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ARTICLE

Mining an Anthropocene in Japan: On the making and work of geological imaginaries

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Abstract

Geology firmly underpins Anthropocene debate, and in particular an Earth Systems Science (ESS) rendering of how lithic and yet-to-be-lithified (or 'drift') material, including the tangible evidence of a state-sponsored carbon capitalism, is reconstituted by anthropogenically 'forced' physical processes. The prevalence of this approach hinges in large part on the authority afforded Geology as a science that names, classifies and explains these materials and their spatio-temporalities (such as the stratigraphies that undergird eras and epochs). We argue that this deployment can: (1) simplify how Geology has diversely framed and explained a planetary history, while glossing over the complex power relations that Geology drew upon as the authoritative narrator of this history, and which it enabled and furthered; and (2) foreclose how the lithic and the drift might be otherwise imagined as part of an Anthropocene condition. We ground this argument by introducing a particular moment of Geological practice: the discovery of a fossil floating fern in a Hashima (Japan) Prospecting Pit. Following an outline of Geology's place within Anthropocene debate we provide an expanded sense of this science by situating this moment within a series of Geological imaginaries, from a state-sponsored extractive gaze and 'romantic' idioms to a grass-roots, practice-based Geological movement in Japan. Our own practice draws on the latter, and adapts two well established Geological mapping techniques, the Geological Cross-section and the Geological Stereonet, to visualise not the ordering of materials out of chaos, but their transmogrification. Such speculation as to how the lithic and the drift might be reworked as an Anthropocene material outside of a chronostratigraphy helps create space, we suggest, for a Critical Geology that delves into the dynamic relations between people, the lithic and the drift, identifying not only key problematics but also the resources that can be drawn on to help build a response.

KEYWORDS
Anthropocene, deep time, Geology, Japan, stratigraphy, visualisation

VIGNETTE

In December 1963, Professor Matsuo Hidekuni of the Department of Geology, Kanazawa University, visited the colliery built into and underneath the small island outcrop of Hashima, 20 kilometres off the coast of Nagasaki, Japan. This site was dramatically transformed at the end of the nineteenth century by Mitsubishi's search for coal. Shafts were cut deep into the bedrock, and labyrinthine concrete living quarters were built up to six stories high, enclosing most of the outcrop. Routinised work and living schedules ensured a 24-hour production of coal that helped fuel Japan's industrial, imperialist and military expansion; which in turn helped the transformation of Hashima, as Chinese and Korean forced labourers were collected and sent to work on the island. By Professor Matsuo's visit, a Japanese workforce of over 5,000 crowded onto a 1.2 square mile island that resembled from a distance a warship floating on the ocean. Mitsubishi provided a cinema, swimming pool, post office, police office, temple, a promenade, roof gardens and shops, alongside a hospital, school and nursery, all enclosed by a sea wall under constant repair. Deep in the Mitsuse Prospecting Pit, and accompanied by Mr Arimatsu of Mitsubishi's Coal Mining Department, Matsuo collected the second oldest fossil record in Asia of the genus *Salvinia* in the family Salviniaceae; a floating fern. He observed that, 'the Cretaceous Salvinia was found in the grey, silty, shale layer containing many pyritised nodules' (1967, p. 50; *Transactions and Proceedings. Paleontological Society of Japan*). Named *Salvinia Mitsusense* (after the Mitsuse Pit, which had also given name to the Mitsuse geological formation), the specimen grew in a bituminous bog, Matsuo speculated, from the late Cretaceous Period, 'when the area concerned was surrounded by such a natural environment' (1967, p. 53). The Hashima-tan coal being mined by Mitsubishi—'the best anthracite in our country' Matsuo remarked (1967, p. 49)—would have been laid down as rotting vegetation between 100 and 66 million years prior. As coal prices sank, Hashima was abandoned in hope in 1974; that is, the hope that transferring from coal to another fossil fuel, petroleum, would allow the continuation of the Japanese economic miracle.

1 | INTRODUCTION

We begin with this vignette because, at first glance, it joins an increasing number of narratives that portray the Anthropocene as a (catastrophic) conjunction of a 'human history' that dwells on the time of our lives amidst our experiences, memories and anticipations, and the 'deep time' of geological processes without, to paraphrase James Hutton (1788, p. 304), vestige of a beginning or prospect of an end. The fossil fern, so carefully chipped out of a coal seam and transported upwards to the light, helps illuminate the diverse temporalities, and associated materials, capacities and potentialities, that, when combined, allowed a carbon capitalism to emerge. To be sure, the carbon capitalism that the Hashima colliery helped fuel has become one of the *leitmotifs* of an Anthropocene, insofar as carbon-based energies contribute to the production of carbon dioxide, and hence to global warming and ocean acidification, loss of biodiversity, and so on, with the added urgency of a future human extinction (Brevini & Murdock, 2017). Moreover, carbon capitalism disgorges a hail of debris, from plastics to fine particulate matter, polycyclic aromatic hydrocarbons, mercury, nitrogen dioxide, sulphur dioxide and carbon monoxide (Perera, 2017), some of which becomes a geosynchronous trace in the geology of the Earth (Murdock & Brevini, 2019). Lithified materials laid down over millennia are transformed in a (relatively speaking) instant into yet-to-be lithified (or 'unconsolidated') drift[1] materials.

These diverse and yet globally extensive drift materials help indicate—at least to many Earth System Scientists (ESS)[2] if not sceptical sections of the Geological community (Zalasiewicz et al., 2017)—an Anthropocene geological formation that sits atop prior formations and their distinctive strata, becoming part of chronostratigraphy that places and evidences time. In this formation, there is rapidly accumulating evidence of how an 'Earth System' of interconnected (atmospheric, hydrologic, cryospheric, biospheric and lithospheric) processes operating over various spatial and temporal scales have undergone anthropogenic forcing. That is, anthropogenic activities are understood to impact upon one then another of these Earthly processes via their exchanges of matter and energy, even unto the immense time cycles of tectonic forces. As Steffan et al. put it, the 'human imprint on the global environment has now become so large and active that it rivals some of the great forces of Nature in its impact on the functioning of the Earth [S]ystem'. Whereas human beings have

always had a biological agency, Chakrabarty (2009, 2018) argues, they are now understood to have a geological agency, dissolving what was an artificial yet deeply entrenched distinction between human history and a planetary deep time. As all our present and possible future human activity becomes conceptually embedded in this growing stratum, then 'What the Anthropocene seems to have imposed upon us', Colebrook observes, 'is one mode, temporality and logic of stratigraphy, where the deep time of the earth's discernible layers becomes the privileged scale for other times and space' (Colebrook, 2016, p. 445).

At second glance, what the opening vignette also allows us to do is unpack this telling tale of Hashima as a microcosm for an ongoing chronostratigraphy, and in doing so problematise the assumptions made in broader arguments as to the connections between geological materials, Geology as a field of ideas and practice, and these planetary problematics. How so? We argue, first, that in these broader debates there is a tendency to simplify Geology as a field of ideas and practices pertaining to the scientific study of the Earth's rocky materials. Certainly, the Anthropocene concept per se has been extensively critiqued across the physical and social sciences, arts and humanities. Yet, in these debates what is often assumed is that Geology itself is a monolithic science that hinges on a chronostratigraphic accounting of the lithic and the drift, and the mapping of resources. It is this Geology that provides the 'one mode, temporality and logic' that Colebrook identifies in the quote above, and which is thus crucial to an understanding of the Anthropocene as a planet-wide, fundamental shift in the balance of forces between 'physical' and 'human'. As Colebrook goes on to indicate, this logic must marginalise other ways of knowing the Earth, not least because Geology's chronostratigraphies are intended to have universal scope—these are the bones of the Earth itself—firmly situating seemingly discrete exposures of geology into a framework that extends across both space and time.

For us, however, it is important to acknowledge, and demonstrate, a diverse field of Geological practice. This diversity matters because it allows us to more closely track how a stratigraphy-focused Geology, striving for universal scope and resonance, emerged amidst a complex geopolitical, economic and cultural landscape, and the import of this for people enrolled in the making of sites such as Hashima. But also this acknowledgement matters because it allows us to draw out how this universalising movement was countered through other Geological ideas and practices. These countervailing activities are interesting in and of themselves from a history of Geology perspective. Their presencing, however, allows us to undertake the second part of our argument, in that they provide productive resources for thinking again through the relations between geological materials, Geological practice, and the planetary problematics that have been assembled under the umbrella term of an Anthropocene. If we release the lithic and the drift from the linear timeframe of a chronostratigraphy, how, we speculate in this paper, might such 'otherwise' Geologies interpret sites such as Hashima? And, if the drift that is splayed across the Earth's surfaces is no longer interpreted solely through a stratigraphic lens, then the following question is opened up for inquiry and practice: how can Geology help frame the problems facing people, their differential exposures to those problematics, and the resources that can be drawn on to help build a response? Though we build our way towards this question here, rather than pursue it, we consider it an urgent one for the emergence of a Critical Geology.

