could be assisted by finding additional ways in which Glengarnock's slag itself can become meaningful, through inserting its story into the multifarious narrative trajectories of this place. Care is needed however, in how these potential new meanings are wielded to engender change. It is also important, when attempting to anticipate latent, as yet unrealised futures, to be mindful of the presence of unknown entities, uncertainties, mistakes and failures therein, as no outcomes can ever be fully predicted.

In addition, this chapter has demonstrated the value of approaching a speculative future in an interdisciplinary manner. The re-envisioned landscape conjured in this chapter came into being through the practice of scientific data analysis. It was simultaneously shaped in my imagination by the narratives, hopes and values of my interview participants. The interdisciplinarity practiced here thus does not reduce science to simply constitute an object of social scientific critique, yet also deliberately refuses to resemble an approach where the social sciences have been – in the words of Petts et al (2008:598) "... cast in the role of... somehow smoothing the way for the necessary technological solutions." Instead, it found commonality with Williams and Keating's (2022:2) contention that "to ask what thought might become is to cultivate a mode of speculative thinking that is at odds with prophetic positions...". By situating scientific results and the big questions they ask of our futures within everyday, local temporalities— the scale at which Fincher et al (2014) remind us caring practices are made visible— an interdisciplinary communality between historical geography and the geosciences was found, where the connections between past, present and future legacies are acknowledged (see Greer et al, 2018 and Lave, 2018, for similar ideas

expressed in relation to the potential for interdisciplinary work to be conducted between historical geography and critical physical geographies).

By following Puig de la Bellacasa's (2011) injunction, and imagining one instance of how others might become affected by the Lochshore's slag, I have unpacked just how multifarious these potential caring others might be. It also became clear however that many more varied voices still— far beyond the scope of this chapter— would need to join this conversation for this conceptualisation to be realised. Of course, as the re-imagined slag landscape generated here is decidedly notional in nature, this chapter was not written with the expectation that this vision would be achieved in reality – not least because the long term, multi-voiced engagement required would not complement the relatively short-timescales of researching for a PhD empirical chapter. The speculative future rehearsed here does however function as a case study, exploring what living in the Anthropocene, alongside the anthropogenic strata that delineate this new geological epoch, could look like. This research justifies why future work examining landscapes of anthropogenic climate change mitigation should adopt a multi-voiced, interdisciplinary and place-informed approach to the task of assessing CDR technology suitability.

Chapter 7: Conclusion

In the opening chapter of this thesis, I described how I became interested in exploring whether the Glengarnock slag's legacies might hold alternate stories to those which I had originally expected. I will thus begin this concluding chapter by returning to my research aims, reviewing how the fulfilment of each has contributed a response to this central guiding question. I will also briefly consider how my work has opened up avenues for future research at my field site. This chapter will next move to reflect upon the broader contributions that have arisen across the empirical chapters of this thesis, as I draw conclusions regarding how my research can be situated within wider scholarly conversations around forgotten and re-encountered material legacies. I will thus return to the themes of Waste, Post-Industrial Afterlives and The Anthropocene, to review how the questions I wished to take forwards at the end of Chapter 2's literature review manifested in my own work. I will then turn to appraise the contributions that this thesis has made to the fields of historical geography, contemporary archaeology and geology respectively, before considering my findings with regards to interdisciplinary practice. Finally, I will circle back round to Michael Given's work with slag, to formulate a final reflection upon how my research has put forward new possibilities for thinking with, and caring about the legacies of this anthropogenic geomaterial.

1. The stories this slag can tell: A return to my research aims

The first aim of this thesis was to use archival sources to recover stories of the Glengarnock slag's past, tracking the many different physical forms assumed by this slag throughout its history, and examining how these diverse materialities were experienced and imbued with meaning. By seeking out voices from the past, to whom this slag mattered, I sought to demonstrate how attending to neglected things can reanimate taken-for-granted histories.

This aim grew from a recognition that the story of slag that I knew at the beginning of this research project was highly partial. Rooted in its own particular historical geographies, the knowledge I had received about slag positioned this material as both a visual signifier of post-industrial neglect, and thus a problem to be overcome through landscape remediation. I witnessed the effects of this narrative to an extent at Glengarnock. During my first visit to the

shoreline of Kilbirnie Loch, I observed the smoothed-out topography of my surroundings, with the slag for the most part concealed beneath soil and vegetation cover. Yet a sliver of remaining slag visible on the loch shoreline invited my commitment to pay attention to it, and this opened up questions around who else might have known this material, and how else I might therefore know it in turn. My search for archival voices that had other stories to tell of Glengarnock's slag was not straightforward, as the long shadow that Covid-19 restrictions cast upon archival spaces accompanied my discovery that the official Glengarnock Steelworks archive had been destroyed. My focus on slag also meant that only a small fraction of the repositories I was eventually able to access were relevant to my research. This did however give me the opportunity to assemble a 'make do' archive (from Lorimer, 2010), by putting a number of very different kinds of source in conversation with each other. By working through the intersections between slag materialities, and the ways these were experienced by my archival subjects, I was able to piece together a longer history, comprising successive slag inheritances. In uncovering the testimony of a works manager, lingering just at the edge of living memory as the Glengarnock Steelworks ceased steel production, I learnt that the Glengarnock slag's basic geochemistry—almost unique in the late 19th and early 20th century Scottish steel industry—was connected to wider, world changing geographies. Edgar J. Windsor Richards witnessed the material innovations required to harness slag's work in the mass production of steel, and brought this inheritance to bear in his pioneering use of the basic Bessemer process, and the by-production of its slag in the Scottish context. I discovered too how the dangers posed by Glengarnock's slag could be world changing for those who inherited the material realities of Richards' vision, through tales of collapsing heaps, choking dust and agonising contact with molten matter. Yet I also came to understand how the labour involved in seeing slag differently can be enrolled in the changing of our own worlds. For Dr Lorna J. Waite, the Glengarnock slag transitioned from a holder of dark opacity to one of refractive lustre. Her slag did not straightforwardly reveal the legacies she sought, but in her sudden appreciation of its beauty, it did reify her conviction that the histories of places and peoples treated as waste are worthy of being taken forwards, and fashioned anew. Together, these stories reanimated my own notions of what a history of slag could constitute. In my fulfilment of this aim, I have produced an account exploring the varied and complex legacies held within past, personal experiences of a particular deposit of steelmaking waste. I have also contributed a story that speaks to Fry and Willis' (2015:6) ambition to "extend and recast" dominant, taken for granted histories of the steel industry, that foreground a "single

narrative” of technological progress, and which conceal alternative histories through their ubiquity.