In the following we begin our argument by noting the crucial role both geology (comprising lithified and lithifying materials) and Geology (the scientific study of these) have played in Anthropocene debate. We outline the framing of the Anthropocene as an emergent component of a chronostratigraphic system, and indicate some of the manifold ways on which such a g/Geological subtending has prompted particular responses across academia. Following this, we build on the arguments of historians of Geological science, and scholars working on a 'geo-politics' (or 'political geology'), to situate and nuance the imaginaries and practices that gave agency and meaning to such work. To be sure, Matsuo's collection of the fossil floating fern provides an insight into how the authoritative science of Geology rested on and enabled an extractive gaze developed by the Japanese state, and was shaped by imperial and industrialising impulses. It also provides insight into how the Geological knowledges that Matsuo drew upon to name and explain his find worked to isolate a planetary deep time that was mappable across an ostensibly universal grid system of extents and units. But also, we find in the expansive field of Geological practice in Japan counterparts—such as the immersive, field-orientated ethos of the *Chidanken* Geologists (AGCJ, no date)—to the systematising work of chronostratigraphy.

For us, this *Chidanken* Geological practice helps provide inspiration for how lithified and drift materials might be imagined otherwise. That is, where a Geological chronostratigraphy binds lithified and drift materials into a mappable formation, with a single temporal gradient stretching from the bottom up, we speculate as to how these materials can be understood as enabling diverse capacities and potentialities. Drawing on our own fieldwork-based Geological Cross-Section and Stereonet of Hashima, we register a range of phenomena and affects, some derived from memory and experience, others from the lithic shaping processes of extraction and construction, and some from the work of wind, rain and gravity. To be sure, the extraction and sorting of coal remains a core concern. But, and following Clark (2017), we read

and map the geological materials involved as Deleuzoguattarian (Deleuze and Guattari, 1988) 'strata' that are distinct formations of matter yet are available to each other for their formation. *Contra* the Imperialising chronostratigraphies that sought to firmly situate the geologies of sites such as Hashima into a planetary archive legible to the Geological gaze, strata, here, are part of an empirical world that emerges from material bodies and the forces they express. These comprise neither iterations of the same, nor sharp-edged differences, but rather a differentiation that proliferates singularities.

2 | ON GEOLOGICAL CHRONOSTRATIGRPHIES AND AN ANTHROPOCENE

The particular importance of Geology to the notion of an Anthropocene epoch lies in the biostratigraphic and geochronological evidence indicating what Earth System Scientists identify as the all-too-tangible conjunction of human activities and physical processes, and the import of this for understanding the past, present and especially the future. A systemic approach (with antecedents including Chorley's, 1962 *Geomorphology and General Systems Theory*) was reanimated by the International Biosphere-Geosphere program (IBGP, 1999–2003), and evident in its 'Great Acceleration' visualisation of so-called 'socio-economic' and 'physical' trends over time. The synthesising work of the IBGP found that the correlations between these indicate the extent to which human socio-economic activity has caused changes in the Earth System (Steffen et al., 2004). Moving forward, 'the grand challenge for ESS is to achieve a deep integration of biophysical processes and human dynamics to build a truly unified understanding of the Earth System' (Steffen et al., 2020, p. 54). This is a project the Intergovernmental Panel on Climate Change (IPCC, 2023)—which reviews research deemed to be relevant—has chosen to also foreground. As Clark (2017, p. 214) observes, in this increasingly prevalent system-based approach, the focus is on how a 'variability in the conditions at the earth's surface—in the envelope that includes all living things—is systematically connected with strata-forming processes. It is by analysing the differentiated composition of the layers that make up the earth's crust that scientists are piecing together the long, eventful history of the "coupled" subsystems of the atmosphere, hydrosphere, biosphere and lithosphere'. In the process 'connections are being made—with varying explicitness—between human interaction with geological strata (prospecting, extraction, disposal, contamination) and the functioning of ecological and earth systems'.

Both biostratigraphy and geochronology have become means of evidencing such widespread forcing. Biostratigraphy (as exemplified by Matsuo in the Mitsuse Prospecting Pit) focuses on describing, cataloguing and comparing sedimentary strata using as a guide the presence of fossil floral and faunal assemblages to build up a model of a stratified sequence of lithic and drift materials. Geochronology focuses on the dating of rock formations, fossils and sediments, and the positing of processes that impact upon the laying down and erosion of these. Both adhere to the same classification of nested timeframes (eons subdivided into eras, periods, epochs and ages) within which strata are understood to be laid down. Both allow for speculation on, and an imaginary reconstruction of, the prevailing environmental conditions within which materials were deposited and eroded. And both emphasise the deep time of the processes required to produce such a planetary archive. This is a cyclical time that extends far beyond human experience, insofar as uplift and erosion follow each other time and again, but which can also be found in the singular biographies of pebbles, sand grains and even radioactive isotopes (Zalasiewicz, 2012).

As part of the approval process for a 'formal' Anthropocene epoch, considerable effort was expended debating the potential Global Boundary Stratotype Section and Point (GSSP) for this (Waters & Turner, 2022). The GSSP is an agreed upon reference point within a cross-section of layered, sedimentary rocks (without tectonic or metamorphic action) that indicates the onset of a significantly new set of environmental conditions across the globe and associated flora and fauna (or, *sans* fossils, a consistent magnetic polarity). Markers reappearing across the globe within a (compositionally highly diverse) Anthropocene drift would include 'specific persistent organic pollutants, modern plastic polymers, industrially sourced fly-ash, bomb-sourced radionuclides, or the preserved remains of invasive species introduced by human activity' (Zalasiewicz et al., 2021, p. 4). Remarkable too will be the absences from the Anthropocene fossil record; tangible losses that accrue from the rising precarity and extinction of species.

Though the bid for a formal Anthropocene epoch was subsequently rejected, there is no doubt that the conjuring of an Anthropocene predicated on deep, planetary time has led to some interesting conjunctures between the new Earth System Science and the GeoSciences and Social Sciences, as well as with the Arts and Humanities. As Swanson remarks, for example, it is apparent to Earth System Scientists, as well as Geologists, that questions over the onset of the Anthropocene raise in turn questions over responsibility: '*telling time*—in their case, through the restructuring of an internationally sanctioned Geological chart—is a profoundly political act' (Swanson, 2016, p. 158, emphasis in original).

Meanwhile, the Geological disclosure of deep time has forced a confrontation with a humanist philosophical tradition that, Meillassoux (2008) argues, assumes a correlationist stance that posits we can never access being outside of thought. Correlationism admits of a time (and space) exterior to the human subject, only to frame this as an *inhuman* reality that exists for the subject. A Geoscientific insistence (predicated on the measurements of radiocarbon and luminescence dating) that such realities exist independently of the subject's own apprehension of them as belonging to their timeframe troubles this correlation between thought and being by drawing attention to their temporal discrepancies. For Meillassoux, what is significant here is not that the quantified geochronological probabilities of the Geosciences somehow refute correlationism, but that the ontological absolutism underpinning such scientific claims cannot be so readily summed up and dismissed as simply 'unknowable' to the subject.

The Anthropocene as a geological materiality is most readily apparent in its interred index fossils, such as plastics, often referred to as technofossils. There are 'likely hundreds of millions of distinct "technospecies"', Zalasiewicz observes, in his direct comparison of manufactured artefacts and pollutants with the evolutionary record revealed by fossilised organisms. 'Many ... are built for robustness and durability—and hence, fossilizeability.... [These] are now evolving several orders of magnitude more quickly than organisms have evolved at any time in Earth's previous history. The rate of evolution is, indeed, so great that few strata, natural or human-made, will be capable of preserving its precise pattern into the far future' (Zalasiewicz, 2020, pp. 36–37). As Dibley remarks, 'The homogenizing and universalizing "us" that populates the narrative of these technofossils and that of the Anthropocene more generally is no doubt a problematic formulation—belying the profoundly uneven contribution of various human populations to the discard that will come to form its sediment' (Dibley, 2018, p. 45). And yet the placing of humanity within deep time—made tangible by the 'trace markers of a distant dead future' (ibid.)—arguably positions Geology as a means of capturing something of the dilemma Meillassoux poses, as we realise the practical as well as existential limits of our capacity to mourn our own passing.

3 | SITUATING GEOLOGY

To be sure, we can read Geology as a recent, interpretive discipline that lies on the periphery of the hard sciences. But, and as we outline with regard to mining Hashima, a more situated understanding of Geology as a discipline acknowledges the thoroughly imbricated (sometimes contrary and antithetical) worlds of natural science, the arts and humanities, business and state-building, and the manifold mediums through which ideas were circulated, translated and differentially put into practice. Literature on the history of colonial extractivism (e.g., Scott, 2021) and geoscience (e.g., Luciano, 2023), a decolonial 'political geology' (e.g., Bobbette, 2023; Yusoff, 2018) and a geohumanities (e.g., Hawkins, 2020), provides an increasingly nuanced account of the emergence of Geology as a discipline within specific institutional, political, economic and cultural contexts. In pursuing our particular provincialisation of Geological ideas and practice, we follow Clancey's (2007) argument that there is no easy read of this universalising discipline as an imperial endeavour. Certainly, classification systems and explanatory logics that emerged out of European-based Geological practice were brought to bear in Japan, such that, for example, geological formations located here were understood to evidence a planetary deep time that was separate from the lifeworlds of those labouring to mine coal, and a history of racialised and classed exploitation and suffering. But, these were set amidst the objectives and modes of operation of a modernising Japanese state and, moreover, diverse imaginaries of rock, people and landscape that coopted such claims, but also countered these.

3.1 | A Romantic, Universalising Geology

In this section, we rehearse some of the European Romantic idioms Heringman (2023) alludes to insofar as these serve as reminders that the extractive gaze of mining was never simply an instrumental one. Geology as a scientific practice, as well as the geological as a source of scientific wonder, was undergirded by a historical sensibility, Szerszynski (2017) observes, that pursued order out of what was perceived to be material and temporal chaos. Romantic literature, for example, certainly disdained mining, and industrialisation per se, for its despoilation of the countryside: 'See, in troops', wrote Anna Seward, in her (1790) poem *Colebrook Dale*, 'The dusk artificers, with brazen throats/Swarm on thy cliffs, and clamour in thy glens... Ah! what avails it to the poet's sense/That the large stores of thy metallic veins/Gleam over Europe...' (Seward, 1790, p. 315). Nevertheless, the time periods evoked by Geology resonated with Enlightenment Europe's speculations on the sublime. Hutton's (1788) *Theory of the Earth*, Furniss observes, strikes a chord with the words of William Wordsworth and Samuel Coleridge, in that there is 'a fundamental tension in Hutton's text between the enormous power

and time-scale of the Geological processes that he invokes to explain the Earth's history and geomorphic forms and their supposed purpose and effects—i.e., the nourishing of (human) life' (Furniss, 2010, p. 318).

The nineteenth century saw a profound change in how an Enlightened Geological practice was to be undertaken, as the founding of the male-only Geological Society in London in 1807 hinged on both 'specialisation' and 'professionalisation'. The Society's members 'exercised proprietorial control over what was regarded as genuine scientific activity, as opposed to mere dabbling' (Thompson, 2012, p. 331). The winnowing out of women's participation in Geology was accompanied by an emphasis on a hands-on description and analysis of specimens, their sequential order through time, and a uniform system of nomenclature, over and against grand theorising as to the shaping of the Earth. As Secord writes, '...the gentlemanly Fellows of the Geological Society of London claimed that their science should be centred, not on a cosmological theory, but rather on a method and an activity—Geological fieldwork, the tracing of rock strata over particular areas' (Secord, 1986, p. 4). This turn was very much driven by a desire, post-French revolution, O'Connor argues, to depoliticise Geology, as 'The ruling classes were still anxious about the possibility of revolution breaking out in Britain' (O'Connor, 2009, p. 331).

Accompanying this expressed depoliticisation of Geology was its simultaneous enrolment in state-building, imperialist expansion and classic geopolitical debate and practice. Abraham Gottlob Werner's 1791 mineral survey of Saxony ushered in a plethora of 'geognostic' assessments of mineral and fossil fuel reserves for the benefit of state mining operations. Geological maps combined a 'practical' use with a fascination for dramatic landscapes, often focusing on the geographic extents of 'primitive' rocks such as granite that contained valuable mining materials and underpinned dramatic scenery (Trower, 2014). Such visualisations, Stafford emphasises, were crucial to the authoritative role of Geologists: 'Mapping demanded the ability to visualise complex spatial relationships and to generalise, from widely scattered data, explanations for processes occurring over millions of years. As blueprints of its structure, Geological maps spread scientific order over the earth's surface' (Stafford, 1984, p. 5). Visualisation, however, was by no means confined to surveys and cross-sections. As O'Connor illustrates, the authoritative status of Geology was also a product of its popularisers, such as William Buckland, who used the mediums of verse and prop, and the mythic bones of an apocalyptic mythology, to convey the new science of deep time (O'Connor, 2007, p. 1824).

By the early twentieth century, interest in stratigraphic accounts of sedimentary strata using fossils had been overshadowed by a focus on mineral extents. What is more, 'Industrial states started to compare their inventories of nature with those of other countries as a means to measure state power and determine and manage power relations' (Westermann, 2015, p. 153). Geologists were trained to locate coal and mineral ore deposits, and to determine their scale and ore grade, but also to assess 'how, and at what cost these occurrences could be made available for human use', and to provide advice as to the possible 'development of mining technology, mine organization, production and transportation costs' (ibid.). Post-1880 what Westermann calls a new series of 'geoeconomic' phenomena—such as a 'usable reserve'—were ushered in that promised both ontological surety as to the physical nature of the Earth and its exploitability.

3.2 | Geology in Japan

The above section briefly outlines the emerging status of the lithic and the drift as at once forceful and strangely 'inert'. That is, they are rendered inert as a passive resource, subject to extraction, and in more philosophical terms as a mass awaiting formation from outside forces (DeLanda, 1997). They are inert too by virtue of their alien physicality, which renders their being apart from human causation and outside of human experience. Existing in an inhuman space–time continuum, they have become the ultimate 'touchstone' for reality. It is this realness—this cosmological substratum—that an anthropogenic 'forcing' of physical processes is posited as impinging upon in an Anthropocene. Yet, as Szerszynski emphasises, this was very much an extension of a complex European, historical sensibility—emerging from Antiquarianism, but also Theology, and manifest in Poetry as well as Geology—onto rock formations, making Earth 'the subject of a history that extends in deep time, independent of, subtending *and* radically conditioning human history' (Szerszynski, 2017, p. 6, emphasis added). This was an evental, historical sensibility that 'progressively gathered the Earth together as a system, the diversity of its visible, surface features now understood as the result of slow, invisible unifying forces such as sedimentation, erosion, volcanism and eventually tectonics' (Szerszynski, 2017, p. 5).

Here, we want to sketch out how this historical sensibility was situated amidst Geological ideas and practice in Japan. Despite a wealth of literature on the emergence in Japan of a spatially unified mode of telling human time (e.g., Frumer, 2014), there is very little critical accounting of the emergence of Geological temporalities. One exception is provided by the work of Barbaro (2009) who, after dispelling the idea that there exists a common definition of 'Japan' as a historically, ethnically and socially homogeneous society, goes on to outline how a rich 'geological culture' relating to the

Earth and its geological materials emerged from Shintoism, Taoism, Confucianism and neo-Confucianism, as well as the different schools of Buddhism. Pre-Meiji lithic imaginaries, he concludes, comprised 'a polymorphic intellectual world, with a number of coexisting views over the Earth, its structure, history and features' (Barbaro, 2009, p. 35), which are then contrasted with Western, 'rational', 'purely scientific theories and methods' (ibid.).

Contra Barbaro, our own approach takes an expanded view of Geology that situates such claims as to purity and rationality. We outline how a rapidly synthesising Geology enrolled Japanese sites such as Hashima through the circulation and translation of ideas, the deployment of particular modes of fieldwork and visualisation, as well as the valorisation of ideas and practices via state support and institutionalisation. As Clancey (2007) argues, and contra established narratives of Geology as a 'colonial science' that was introduced into Japan only to be replicated, this was not a matter of one epistemology supplanting another. The extractive gaze of Geology very much resonated, we show below, with the imperial objectives of the Meiji state and, indeed, incorporated earlier and ongoing Japanese surveys. What is more, the 'modernising' of a Western Geology was itself facilitated by the production of knowledge in Japan, by Japanese scholars, such that, for example, 'If one wanted news of advancements in seismology at the turn of the twentieth century, one read what was happening in Tokyo, in a journal produced there, and based on instruments invented there (and widely copied in Europe)' (Clancey, 2007, p. 208). A focus on Japan as a key site of imperial knowledge production and extraction operating in dialogue and contestation with European and American empires also complicates the ways in which these modes of operation are conceptualised on a global level, and how they have been differently racialised and spatially organised.