Opportunities for further research have also been opened up by this work. The digitisation of Dr Lorna J. Waite’s thesis and its associated creative works has rendered this output digitally accessible for the first time. This is also the first time that the archives I employ in this thesis have been put in conversation. Here this has been done in order to assemble an archive of the Glengarnock slag’s history, but I have extracted and crafted only one account of many possible stories opened up by these sources. My adoption of Lorimer’s ‘make do’ process of combining voices from these archives could also therefore be applied to a myriad of other facets of the Glengarnock Steelworks’ past in the future. This proposition is especially significant in light of the destruction of the majority of the works’ archival remains.

The second aim of this thesis was to adapt traditional archaeological field techniques to survey the landscape created by Glengarnock’s slag, amidst the regeneration work that brought the Lochshore Park into being. Whilst new forms of heritage interpretation emerged into this place, positioning its slag as an agent of historic landscape change, I used my field experiences to craft a different kind of narrative. By gradually familiarising myself with a number of specific slag formations, I aimed to show that the Lochshore slag is itself continually being shaped by ongoing processes of transformation.

Whilst my previous aim looked to explore how Glengarnock’s slag has been experienced in the past, here I turned to narratives that were being formed around this material in real time, in the context of the Lochshore regeneration project. Newly emerging heritage infrastructure focussed its interpretations upon the slag’s past capacity to enact change, as its deposition into Kilbirnie Loch at once reshaped the boundaries of this waterbody and created new terrain. Yet by investing time repeatedly walking through this anthropogenic landscape, what emerged for me was this slag’s capacity to itself be changed, as it became ‘mashed up’ (Di Paola and Ciccarelli, 2002) into relations with other living and non-living entities. On the slag beach for instance, neat demarcations between what could be considered ‘natural’ or ‘manmade’ became blurred, as slag, rocks, bricks, driftwood, and unidentifiable rusted objects lay alongside each other, and plants colonised this multi-geneous substrate. At the same time, this place confounded disciplinary divisions, so that understandings of what could be considered ‘geological’ or ‘archaeological’ were broken down, and subsequently opened

up. The slag platform meanwhile demonstrated how slag could continue to transform after it was meant to be forgotten. Its petrified calcite crust— formed in the intermittent meeting of slag and loch water— expanded the horizons of my own geological imaginaries beyond notions of endurance and post-depositional permanence. Instead, I was introduced to one of many manifestations of the ongoing-ness of this anthropogenic geomaterial. My newfound appreciation of unexpected slag afterlives was again expanded through my efforts to interpret a slag stratigraphic section. I had hoped to find clues about the section's origins, but my engagement with its layers instead placed me in the middle of their ongoing story. Here, it was the absence of slag that revealed how the transience of material realities can be bound up in lost futures, as the slag's removal from this place was invested in a hoped for, but never realised perpetuation of the Glengarnock Steelworks' presence in this landscape. Finally, I discovered a particularly lovely manifestation of this slag's afterlives in a collection of tiny slag stalactites. In their improbability, these formations seemed to encapsulate the Glengarnock slag's capacity for transformation. Yet their fragility also captured a sense of anticipatory loss, that accompanied my explorations of this slag's perpetuations into my present, and other uncertain futures. By recounting the ways in which I familiarised myself with the Lochshore slag landscape, I have shown how this slag has been physically shaped by ongoing processes of transformation following its deposition. Yet in these transformations, I also found new ways to know and to represent this material. My own shaping of Glengarnock's slag, through its depiction in this thesis, was thus also a result of my own assumptions, expectations and beliefs becoming subject to change.

My necessary adaptation of archaeological techniques, deriving from a need to minimise the numbers of people inhabiting an actively regenerating landscape facilitated an up-close and personal approach to surveying Glengarnock's slag. Now that the construction work has abated however, new research opportunities could be pursued here, by opening up the means through which I engaged with Glengarnock's slag to others. Replicating the method through which the conversations between I and my companions were recorded, alternative discussions with volunteer participants could be captured, as they in turn walk through this landscape, and develop their own relations to its slag. These experiences could be integrated to develop a compendium of ongoing slag knowledge, to encourage the discovery of further connections between this material's pasts, presents and potential futures.

The third aim of this thesis was to speculatively re-imagine a Lochshore Park future where slag is valued by its local community. To do this, I investigated a particular property of steel slag – its ability to mineralise and thus capture atmospheric carbon dioxide. I performed scientific analyses of selected slag samples to determine how the Lochshore Park’s physical landscape could be shaped to enhance the efficacy of this process. I also conducted interviews with local community representatives to extrapolate how slag carbon capture might align with existing aspirations for this place. By putting the outcomes of this work in conversation, I explored the implications of a resultingly unconventional approach to waste management, whereby both slag and its local community are rendered visible through this endeavour.

My final aim anticipates a reimagining of alternative ways of living in our world, grounded specifically in the act of paying Glengarnock’s slag closer attention. Substantiating this thought experiment in the coming together of two very different sets of empirics, I firstly subjected Glengarnock slag samples to X-ray diffraction, thermogravimetric analysis and scanning electron microscopy techniques, to re-envision how the Lochshore landscape would look if it was physically reformed to encourage passive legacy slag carbon capture. I also conducted interviews with individuals engaged in the Lochshore regeneration process, to gauge how a Lochshore future prioritising slag carbon capture might dovetail with pre-existing community aspirations for this place. What emerged most strongly from this work was a departure from convention, in terms of both slag and community visibility. The results of the small scale scientific study I conducted suggest that the CO₂ mineralisation process would be maximised at this site through the exposure of its slag to the elements – contrary to past practice here, where most of this material was buried. Similarly the ‘time stories’ (Fincher et al, 2014) shared by my interview participants reflected a communally held desire to counter the legacies of deindustrialisation in this place, when community hopes went unseen. My reimagination of the Lochshore slag landscape thus envisioned a future where, rather than being hidden from view by visual mitigation measures or distanced decision making, the Glengarnock slag’s carbon capture is also exposed to be experienced by its local community. The ability of Glengarnock’s slag to capture atmospheric carbon dioxide was a surprise to nearly all who encountered it in the course my research, including myself. The speculative future I built in this study envisioned an alternative scenario, where slag CO₂ mineralisation was valued to the extent that its presence might be prioritised in the Lochshore landscape. Yet the importance of holding space for that which remains surprising, unseen or

unknown was also instrumental in my critical evaluation of this particular projection of ‘living well’ with an anthropogenic geomaterial.