In Japan as well as Europe, Geological imaginaries unfolded amidst a range of creative and experimental geological practices. Following Tokugawa Yoshimune's easing of restrictions on Chinese language books on Western science in 1720, for example, groups of scholars pursued their own empirical assessment of these ideas (Katagiri, 1982). Hiraga Gennai, pharmacologist and inventor, wrote books on nature subjects, prospected for ores and tried to have new mines opened up (Roberts, 2009), while Kimura Kenkadō, botanist and poet, wrote comments on his collections of stones and fossils. China continued to be a key source of Western Geological expositions over the next century. In the 1850s and 1860s, Chinese translations of English language Geological texts were being published by American and British missionaries in China with the help of Chinese colleagues. Charles Lyell's *Elements of Geology* (6th edition, 1865) was translated into Chinese by American missionary Daniel Jerome Macgowan and Hua Hengfang, to be republished in Japanese in 1882 (Yatsumimi, 1993). We might also note that this flurry of interest in European accounts of tectonic forces was attenuated by the 1855 Ansei earthquake and subsequent fire that destroyed much of Edo.[3]

The early Meiji period saw an accelerated importing of scientific ideas and technologies—as well as new notions of time to situate these[4]—as Japan's rulers sought to transform the country into a geopolitical power that could contain Western influence, but also extend Japan's own sphere of influence. Support for Geology—as well as Cartography (Kobayashi, 2012)—was firmly tied into the extraction of resources and the renegotiation of trade relations, resulting in, as Braun (2000) states with regard to Canada, the 'geologizing' of the space of the state. Geology was not simply the recording of lithic and drift materials, but was a means by which a 'vertical' territory could be rendered visible and regulated by appropriate governance mechanisms. The Meiji government claimed ownership of all coal mines in 1872, and foreign visitors were invited to prospect for mineral resources and mines, resulting in detailed Geological maps of the four major coalfield areas of Japan. The 1873 Mining Law gave 15-year concessions to business in return for royalties, and the Meiji government entrusted businesses such as Mitsubishi and Mitsui Bussan with the international marketing of coal. In 1890, these exploitation rights were allowed to be permanent. Meanwhile, media reports noted the slave-like conditions of the miners, 'virtual prisoners bound by debt, unfair contracts, personal ties to labour bosses, and at times real ropes and manacles' (Lewis, 1990, pp. 196–197). Workers undertook periodic strike action in the decades following 1890, and more active protest when management promises were reneged, and various factory inspection laws proved negligible.

An emphasis on the history of mining per se in Japan allows us to track the human costs, at sites such as Hashima. But also—and echoing Chakrabarty's (2009) comments on the effective work of an artificial divide between a human and a planetary time—we can note how this history of trauma and suffering did indeed become estranged from a Geological sense of Earth history that recognised as 'human' only the tempo of myth. In 1876, for example, John Milne was appointed as the Professor of Geology and Mining at the Imperial College of Engineering in Tokyo (see Gooday & Low, 1998). He also undertook work on the 'Stone Age of Japan' (Milne, 1881), excavating shell mounds, and turning to mythology to corroborate his estimates of when certain groups occupied Japan. Milne was an exemplary member of a cohort of Antiquaries, Archaeologists and Geologists seeking to locate a 'prehistoric past' by carving out an Earth history autonomous from humanity. Here, and very much in resonance with a prevailing racialised environmental determinism, Milne commented on the 'fatalism, unpredictability, and a fascination with the temporary' (Clancey, 2011, p. 396) in what he took to be a 'national character' shaped by regular seismic activity.

Geologist Edmund Naumann enacted a similar entanglement between a planetary history that could be mapped and recorded as part of a global sequence of geological periods, and a timeless mythology. He arrived in Japan in 1875, following a Japanese invitation given to the German Foreign Office. Naumann spent the next 10 years surveying Japan's geomorphology, hiring Japanese assistants and using surveying equipment bought in the USA. He founded the Geological Survey of Japan in 1878, and the ensuing 'Reconnaissance Geological Maps of the Japanese Empire' were drawn on a scale of 1:400 000.[5] Naumann taught Geology at the Kaisei Gakkō School and was the first Professor of Geology when the school became a part of the newly established Tokyo Imperial University. In addition to researching the history of volcanos using outcrops and the testimonies of local communities (e.g., Naumann, 1877), he re-examined the ammonite collections of fellow 'contract foreigner' Benjamin Lyman, concluding that these species were identical with those reported from the Cretaceous in the eastern part of the Indian Peninsula (Naumann, 1880). Naumann's work on Japan as a tectonic appendage to the Asian continent was in turn used and adapted by Swiss Geologist and Palaeontologist Eduard Suess—proposer of the supercontinent Gondwanaland—to integrate Japan into his monumental global Geological archive, *The Face of the Earth*. Suess draws directly on Naumann's Geological Surveys of Japan (conveyed to him by Naumann, with accompanying letters), which he notes, were 'based on the result of many years of arduous work carried on with the cooperation of able Japanese geologists and a large number of fresh observations' (Suess, 1904, p. 177).

This new Geological timeline, Tanaka emphasises, of 'prehistory, the Palaeozoic, Cenozoic, Neolithic, etc … is completely autonomous from human activity' (Tanaka, 2009, p. 48). Naumann, for example, narrated Mt. Fuji as a key volcanic agent in the Fossa Magna tectonic rift, and the Shizuoka Tectonic Line. But, in the same vein as many of his colleagues in Europe, Naumann also romanticised the landforms he observed: after his return to Germany, Naumann wrote the libretto for the opera *Götterfunken* (1901) based on an old Japanese tale *Taketori Monogatari* (*The Tale of the Bamboo Cutter*). Here, a woman returns to heaven on the smoke-cloud of a volcanic eruption (Yajma & Yamada, 2015).

Such 'contract foreigners' were hired until a suitable cohort of Japanese experts could be trained up, and by the turn of the century top academic posts were being held by male Japanese scholars who continued to embed sites within a Geological imaginary. Biostratigraphic techniques, for example, were developed by Yabe Hisakatsu (1927), while the defining characteristics of the Cenozoic, Mesozoic and Palaeozoic formations, along with their periods and epochs, were confirmed (JAHIGEO, 2011). Visitors such as Marie Stopes, who conducted research into ancient ferns and coal balls at Tokyo Imperial University, 1907–8, helped maintain the circulation of Suessian ideas (Stopes, 1910). A Geological project of enrolling Japanese sites by noting evidence of Geological periods already identified in Europe was not, however, straightforward. As Yajima notes, 'The Japanese geologists had to work out their Quaternary geology with no glaciation "symptoms"' (Yajima, 2008, p. 179), and so biostratigraphic markers, such as Professor Matsuo's fossilised floating fern, became key. Undergirded by an array of fossil evidence, Tanaka argues, 'This work brought Japan into the same kinds of morphological histories that comprised the discursive fields of the West' (Tanaka, 2009, p. 48).[6] Placing the emerging knowledge of Japan generated by people like Milne and Naumann within a Geological history of the Earth served the function of, in Tanaka's (2009, p. 41) words, 'separating geophysical forms from the cultures that inhabited them'.

In the run up to World War II, 'mineral education' was taught as a branch of *Hakabutsu* (or 'natural history'), though most teachers in the technical colleges and (teacher-training) normal schools came from a Biology background (Sato et al., 2017). Geologist Kobayashi Teiichi advocated the teaching of *Chigaku*—the 'generic name of sciences that target the Earth' (Kobayashi, 1942, p. 1474)—encompassing Astronomy and Oceanography as well as Geology and Mineralogy. In 1949, under Allied Occupation, the Japanese educational system was transformed. Imperial universities were renamed, private colleges (including women's) could become universities, and training centres were collated into US-style four-year universities. Geology, however, was by no means a monolithic discipline. We can also trace the work of 'grassroots' Geologists who prioritised field assessments of how particular landforms had formed and been transformed. The *Chigaku dantai kenkyūkai* (The Association for the Geological Collaboration in Japan, established 1947), abbreviated to *Chidanken*, for example, sought to propagate an egalitarian method of field research built on 'those whose labours involves endless walking and exhaustive observations, whether amateurs or semi-professional geologists' (Nakayama, 2009, p. 95). These Geologists eschewed the search for underlying, uniform laws that dictated process, and instead looked to how the singular, individual characteristics of forms emerged in context.[7] This movement is one of the inspirational points for our own engagement with the lithic and the drift in the following section. Situated as part of a post-War 'geoscience culture', *Chidanken* participation reveals the diverse ways in which the stratigraphic temporalities, tectonic events and lithic histories of Geology rubbed up against, as well as resonated with, extant imaginaries (see Nakayama, 1974; Tochinai, 2018).

The capacity of geology to evoke an atmosphere was also deployed by Geology student, poet, teacher and farmer Miyazawa Kenji. Miyazawa was trained in Geology and Soil Science at the Imperial College of Agriculture and

Forestry, Morioka City, and led the compilation of a Geological Map of Morioka in 1917 before becoming a teacher at the Hanamaki Agricultural High School. He 'used the colours of minerals to evoke atmospheric phenomena such as the colours of the sky, clouds, mist, sunshine, etc. and also utilized the rhythms of mineral names' (Kato, 2010, p. 7) to animate his poetry. Geological terms became part of a narrative on place, with an ear to how these sounded alongside terms from Buddhism, whose grand cosmic vistas, Sato (2007) argues, Miyazawa understood to resonate with the findings of Western Science.

The research of Professor Matsuo of Kanazawa University can be situated during the period of postwar recovery and then rapid economic growth (1945–88). Components of the entity that became known as Kanazawa University had been founded in 1862 for the teaching of 'Western medicine and learning', but the university itself was officially formed in 1949 from several institutions. Geology became a unit in the newly formed Faculty of Science. Matsuo's biostratigraphic work—his carefully chipped out floating fern fossil—contributed to a broader effort by Geologists and their field assistants to collect rock samples from marine outcrops using aqualungs and dredger buckets. Where Matsuo narrated his find within the discourse of a palaeontology, others were concerned with a geophysical prospecting, assessing the heavy mineral frequencies of the rock samples collected. Underpinning each study, however, was an encompassing vision of a chronostratigraphic system (e.g., Figure 1, produced by Yamamoto et al., 1967) that was grounded via collected fossils and dateable minerals. Such visualisations authoritatively placed sites such as Hashima within a classification schema proffered as universally applicable and correct while also deploying regional nomenclatures for specific formations (such as the Mitsuse), thereby evidencing the advancement of a distinctive yet recognisably expert Japanese Geology.

The 1960s, however, were to prove a tipping point. Coal production reached its peak (Higuchi, 2003), but mines were showing signs of exhaustion and fluid fuels had cheaper forecasts (Shimanishi, 2011). Hashima Colliery closed in 1974, with Mitsubishi moving workers to other company sites (Kimura, 2010).

4 | OTHERWISE GEOLOGIES OF HASHIMA

The sketches, above, of the emergence and unfolding of Geology emphasise the significance of diverse prior and contemporaneous imaginaries as to the nature of the lithic and the drift, and debates on how best to apprehend and analyse these. What we hope these sketches have made clear is that the archival temporality so apparent in Anthropocene debates—wherein an Earth archive read from the bottom up underpins comments on the apocalyptic conjunction of a stratigraphically evident 'deep time' and a 'human history' of anthropogenic forcing of physical processes—is not a simple given, or 'planetary condition'. It is, rather, a sedimentation of an evental notion of history that promises a global reach spatially as well as temporally.

With regard to how geological materials are understood to be enrolled in planetary crises, there is a growing body of work that disregards their chronostratigraphic ordering. The Anthropocene, Clark (2011), for example, observes, raises questions about the long-term aesthetic and experimental, as well as material, working of Earth processes, and the agential limits and conceptual horizons of Western, sovereign notions of human agency. For Clark (2012, p. 276), one such creative force is a 'pyropolitics', wherein a calculative fire 'negotiates the rifts in the body of the earth, cauterises the planet's wounds, consumes its excesses, and probes its potentiality'. For Dixon (2015, 2019), a 'geo-politics' is predicated on the vagaries of a 'geology-becoming', wherein heat, stress, fracture, transduction, sublimation and accretion enact a differentiation that enables and exceeds the tempos of cellular life. With regard to Hashima itself, Lavery et al. (2014) narrate a grotesque, Lovecraftian admixture of flesh and rock, organic and crystalline, and the fate of a species lost in deep time.[8]

But, how might the countervailing Geological imaginaries we present in the preceding section be productively brought to bear? Our own speculation proceeds from Rudwick's (1976) irruptive arguments as to the persuasive, explanatory role of a 'modern' Geological image-making (see also Ciancio & Laurenza, 2018; Oldroyd, 1996; Scott, 2021). That is, Geology has set itself the task of describing and explaining the depths of the Earth; and yet, its visualisations are aimed at presenting timescales that are outside the grasp of human perception (Gohau, 1990). Visualisations such as Geological surveys and cross-sections are a crucial means of asserting an order to these materials, and reconstructing what is taken to be an Earth archive within which localities can be seen to be embedded (albeit within an imperceptible continental drift). Indeed, Matsuo inserted his fossil find into a columnar section of the site that places lithic formations within by now firmly established chronostratigraphies that span millennia (Figure 2).

In thinking through how our own visualisations may be irruptive, we aimed to populate a Geologic cross-section, and a Geological stereonet, of Hashima. Taking to the field for a hands-on encounter with the lithic and the drift is, of course, a

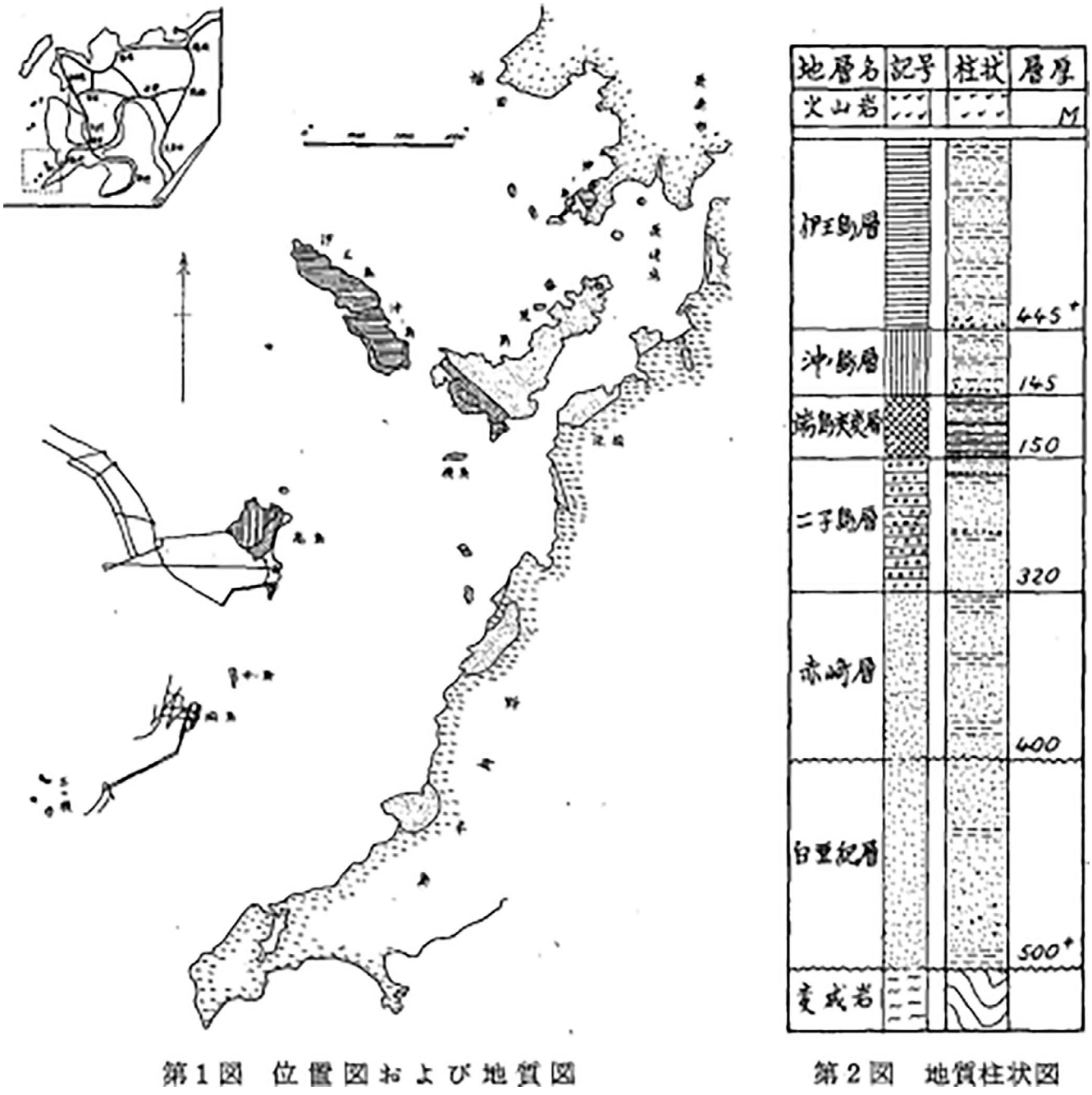

FIGURE 1 The chronostratigraphy, and associated outcrops, within which Hashima was mapped by Yamamoto et al. (1967, p. 207).