Due in part to its relatively small scale nature however, many questions were opened up through my fulfilment of this aim, especially regarding how a successful realisation of this thesis’ re-imagined Lochshore future might be more widely defined. A first step for further research on this topic should therefore involve an expansion of the work conducted here. Wider recruitment of participants, (including individuals from both the local community and additional disciplinary perspectives) and a reformulation of interview questions to more explicitly put contributor experiences and slag carbon capture in conversation, would allow perceptions of the Lochshore slag’s potential to mineralise CO₂ to move beyond mere expressions of surprise. Larger numbers of participant voices and better communication around slag carbon capture would thus create a forum whereby a deeper critical evaluation could be made of the speculative future I have introduced in this thesis. Importantly, such work would revolve around carbon capture that is already happening within this landscape, and could thus avoid the “gap between rhetoric” and reality which Howell et al (2014:505) warn can negatively affect community engagement with the promise of CO₂ removal.

2. Thinking with slag: Contributions to research themes

A key motif that emerged from my review of scholarly work surrounding the theme of Waste was a desire to turn away from an ‘out of sight, out of mind’ approach to thinking with discarded matter. Yet the manner in which we might foreground waste in our work raises questions around the extent to which an enthusiasm for exploring the unpredictability of waste afterlives might distract us from the often unheard voices of those who live with these materialities. This question was one I tried to think through in my own work. In Chapter 4, I assembled a ‘composite biography’ (Brophy and Edensor, 2023) of Glengarnock’s slag, tracing the stories that emerged from its use and afterlives. By presenting a multi-voiced narrative, that wended its way between different archival sources, I was however also able to write a history that remained alert to disparities in how the unpredictable materialities of Glengarnock’s steel slag were experienced by those who knew it. Each of my archival subjects was surprised by this slag, as it variously rewarded experimental tinkering, posed sudden dangers, and conveyed moments of unexpected disappointment and enchantment. Yet

the extent to which these surprises could be translated into desirable outcomes offered insights too into the legacies of social inequity – some were enrolled in the advancement of industry and capital, others were simply dealt with as best they could be, and others still were put to work in a personal reckoning with this history. I retained a sense of my own privilege then, when exploring how I could translate the slag surprises I was presented with into further research findings. In Chapter 2, I spent time attending to the perspectives of those who work with waste, both in settings that we might expect, such as landfill sites, and those we might not, such as curatorial spaces or archaeological sites. A significant impression arose from this work regarding the capacity of waste to unexpectedly challenge our authority when it disrupts conventional ideas as to what we should do with it. This dynamic was certainly present in Chapter 5, as my exploration of the Lochshore slag landscape yielded disorientating questions on how best to interpret the unfamiliar nature-culture hybrid landforms encountered. In Chapter 6 meanwhile, and as previously mentioned, the ability of Glengarnock's slag to mineralise carbon dioxide came as a great surprise. Yet whilst I sought to speculate a Lochshore future where this waste afterlife had come to the foreground, this imaginary was also co-built with voices that reflected the experiences of a community living alongside this slag through times of industrial redundancy. I also tried to make room for the presence of the unseen or unknown in my critical evaluation of this future, based upon an awareness of the unpredictable ways that waste landscapes, and all they encompass, can continue to surprise us. The determinedly place-based nature of these insights in particular presents a timely contribution to the fast developing body of literature surrounding the carbon capture potential of legacy alkaline wastes.

My review of literatures pertaining to the theme of Post-Industrial Afterlives generated two related questions. I was firstly interested in considering how I could balance the influence of those who have conducted personal explorations of the affective experiences offered by post-industrial settings, without re-erasing the typically already neglected histories of these places. In this sense, my engagement in Chapter 4 with the poetry of Dr Lorna J. Waite's archive offered a special opportunity; to listen to a story told by a self-avowedly working class voice, whose exploration of the former Glengarnock Steelworks site came both to reflect and transcend the personal toll wrought by deindustrialisation. Through my interpretation of the meanings invested in slag through Lorna's poetry, I found my way to the end of this tale, where, figuratively standing on the shoreline of Slag Hill, Lorna encourages her readers to find new post-industrial futures with the complex legacies held by the remnants of former

times. Bearing this message in mind, I sought to remain alert to how the past might materialise in my own explorations of the modern day and potential futures of the Lochshore Park. More specifically, I wished to consider how the legacies of ruination, or ongoing neglect, might be perpetuated in efforts to regenerate this landscape. The most striking example of the interface between the industrialised and deindustrialised pasts of the Lochshore were the landforms that emerged as a result of slag carbon capture. In Chapter 5, I investigated how these features—including mineralised stratigraphic layers, stalactites and a shoreline platform—had been left largely uninterpreted by the new heritage narratives emerging in this landscape. Yet as I worked towards an alternative heritage narrative, which positioned the Lochshore slag as a bearer of ongoing transformation, the act of authoring these landforms left me hoping that they will remain just as they are. This paradox arose as the day-by-day temporalities of my emerging care for the Lochshore slag encountered the uncertainties inherent in the futures encompassed by an entity’s ongoing neglect. My experiences offer a case study with which other heritage scholars and practitioners may identify and wish to further explore, situated in a potentially fruitful middle ground somewhere between a straightforward desire for conservation, and a straightforward acceptance of material transience. They also provide evidence of what Hutchison (2020:3) identifies as the “intensities of... attachment, reflecting new, distinctive heritage values” that can emerge in “New Scottish Landscapes” – places that collectively encompass the quotidian, post-industrial settings of life in Scotland’s heavily populated Central Belt, in contrast to this nation’s more traditionally heritagised “... quintessential landscapes [that] are mountainous, remote, rugged and wild.” In Chapter 6, I imagined how the CO₂ mineralisation process itself might be deliberately perpetuated into the Lochshore Park’s future. Legacy slag carbon capture provides a novel example of the ways in which former industrial sites can become crucibles of scientific interest and environmental benefit, encouraging calls for a state of ongoing ruination to be maintained in these settings. My re-imagined future slag landscape holds onto this reminder of the Lochshore Park’s former neglect, but in simultaneously proposing to radically exceed the extent to which it has currently materialised in the present, cannot really be said to wholly align with these positions. Yet my research in this context suggests that both material manifestations and local experiences of the past should be worked with to open up productive conversations regarding new post-industrial futures.

In March 2024, the International Commission of Stratigraphy’s Subcommission on Quaternary Stratigraphy (ICSSQS) turned down the proposal to instate the Anthropocene as a

new unit of geological time. This cast the literature I had reviewed upon the theme of the Anthropocene in a new light, raising the question of how this now formally rejected epoch might continue to be storied in ways that transcend chronostratigraphic doctrines. In this thesis, I have sought to provide one such narrative, situated in the interstitial spaces between geography, archaeology and geology, opened up by the question of how these disciplines might be changed by the Anthropocene's implications. I have constructed a multi-temporal, granular narrative surrounding an anthropogenic geomaterial, by exploring the Glengarnock steel slag's legacies and the entangled worlds they encompass. In Chapter 4, my work with three archives, which between them span over a century, revealed a far-reaching history encompassing the worlds made and unmade by the global expansion of the steel industry. Throughout this thesis, I have returned to the moment that I discovered the Glengarnock slag had been found to be non-toxic (relative to the proposed uses of the landscape it occupies and partially constitutes). Yet in its capacity as a by-product— or what Paton and DeSilvey (2016) term a 'shadow object'— of steel, this slag represents a localised occurrence of the human-material entanglements by which one of the world's heaviest carbon emitting industries came to be. I thus found that this slag was, in the words of Jonathan Gardner (2023:35) not "... poisonous to life... [but] nonetheless evidence of past toxic human behaviour." Arguably, late 19th century experimenters in slag geochemistry did not have a clear idea of the planetary climate crisis their successes would inflict. Yet before this project, I too was unable to anticipate the possible implications of an entanglement between atmospheric carbon dioxide and steel slag. My review of literatures surrounding the Anthropocene left me curious as to how we might live with its material signatures, and in particular, those which have been transformed by their surrounding environments. In her book *Hope and Grief in the Anthropocene: Reconceptualising human-nature relations*, Lesley Head (2018:167) offers suggestions for how we might come to reconcile our identities as "Anthropoceneans." Among her proposals is the recommendation to "practice hope rather than feel it" by finding promise in unexpected places and everyday materials (ibid:168). The speculative future that I built in Chapter 6 offers an example of how this suggestion might be grounded in a particular context. By putting the aspirations held by representatives of the Lochshore slag's community in conversation with a scientific hypothesis, one vision of living with the Anthropocene's material imprints emerged. I would suggest in turn that 'Anthropoceneans' should not hold science and emotion apart, but instead put them into mutual practice to imagine different futures. Finally, I wish to circle back to the matter of how we might story the Anthropocene beyond the chronostratigraphic. Inherent in this question is my assumption that the

Anthropocene proposal's rejection by the ICSSQS would, at least temporarily, allow this epoch to entirely transcend the debates that have, until recently, closely orbited its stratigraphies. In Chapter 5 however, I encountered a slag landscape feature that revised my thinking. My work interpreting the stories held within the Lochshore's slag stratigraphic section showed me that there are opportunities to explore a different kind of Anthropocene stratigraphical enquiry, one which is more attuned to local, recent human histories and which is interested in the ways that life in this epoch has been experienced and reckoned with. More broadly, this thesis has also contributed to an as yet small but growing body of research focussing upon the properties of specific anthropogenic geomaterials, which Zalasiewicz et al (2017:18) suggest could offer an "alternative prism" through which to understand the Anthropocene.

3. Intra- and interdisciplinary contributions

In the preceding sections of this concluding chapter, I have dealt both with my research aims— which each map onto one of my empirical chapters— and spoken to the conceptual themes that unite them. Here I follow this pattern of moving from the particular to the general, by firstly considering the contributions this thesis has made to the individual fields of historical geography, contemporary archaeology and geology, before reflecting upon the findings I have generated regarding interdisciplinary practice itself.

This thesis has centred its work around a particular material entity, which puts me in the company of historical geographers who are, according to Slatter (2019:2) "... increasingly engaging with material things" in their research. In her introduction to a special issue on 'Materialities and Historical Geographies' however, Slatter goes on to observe that there has been hitherto little explicit discussion on "... the role and place of material sources and methodologies within historical geography research" (ibid). Slatter reviews a number of ways in which these conversations may be started within the sub-discipline, and two of her suggestions are particularly pertinent in terms of how this thesis has contributed to a development of these discussions. First, she identifies the 'unsettling' influence that work with materials can effect upon conventional narratives, be they "well established social stories" or the "established contexts" of an object when it is in use, as opposed to its afterlives following the moment of its discard (ibid:3-4). In addition, she highlights how historical

geographers can work with materials to explore how space has been produced by the entanglement of human and non-human forces. My work in this thesis has engaged with a material that is at once anthropogenic, discarded, continually becoming, and an agent of landscape formation as well as change. In exploring its stories, I have woven alternate threads into well-established narratives of industrialisation, deindustrialisation and post-industrial regeneration, maintaining a focus on personal-scale perspectives to draw out and assert the place of slag in the making of place. I have found the concept of material legacy, or inheritance, especially useful in this work, as it has allowed me to write history between and through different archives. Yet exploring this slag's legacies has also expanded my experiences beyond the archive, and into new intersections of spaces and perspectives, be they in the interplay between social media memories and present day landscape interpretation, or through oral history interviews that became future building 'time stories.' My particular study of material legacies has thus offered the historical geographer novel spaces to inhabit in their research, as well as a means to further develop "polychronic" explorations of past, present and future temporal intersections by sub-disciplinary practitioners (Marković, 2024:33).