methodological practice that Geology has long advocated. For us, our inspiration was the *Chidanken* movement, wherein such an immersion is much more than data gathering. It is, rather, a means by which a multi-sensory engagement with diverse geologies is (what might be called) an affective relationship that prompts and re-prompts thought. That is, the use of the geological hammer, the reading of a topography through a clinometer, the striking of forms upon the eye, and the sketching of forms in situ—the feel of the earth through the feet—are geosocial acts, generating hypothesis after hypothesis with no acknowledged certitude. As Nakayama explains, this commitment was both 'a bold stand against the superiority of exact science and mathematico-physical reductionism' (Nakayama, 2009, p. 91) apparent in university-based Geology programmes, and a 'denying and dissenting spirit' (93) against the elitism that the *Chidanken* saw in these same institutions. We used these techniques at Hashima—our understanding of form and process augmented by Geological maps and other materials located in regional archives[9] as well as the reminiscences of our guide—to construct, first, a Geological cross-section of Hashima geologies (Figures 3 and 4).

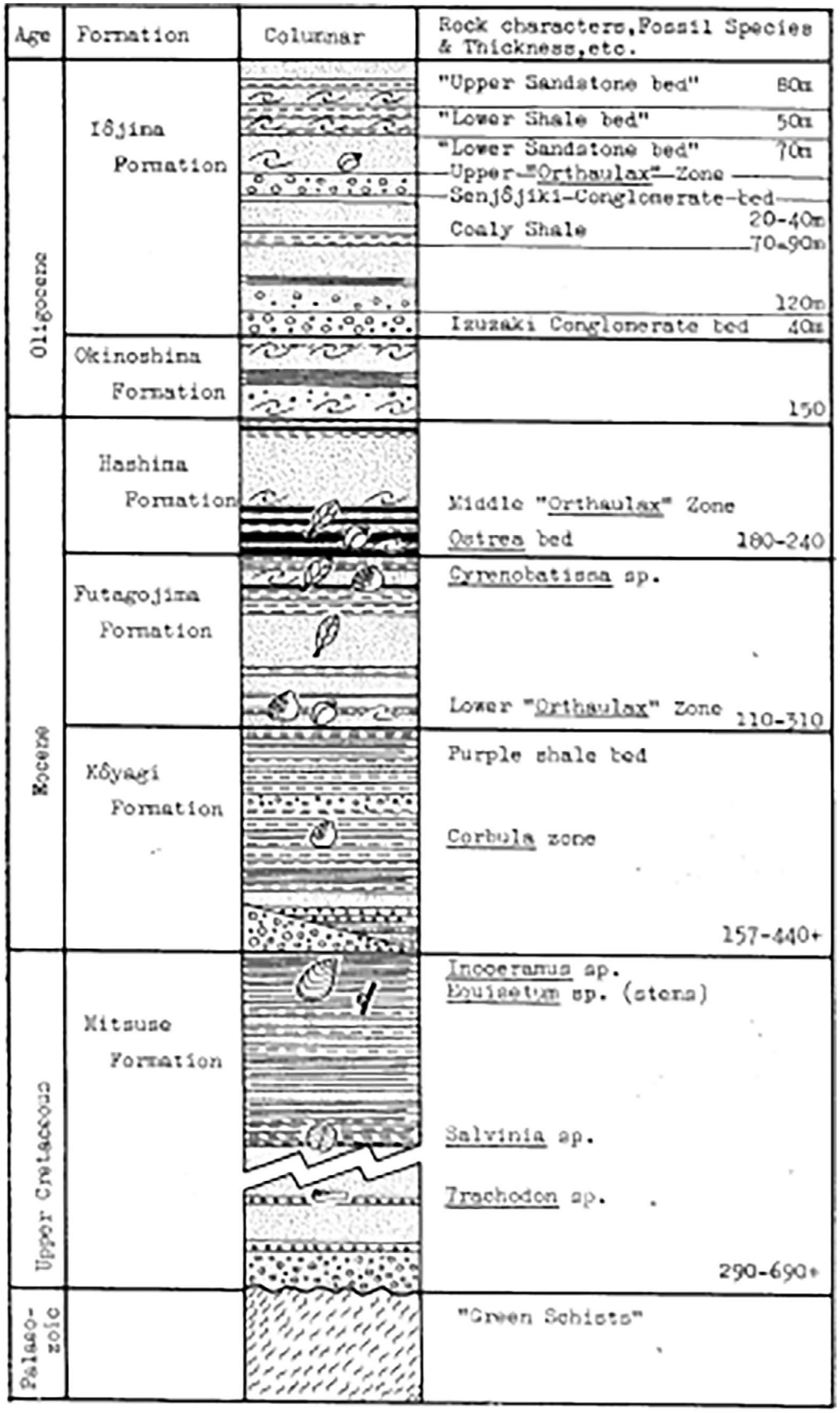

FIGURE 2 Columnar section from Matsuo (1967).

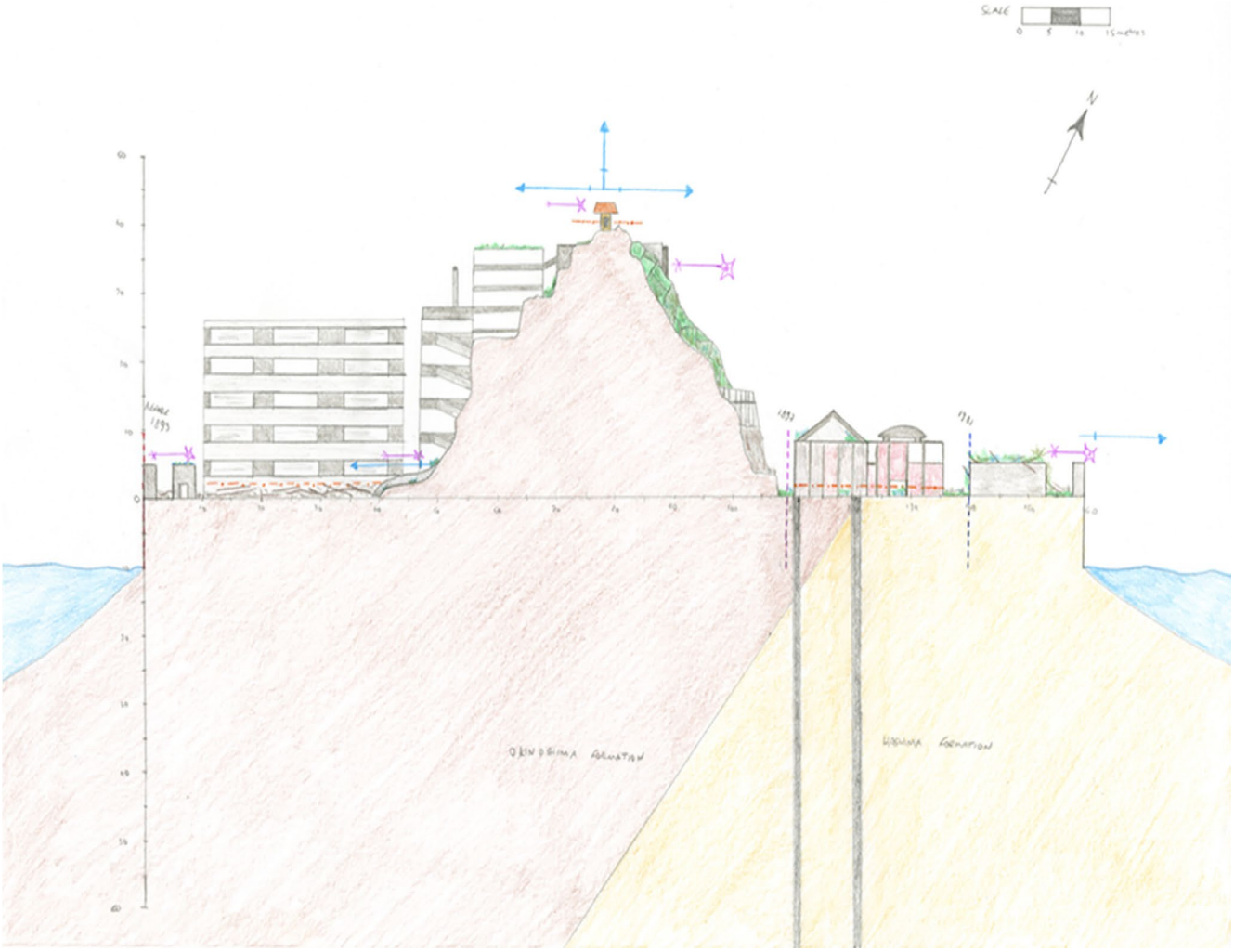

FIGURE 3 Geological cross-section of Hashima.

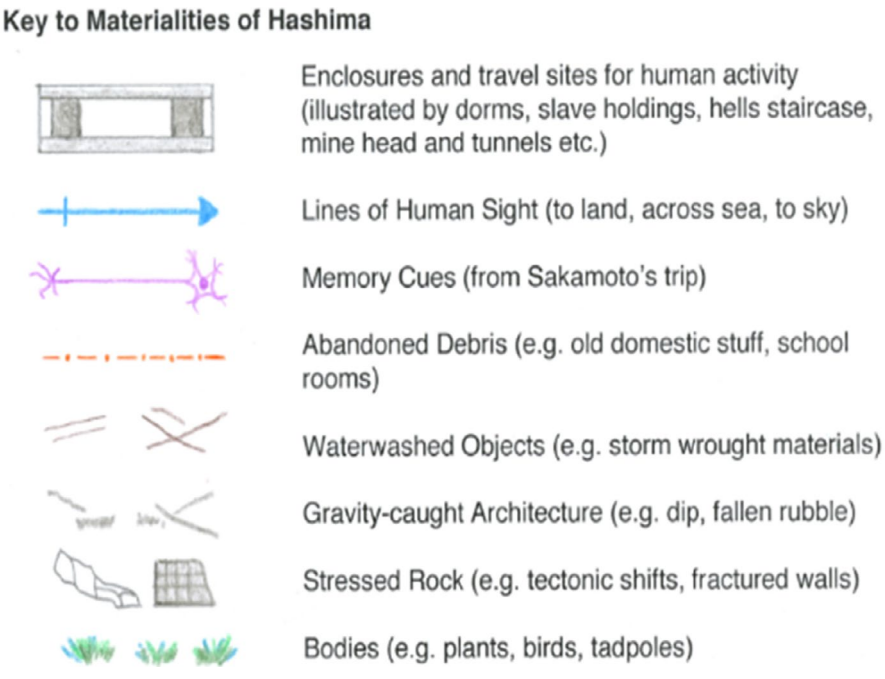

FIGURE 4 Key for geological cross-section.

Finding the bedrock lithology of the site was challenging; outcrops were clad in netting and plant life, each caught in its own negotiation with gravity, friction and entropy. The odd outcrop poked out in awkward corners, offering an opportunity to feel the waxy texture of the Hashima-tan. For the most part we clambered over, through and under the rubble of wood, glass, concrete, iron and slag; a heterogeneously sized and constituted drift transported, settled, transported and settled time and again through the operations of landfill, construction, nuclear explosion, storm surge, repair, root action, wall collapse and cyclones. In our Geological cross-section we have maintained the notion of strata; but, and following Clark (2017), this is in the vein of a Deleuzoguattarian rendering of distinct formations of matter that yet are available to each other for their formation. We can discern a geological stratum—the gradual sedimentation of rock—that is a particular 'form of content'. But so too is the excavated mine, which has become an extraction device for a type and quality of matter, the Hashima-tan. Keeping with Deleuze and Guattari's (1988) line of thought on a 'Geology of Morals' in *A thousand plateaus*, both strata have their particular form of organisation, selecting for certain elements such as grain size and lignite content. What is more, we can deduce a geological stratum—the 'cementing' of grains and larger pebbles, reinforcing iron bars and organic materials (each with its own lineages) into a hard sediment, or 'rock'—that is a 'form of expression' of materials. That is, this rock has accrued another set of capacities, such as an obduracy against compressive stress that allows it to be built upon and tunnelled, and a permeable lattice that can allow seawater egress, which in turn can trigger corrosion of the iron reinforcing, and 'spalling'. In the same vein, the colliery as an empire-building industry is a form of expression of materials, as are the look-out points affording nearby residents across Nagasaki Harbour a sense of place and a touchstone for reminiscences of life on Hashima. The lattice, the colliery and the lookout points are distinct stratums that operate in the world in a manner that grains, coal, and concrete cannot.

Where an 'established' Geological cross-section binds all materials together into a formalised chronostratigraphy, the Hashima we envision is composed of multiple formations and tempos, each distinct yet inter-mingling with others. The key (Figure 4) indicates 'gravity-caught architecture' for the debris and rubble that is working its way downward in ever-shifting formations; 'waterwashed objects' highlight the significant interaction of the debris with water, either atmospheric, or from the hydrosphere (e.g., sea, or storms and flooding); and 'bodies' identifies where birds were seen

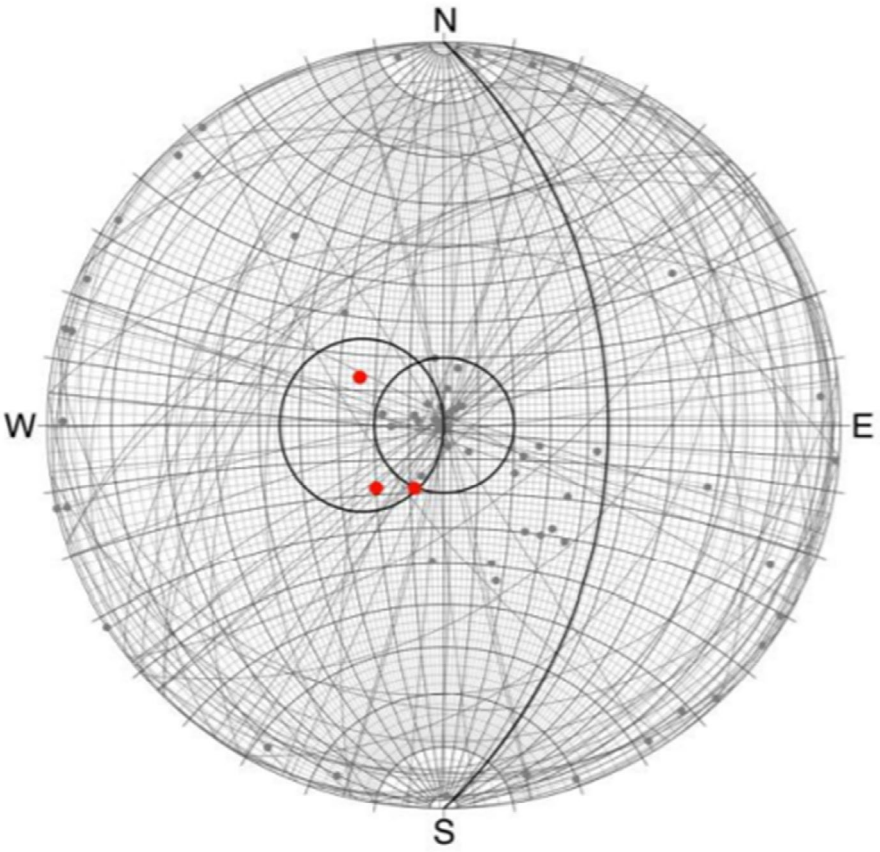

FIGURE 5 Geological stereonet for Hashima.

to nestle in and launch from stony appendages, and tadpoles swim in sheltered cavities. 'Stressed rocks' indicates where defences built on the bedrock to protect the island have now fractured or collapsed via landslides or earthquake activity; and 'abandoned objects' indicates the lack of maintenance of the school, mine shaft and other infrastructure, but also the removal of state care for the site and its futures.

Delving more deeply into part of one particular stratum—the cemented and spalling dormitories clustering round the outcrop—we can bring another visualisation to bear, that of the Geological stereonet. Here, a compass clinometer is used to record the dip (the angle of tilt from the horizontal) and the slip (the direction of the dip) of layers of rock, sedimented and folded over millennia, and to give insight into their condition of origin as, perhaps, a deep sea, or a shallow coastline, as well as the tectonic forces that compress and stretch these layers. By recording the dip and the strike at a series of locations, a stereonet of the layers (as these are manifest at the Earth's surface) can be modelled.