Reflecting recently upon "... the 40 years since archaeologies of the contemporary... first appeared" McAtackney (2020:215) recognises "... an established sub-field that no longer has to justify its existence" (ibid:217). Later however, she complicates this assertion, questioning the metrics by which the label 'established' can be applied. Indeed, and perhaps as is to be expected of a sub-discipline whose existence issues a radical challenge to the temporalities typically inhabited by traditional archaeology, persistent doubt seems to linger around the utility of contemporary archaeology, even as it has simultaneously "... undergone a seismic shift in self-definition, confidence and relevance" (ibid:215). The potency of these anxieties is captured by Hill (2013b) in her account of how her own PhD work became unexpectedly subjected to scrutiny, in both national media and sub-disciplinary forums. Those appraising her work, and by extension, contemporary archaeology itself, grappled with a key question – why bother to excavate the recent past, when it is still present in living memory? The work I have undertaken in this thesis allows me to add my voice in countering this reservation. Although the slag landscape I explored came into being in the last century, and there are those alive today who remember instances of this material's initial deposition, my research revealed how quickly the process of *forgetting* occurs. I found that this loss of collective memory was aided and abetted by a sense of social shame rooted in experiences of

deindustrialisation; the rapidity with which both anthropogenic and environmental changes occurred in this post-industrial landscape; and the fact that these waste deposits did not necessarily garner much notice even in times when the Glengarnock Steelworks was operational. Offering a systematic means of paying attention, my application of adapted archaeological techniques in this contemporary context allowed me to formulate questions to ask of its slag, that would not otherwise have occurred to me. Yet in seeking answers, I also turned to work within settings and relations that are underexplored by contemporary archaeologists. In her state of the sub-discipline review, McAtackney (2020:223) observes that “outside of the confines of explicitly community based or public archaeology, there is very little engagement with how we work with people.” By seeking out traces of the Glengarnock slag’s past, present and possible futures in archives, social media forums and through interviews, I have contributed to an ongoing opening up of ways in which researching with people can complement the contemporary archaeological survey’s revitalisation of forgotten histories and perpetuating materialities.

This thesis has also contributed to calls from within geology and wider geoscience perspectives for disciplinary practitioners to reconsider their relationship with the human. Early in my research process, I discovered that the potential chemical toxicity of the Glengarnock slag had already been assessed and found negligible. This presented an initial setback in the context of my own project – although of course these findings more broadly represented good news for the slag’s local community. Instead of solely understanding human-made things as agents of environmental change however, I found that I could instead explore an example of how the environment works upon anthropogenic geomaterials. I have thus provided a novel example of this process to the as yet still small body of work that focusses upon the agency of physical processes in landscapes dominated by our material presence (Dixon et al, 2018). In my use of Paton and DeSilvey’s (2016) notion of ‘recombinant geologies’ however, I also complicated this agentive dichotomy, by tracing how recursive human-environment interactions produced different slag morphologies, through a history far shallower than those typically considered by geologists. The initial furnace-based formation of the Glengarnock slag was derived from the coming together of geological materials with human labour, technologies and networks of inherited knowledge. This slag’s subsequently accumulated deposits were subject to sudden mass movements, as the waterlogged ground they rested upon struggled to support their weight. Their topography also

underwent anthropogenic flattening and rapid erosion, as whole layers of their stratigraphy were smoothed out beneath an extensive horizon of clay topsoil, or removed and transported elsewhere. In the following period of human neglect, the environment went to work upon this slag, as hydrological and atmospheric compounds reacted and precipitated calcite onto its surfaces. Yet the extent to which this occurred relied on human notions of aestheticism, as most of Glengarnock's slag was concealed from view. Growing anxieties around anthropogenic carbon emissions might one day expose and reshape this material's recombinant geologies again. Whilst demonstrating the difficulty of separating human and physical agencies in my study context, I have also accounted for my own presence in my research, paying attention to moments of disorientation, doubt and even delight when engaging with the Glengarnock slag. By explicitly acknowledging and writing through the shared concerns that natural scientists, social scientists and indeed humanities scholars hold with regards to issues of uncertainty, accountability and the politics of knowledge production, I have additionally demonstrated how these perspectives can mutually shape and inhabit the same imagined future. My work has thus offered a blueprint to scholars interested in how the production of geological (or more broadly, geoscientific) knowledge can occupy the same spaces as human emotions, aspirations and actions.

It is apparent that my review of this thesis's intra-disciplinary contributions features a recurring trope – an encouragement to each field to explore atypical research spaces and/or relations. This advocacy arose from my commitment to working at and between disciplinary boundaries. In Chapter 4, I employed Lorimer's (2010:258) concept of a 'make do method' in the building of my 'make do' archive, constructed as I juxtaposed the fragments of a particular past. In fact, this research project as a whole could be viewed as resulting in a 'make do' thesis, which holds splinters of disciplinary influence up against each other to alter my inherited understandings of both industrial waste and research practice – or as Lorimer puts it, to "... see normality differently, even just a little squint" (ibid). This research project's initial, foundational assumption regarding the Glengarnock slag's toxicity was quickly proved wrong, forcing me to instead pose a far more fundamental question of this material – "what exists, there, then, in the moment" to research (ibid)? In seeking out the stories that this slag had to share, I used interdisciplinarity to build a research practice that was "experimental... resourceful... and holistic" (ibid:259). My 'make do' thesis wove together "narrative threads" from historical geography, contemporary archaeology and geology, which, in the novelty of conducting interdisciplinary work, "... emerged in unexpected ways, by twists and turns"

(ibid). As explored in Chapter 3, my interdisciplinary practice was also shaped by my responses to the unexpected challenges presented by my research context. In keeping with Lorimer's characterisation of a 'make do method', the work that eventually became this thesis took shape "on the hoof... improvised according to circumstance" (ibid:258). For this reason, the interdisciplinarity practiced in each of my empirical chapters looks subtly different. In Chapter 4, I used an archival approach familiar to me as a historical geographer, but incorporated different disciplinary perspectives to help me devise a way to foreground the presence of an inanimate object in the historical record. In Chapter 5 meanwhile, site access issues necessitated a combining of disciplinary approaches, refashioning traditional archaeological techniques to accommodate a surface-based, largely individual approach to landscape survey. As access restrictions gradually eased, I was also able to foster the literal coming together of different disciplinary voices in the Lochshore slag landscape. By contrast, in Chapter 6, I gathered natural and social scientific sources of data entirely separately. Unsure of how best to use the results of each individually, I eventually realised that I could put my analyses of this data in conversation, to speculatively re-imagine a slag future lying at the nexus of these different approaches. Through these experiences, I have come to appreciate that the practicing of interdisciplinary itself can be formed and transformed through the geographies, or particularities, in which any given research project is realised, a process which (drawing on Donna Haraway's 1988 concept of 'situated knowledge') I call 'situated interdisciplinarity.' This notion encapsulates the final insight produced by this thesis, as well as a contribution both to studies of interdisciplinary and geographical literatures surrounding the importance of place in the generation of knowledge. It embraces the observation that our ideas surrounding interdisciplinarity cannot be prescriptive, as this research approach instead come into being through the contexts in which it is practiced.

4. Final reflections

One day, as I was walking along one of the Lochshore Park's freshly constructed footpaths, I looked down upon the Kilbirnie Loch shoreline and realised that its slag was not there. Where this waste product had once formed a dark crescent of material, now only loch waters lapped at the embankment supporting the path. I looked around rather wildly. Had the builders of the new route opportunistically used this slag as a kind of aggregate? After all, it was there for the taking. Numbly disappointed, I retreated back the way I had come. All I had witnessed, I

reasoned with myself, was the writing over of what had until recently been this landscape's latest palimpsest layer, the evidence of the old at once subsumed by the signature of the new. This was just another iteration of the Glengarnock slag's many afterlives— but it still felt like a loss. It was only as I neared the new community hub building that I realised my mistake. My visit had been preceded by several days' worth of downpours. The levels of Kilbirnie Loch had simply risen as a result of the rain, and would fall again in time – its own overwriting of the slag shoreline just a temporary phenomenon.

This thesis has charted how I grew to care about Glengarnock's slag. Before this project, I barely noticed the landscape that lay on the other side of Kilbirnie Loch, but now, I pay attention to this place each time I pass it by, checking still for the presence of the slag that lines the opposite shore. Yet why might caring for a deposit of industrial waste matter? In Chapter 1, I spent time with the work of Michael Given, who provided the only other perspective I have been able to find on thinking specifically with slag. Given compellingly demonstrates how slag can capture elements of the past and our relationship to it. In the course of this research project however, I have found that this anthropogenic geomaterial can also speak to our present moment, and specifically how we are currently engaged in reconceiving the relationships between humanity's pasts, presents and futures. Tronto and Fischer (1993, in Puig de la Bellacasa, 2017:3) define care as “everything we do to maintain, continue and repair our world, so that we can live in it as well as possible.” This thesis has shown how coming to care about Glengarnock's steel slag can open up a dialogue about our anxieties regarding the question of how best to care for our world just now. As we grow more aware of both our own influence upon our planet, and our lack of control over the consequences, my choice to pay attention to a neglected local deposit of industrial waste has put forward one example of how we can be productively challenged by the material legacies of our past.

My work with Glengarnock's steel slag has also demonstrated that in their capacity to surprise us, material legacies can at times be difficult to maintain or anticipate. How our own legacies might be inherited in the future can only ever partially be known, as so much of their ongoing afterlives lie before us. For instance, projected climate change scenarios forecast warmer, wetter conditions in the future, which may well swell the waters of Kilbirnie Loch such that it will more frequently claim back the visible portions of the anthropogenic slag landscape whose constituents began, over a century ago, to intrude into its depths. In the far

future, the sliver of slag beach upon which this research project commenced might finally be rendered entirely invisible, the loch waters ultimately stealing back its histories, possible futures, and indeed, the presents of this thesis. In the words of Catilin DeSilvey (2017:2) however, such circumstances can be viewed as either “half empty or half full.” I have contributed just one more written entry into the recorded legacies of the Glengarnock steel slag, such that my work with this material has continued a conversation which has intermittently flowed through time, from the first furnace heat to the last, and beyond. Even if these most extensive last material remnants of the Glengarnock Steelwork are one day reclaimed by Kilbirnie Loch, perhaps in encountering this thesis, future others might come to know these stories for themselves, and use them to think through the worlds waiting in the overlooked margins of their own environments.

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Appendix 1

Full versions of Dr Lorna J. Waite's poems, which appear in extracted form in Chapter 4 of this thesis. The poems are listed here in their order of appearance in this thesis. My sincere thanks to Professor Murdo Macdonald for permission to reproduce these pieces here.

Shift Change

(Waite, 2011a:183)

Where are the words o my steel imagination ?

Fettle

Bloom

Tap

Teem

Whaur did they take the lost furnace ?

“H” was its name, they aa had names

Men intimate wi their temperament

Ca’d tae name their world.

Are there shiftin teams o steelworkers

Oan the shores of Slag Hill

Waitin to be remembered

Am A the only one who

Sees the land like this...?

The eye o the furnace teems metal through my veins

A woman o Hephaestos, my bones are metal,

Winged feet an golden shoes I emerge fae the oozy clay o the sunny neuk Valley born wi an upturned eye

A made-self creation myth

Withoot god.

On Slag Hill: Make New Plans For The Loved Land

(Waite, 2011a:221)

On Slag Hill

Stains of iron rust the bank of the loch
In resigned geologic neglect
Manganese, iron ore, sulphur
A waste tip of memory.

I stand on the metal of the fathers,
The workers of the furnace rolled steel
And see the teardrops of the last tap –
In the steeltown all is quiet now,
Still the sound of metal on land –
The swans keep faith with water,
The oystercatcher in early morning
Reverie sounds the Blastie call to wisdom.

Fishing lines and half moon tents
Lace the shoreline in graceful wave -
Hands no longer grasp the tap hole
Running rivers of metal through
The veins of the black iron land-
Men sit and contemplate
The stir of surface meaning-
The counter balance of history
May tip in our favour
A metronome of history's rhythm
With power of metal and the knowledge of the hunter -
Did the crannog people worship the land?
Gaze at the moon in water-fringed liquid splendour Make metal here too?
Have food at their favourite spot...

Specular light, like the eye of the furnace
He struggled to open the closed entrance –
Teeming was a hard job, double shift toughness
“Too clever to work there, a gentleman”,
They all say in recollected telling -

On Slag Hill, my iron tears run rivers through my face
Craters of metal like the moon pit the surface in grief
Tell tales of lost faith, the injured bodyland
A collective trauma of sorts,
The wise guru of Vienna would intone,
Still felt keenly in throat
A choking of voice strangled
By removal of the chords of history
We still sing our song

An elegant refrain of friendship -
 Nameless Blasties wi the steelwork blues
 Breathe the air of the bird
 Make new plans for the loved land
 She is in us all, I bear her wound
 Extract seeds and fruit of story from the relics.

For ye see, he died there.
 My reliquary is the rusting pipe,
 Slag glass, fossil black, glistens
 From the landfill of rubble, an ancient world
 Of crustacean and industrial architecture of stone,
 Lies waiting to be seen... shining
 Through the empathic eyes of the spirit giver
 The smith-god had helpers
 Golden women with wheels of steel,
 My hair streaks the wind in blonde wisps
 Like kite tails flying over land,
 Keeping company with the dead ones Resurrecting your memory,
 Emboldened by love -
 This spirit holds death close to water
 Consoles the night-time wanderers.

Fur Me, It Wiz Sculpture
A Blastie Honours Glengarnock Steelwork
 (Waite, 2011a:272)

Fur me they wur sculpture
 Nae kennin how tae say this
 Fur we nevur gie the status o art
 Tae oor repeated memories o formation.
 A rescued masel fae the tragedy o the unloved
 Fae the view through the windae o the wurk
 An oan the tap o bings, hurlin the rid blaze o blame
 Doon they gentle, slopin banks
 Ahint whaur we used tae play.

A felt awricht seein the big furnace chimneys
 Cum at me through the train windae,
 The Marxist historian in me kens yer way a lukkin
 At worker production an the revolutionary struggle
 O the industrial west coast working class.
 The traditions o the political left pugle me oot,
 Naebody asked the weans fur their opinion onywey.

We got aff the train tae see Ye
 Mak the night sky skinkle
 Ower railway sidings stockin art by the pile,
 Raws o steel, a heapit stook o angle
 An monumental size, ayeways shapeshiftin
 An changing form
 Maks me think o Serra
 Noo I've been tae the art college.
 Aye, a ayewiz kent they wur sculpture.

Even tho a ken the grun is fallow noo,
 Wi our extracted wealth, the upsurge o metal,
 Fae underneath oor feet, a ken a' that,
 Wi wisdom heid o Hygieia,
 A ken the illness, a ken the poverty,
 A ken the wey o metal,
 A ken the story,
 A ken me.

A miss they chimneys....
 A miss the wurk.....
 Fur me, it wiz sculpture.

A Am Done Wi The Daein

(Waite, 2011a:268)

I huv gaithered an soarted
 Threeds o ma wheeshted wurld,
 A am done wi the daein –
 A huv fettled the discontent –
 An tapped an teemed
 Wi the words o ma ain creation.
 A hame made red wud Blastie,
 Nae tellin an nae rantin,
 Jist the recitin o grievance –
 A refusal tae dae the easy thing
 An no say onyhing –
 Seein a different way of envisionin
 The felt textures o sang water
 An steel wool,
 Haudin me in nets o entanglement
 Warpin ma imagination o us,
 I have done the daein o the weave,
 Combed oot the violence o the clearance,
 Tidied up the grun o her greenness,
 Telit stories o oor hairt place,
 Rubbed it wi the gentle touch o the beloved,
 Fashioned stories o imagined devices,
 Enriched ma love o ye aa
 Wi the breid o fiction.
 I hae kneaded the memories o my ain folk
 An listened wi the whispers o the ancestors
 Safe aside ye, we endure
 Yer industry o history is in me.

My Body Is A Work Of Steel

(Waite, 2011a:185)

The intricate stitching of unseen scars
Are the undergarments of creativity –
Layers of transparent concealment
Prefiguring the birth of language.

I have overturned the positivist method
Story is after all closer to truth,
Histoire is fiction in the alliance
Of language and power to name –
We are close to song in the traces.

Of the last bloom, of our steel
In the care home of the state,
She languished exhausted, silent
Rusty rollers of time
Crushing metal Myths -
I tried to see your beginning, depict
The working class genealogy
Once upon a time
Was made up to make up
For the unwritten, trust memory
Before authority, of creative origin,
Peer through the telescope to early days
Your stars of coal mine and iron
Forged empires and destroyed towns.
We bore the ambivalence of metal
In magnetic fields of iron belonging.

The Repetition Of Naming: For Barbata Steveni
(Waite, 2011a:204)

Retrieve....

I see the constellation,
 The twirl of power and the name, mostly yours –
 A weave is not a linear truth
 Women sift and see the hunter's compassionate empathy
 Necessary view of what must be done –
 Artemis taught you her lessons well.
 I listen to her, see your smile of radiant play,
 Mind of sharp concern, always been so, I intuit
 Wisdom is ageless, some born to know
 The border you inhabit is young as it is free.

You have led me to a place of aesthetic tears
 Understanding through the artist
 Our complexity as loadbearing –
 As metaphorical as our metal
 Garth's sample from the well of the mother
 Close to the ancestral place,
 The soft golden yellow of tonight's full moon
 An aura of astronomical humour surely ?

For you are tidal influence
 Of event and history, a compass of meaning
 North to south to look back on the path with no form,
 A timeless cosmology found in the red brick of London.

The Work Likes Tae Be Remembered

(Waite, 2011a:269)

A hae wrapped maself in a plaid o memory
Cradlin yer water unner ma haun oan the hill
The lang view fae the scheme afore the treeline ends.

A hae sat by ye an pured ingots o grief an lost love
Intae yer bounded coarners
O my map o a sense o belongin
Huggin rusty stains oan a manmade waste.

Ye will ayeways be wi me ye ken
As backdrop tae maself
Ma youth has gone wi yae,
Ma een still shine
Wi the sparkle o yer licht in the dimmin shadow
O the work, yer memory disnae haunt ,
Steel hairts o silent chambers echoin a pulse.

The rhythm o ma words will return tae ye,
As source, the water an the metal hae built ma mind
O monumental imaginins an ma shift will
Change wi the burden released,
The work likes tae be remembered by me.

Dreaming My Ancestors

(Waite, 2011a:250)

My dear dead were dancing
 They were laughing, imagine that!
 Saturn's rings of grief on a dream moon moor
 Playing ring a ring a roses, a beloved childhood game –
 Laughter offers no guidance, laughter has direction.
 The dead danced with the rotation of the earth
 Left-handed revolution of sound
 Astronomical anti-clockwise circles of enchantment.

The circle fractured, opening a fissure to the black world
 Submerged in a viscous oil, coal seams ripple through muscle,
 Dead matter grows to new life, swimming through the black suffocation
 Of grief, Time, it all takes time, Saturn knew this,
 Old father issues spiral across archaic space.

Will the Good Samaritan collect me from this ironstone shore ?
 Who holds out help from the dry ground of Kilbirnie Loch?
 The hand reaches with nimble fingers
 Smooths away the burning scars of historic mines
 In hidden coalseams, a dress of tongues licks away
 That oh so Scottish black dirt of others' wounds.
 They do not belong to me I have carried them through vaults,
 Channels of time, a geology of memory
 Compresses the hallowed ground.

There is no baptism into fresh water
 No need for cleansing after all Face awakened to the sun,
 Naked and bright, wise and still,
 Metallic and brave,
 This backbone of steel within me
 Holds me in water, buoyant and free
 Arches in a steel tunnel of grace
 Through my bones.
 Psyche sat beside the water :
 Alone, she sifted the layers
 Stratas of human consciousness
 Blackband ironstone land, a magnetic
 Resonance of our element
 We hewed from the earth an industry of self
 The making of us, the destroyer of us
 The impermanence of the steel world
 The limits of extractive knowledge
 An ecology of possibility and quietness
 Beside the loch, stillness returns
 A transitional state....

Appendix 2

Text of the Author's post on the KB Steelworks Facebook page.

“Hi all, many thanks for allowing me to post on this page! I’ve been a member of this group for a while, and I really enjoy seeing all the photographs shared by members. I am currently working on a research project at Glasgow University about the slag waste that the Glengarnock steelworks produced (a bit of a niche topic I know!) As part of this, I have been doing a bit of archaeological work with the slag that has recently become freshly exposed as a result of path construction for the new Lochshore Park. A lot of questions have arisen from this work, and I thought it might be an idea to post some of these questions here, in case anyone had any information they could share on this.

I am interested in finding out more about:

1. The process of tipping the slag waste – e.g. how was this done, how often was this done, where was this done (i.e. into Kilbirnie Loch or on top of previous slag deposits, or both)?
2. The experience of slag tipping – what did this look, sound etc. like? Were there any variations in the experience of slag tipping, or was it very repetitive? What did the slag look like after it had been deposited (I’m especially interested in what the area of slag that grew out from the south western shore of Kilbirnie Loch looked like).
3. If the slag tipping was a common sight for many workers, or more of a process that went on without much general attention paid to it? Were many people involved in the slag tipping itself?
4. The Slag Works that was located to the north west of the site – was the slag intended for export processed differently to that which was dumped on site?
5. What happened to the slag after the steel works closed? Was it moved around/bulldozed in any way, or was it mainly left where it was?

I completely appreciate that this is quite an unusual thing to be curious about, so absolutely no worries at all if no answers can be provided here – but many thanks in advance if anyone does have any knowledge they can share! If you have any questions at all about my research, please feel free to contact me at j.kirk.1@research.gla.ac.uk . Thank you very much for your attention in reading this post!”

Appendix 3

List of questions posed to interview participants

For participants associated with the Lochshore regeneration project.

- For purposes of introduction, can you outline your connection to the regeneration project? How does your work fit into the wider scope of the Lochshore regeneration plans and how did you come to be involved in this project? What does your day-to-day work on this project entail? Are there any particular groups or individuals that you collaborate with in the course of your work on this project?
- My own PhD research project revolves primarily around the steel slag which underlies much of the Lochshore site, and which is also exposed on the south west shore of Kilbirnie Loch. Has the presence of the slag been a consideration in your work? If this is the case, why? Has the slag presented problems in the development of the project, or has it been beneficial in any way? Alternatively, if the slag has not featured in your work, is there a particular reason for this?
- Relatedly, are there ways in which the wider landscape (including and surrounding the Lochshore site) have influenced your work? Are there particular places at the Lochshore site (or within the wider landscape) which have emerged as being particularly important in your work? If so, why?
- Are you aware of ways in which the community has used the Lochshore (either formally or informally) in the years after the steelworks was closed? How do you envision the community (or different communities) using the space after the regeneration project has been completed?
- Is the past, the present or the future of the Lochshore site the most important timeframe informing your work? Or is it a combination of all or some of these? Why is this?
- Have you come across any stories (funny, poignant, intriguing) about the site in the course of your work which have stood out to you? Do you have a story about your own work on the project which could sum up part of or all of your experiences?
- Imagining that you had unlimited budget and power, what one thing would you incorporate into the Lochshore Regeneration plans to capture the aspects of the project that are most important to you?

Additional Questions for Participants formerly employed at the Glengarnock Steelworks

- For purposes of introduction, can you give me some background on your work at the steelworks? When did you start working there? What did your job involve?

- My own PhD research project revolves primarily around the steel slag that was produced by the steelworks and is still present around much of the site. Did your day-to-day work have much to do with the slag- if so, how did the slag feature in your experiences at work? If not, were you aware of the slag elsewhere in the steelworks? (Where it was produced, where it was disposed of, the people who worked with it, how it was generally spoken about etc)?
- As part of your role, which were the places you inhabited most frequently in the steelworks? Can you describe them to me- what was going on in these places? Were there any particular places in the steelworks which were important or meaningful to you, in terms of your role specifically, or more generally? Were there any places you maybe were always curious about but you didn't/couldn't access for some reason? Were there places beyond the steelworks itself that you visited as part of your work (e.g. other steelworks, other industrial locations etc)?
- If someone was compiling a definitive history of the Glengarnock Steelworks and they asked you to share some stories which had to be included, what would you choose and why? Were you there or did you hear about this from another person? If you didn't experience the events in the story first hand, how do you think you would have felt to be there?
- How did you feel about the landscape that had held the steelworks, after the works had closed? Did you ever visit the steelworks site after it closed, and if so, what did you do when you did? Are you aware of how the site was used or managed after the steelworks closure?
- In terms of the current regeneration project, do you think that it is important for the steelworks to be acknowledged in some way in this redeveloped landscape? If you replied yes to this question, why is this so, and what would you like to see? If you replied no to this question, why is this? What are your hopes in general for the future of the Lochshore?