At Hashima, we measured the dip and slip of high-rise, reinforced concrete buildings, a stratum that currently holds to the vertical, but which is leaning, and occasionally lurching, towards the horizontal (Figure 5). That is, none of the measured walls of the buildings are at 90° angles. Rather, they lie between 84° and 89°, indicating that the buildings are unfurling away from the outcrop; and, they will tend to reach a tipping point together, and spall and fall within the encircling sea wall. In this process, we can envision one form of expression—the dormitories—transmogrifying into a form of content, as the disaggregated pebbles, and rusted bones of steel become washed and sorted by wave action. Whereas stereonets are generally used within Geological field work as a graphical tool to represent the hemisphere of a globe and to present, analyse and interpret three-dimensional data, here Figure 5 warps and weaves the lithic materials from buildings and structures to explore the stresses and frictions between buildings and bedrocks in two dimensions.

5 | CONCLUDING COMMENTS

Our opening vignette of Professor Matsuo's visit to Hashima, and his extraction of a fossil floating fern, provides an entry point for a consideration of how carbon capitalism, and its (undoubted) effects on global climate, has been read as a fatal conjunction of the deep time of the lithic and the drift, and a human history of exploitation of resources and labouring, colonised and racialised bodies. That exploitation is very real. But, to read sites such as Hashima as the 'end' of either a human history or a deep time is to overplay Geological Science as some kind of guarantor of the nature of a planetary condition, and to underplay the power dynamics at work in the emergence of deep time as a counterpoint to a posited human history.

These interpretive tendencies—crucial to the epistemology of an Earth System Science, and increasingly urged as a necessary reckoning with anthropogenic forcing by the IPCC—provide an evental, stratigraphic mode of knowing the Earth. To be sure, the techniques of Geology can alert us to the profound reshaping of the materially diverse drift, and increasingly, of the rocky outcrops and strata of the lithic. Moreover, these can be linked to warming skies and oceans, loss of biodiversity, and new forms of precarity and exposure. They can even be linked to new forms of solidarity in the face of these conditions, from community-based science to nature-based solutions. No small wonder that many members of the Geology community find themselves in the awkward position of seeking to realign learned techniques away from fossil fuel support and towards some form of net zero transition. It is certainly the case that this Geological capacity has indeed been largely predicated on a prior, and continuing, state-sponsored search for resources to be extracted.

Yet, Geology has its own diverse epistemic landscape, past and present; and it is this diversity that can be mined for creative engagements with the lithic and the drift (Dixon, 2018, 2021; Dixon et al., 2016; Donald & Millar, 2018; Lavery et al., 2014). What we have worked our way towards in this paper is just such another mining. We have used a Deleuzoguattarian stratigraphy of forms of content, and forms of expression, to rework the notion of strata. Here, strata no longer reference an inhuman deep time; nor do they reference a conjunction of deep time and human history. Rather, they reference a multitude of tempos adhering to particular formations of matter. This stratigraphy is at odds with the 'pure' Earth history that visualisations such as the cross-section and the stereonet have traditionally been utilised for, their authoritative demarcations buttressing a knowable, organised geological realm.

In working towards these geologies of Hashima, it may be assumed that we are ultimately arguing for the supplanting of a well established Geological stratigraphy with a Deleuzoguattarian framing of strata. But we would emphasise that a Deleuzoguattarian geophilosophical approach—even if one could sum up a series of guiding principles—is also composed from diverse imaginaries that also speak to particular legacies, problematics and concerns that should also be acknowledged and interrogated. It does not exist in its own space–time continuum. What we *are* arguing for, is two-fold.

First, we would argue for a more explicit consideration of how recent efforts to examine the Anthropocene via a 'subtending' of human history by reference to a geological context, and of tracking the anthropogenic forcing of physical processes, rely on particular spatio-temporal imaginaries. That is, to what extent is the emergence of a geologically inclined geopolitics, geohumanities and a geopoetics, as well as the articulation of a geopower, actually an inclination towards a by now well sedimented Earth System Science-led Geological framing of the 'geo'? Second, this critical interrogation, we argue, presumes and values a wider conceptual space in which these proliferating geo- prefixes might be (critically) afforded flesh and form in a Critical Geology. This endeavour might well draw on other 'Earth reading' fields, such as Geomorphology, and its emphasis, to paraphrase Brown et al. (2017, p. 432), on 'process' and 'rate' rather than a stratigraphy, and the fast-growing Critical Physical Geography (Lave et al., 2018). But also, as we have shown here, it might well draw on elements of Geology's own back catalogue.

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DATA AVAILABILITY STATEMENT

No data are available aside from the material presented in the article.

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Endnotes

[1] As Dixon explains, 'Drift comprises the surficial detritus of unconsolidated sediments, such as boulders, gravel, sand, silt and clay, that lie atop and obscure the consolidated layers of rock … Drift lies in discontinuous patches of disparately sized and chemically composite materials that are the product of river, lake, ice, marine and aeolian depositions. Often bemoaned by Geologists as obscuring the real bones of the planet, it is this drift that has, nonetheless, become increasingly central to debates on the transformation of the environment in the Anthropocene as this material has been drained, farmed on, crushed, concretized, built with, bored, extruded, tunnelled and excavated' (Dixon, 2018, p. 130).

[2] Earth Systems thinking is itself a diverse field. There is an intermittent, critical debate, for example, on how a less epistemologically ambitious form of systems-thinking might be more open to place-based geomorphologies (Richards & Clifford, 2008), as well as how systems might be flexibly and inclusively interpreted as a testing ground and prompt for discussion on forms of connectivity (Maslin & Lewis, 2015).

[3] In a similar vein to Kant's ruminations on the 1755 Lisbon earthquake, the Ansei quake 'produced new ideas about human agency vis-à-vis earthquakes' (Smits, 2013, p. 4). Clancy points to the manifestation of a Japanese idea of 'world rectification' (*yonaoshi*) in the aftermath of the Ansei earthquake of 1855, 'in which victims see the disaster as opening up space for rebuilding a better and more just world than the one recently destroyed' (Clancey, 2011, p. 397). By the time of the 1898 earthquake, however, the scenes produced in woodblock prints 'were now Western-inspired landscapes in distress' (398). And yet, these were the ruins of Western infrastructure: 'By contrast, Japanese landscape features … remain as mute, unaffected witnesses to the mayhem below' (Clancey, 2011, p. 399). Moreover, whereas prior depictions had noted winners and losers, now all were depicted as worthy of sympathy; images of disaster that were 'perfectly compatible with the Meiji nation-building project, in which all Japanese were subjects in a new empire, or members in a family state' (ibid.).

[4] The development of Geological Science throughout the Meiji period is an explicit part of the development of new notions of time. For Tanaka (2009, p. 24), the declaration in the Charter Oath—which marked the onset of the Meiji revolution by noting that 'Evil practices of the past shall be abandoned'—is a marker of the desire to separate the present from the past and 're-emplots that past as an earlier, dead moment of one's "experience"'. The development of the new time of the Meiji period was facilitated by both the creation and dissemination of newly national, documentary histories, and the embedding of the notion that the islands themselves had a past.

[5] The office was renamed the Imperial Geological Survey (*Chiskitsuchasaj*) in 1882, as 'It was now felt, in the interests of industries rapidly developing in the Empire, that, as far as possible, the investigations carried out under the Survey should be directed to matters premising to be of practical importance … with the object of affording assistance to mining, agriculture, and other branches of applied science' (Inouye, 1924, pp. 11–12). In 1899, a single Geological map of Japan on a scale of 1:1,000,000 was produced (Yamada & Koido, 2007).

[6] Concurrently, it must be emphasised, these rapidly developing Japanese Geological imaginaries were applied to Japan's imperial acquisitions, as well as its geopolitical sphere of interest. The South Manchuria Railway Company, for example, established a Geological Institute in 1907, to which many young Japanese Geology students were sent by their universities, while systematic Geological surveys in Korea and Taiwan were 'carried out after the Japanese occupation by Japanese Geologists, either of governmental or university organisations or private mining companies' (Nakano, 1970, p. 66).

[7] The *Chidanken* was part of the Association of Democratic Scientists, which advocated for a new educational system that resisted both feudalism and militarism, and was committed to enriching people's lives (Walker, 2013). According to Nakayama (2009, p. 90), the key text for this movement was Ijiri Shōji's *Koseibutsugaku* (*Palaeontology*, 1949), reprinted in 1954 as *Kagakuron—koseibutsugaku o chūshin to shite* (*On science—centring on palaeontology*).

[8] Lavery et al. declare their intent to 'mine the baroque as a means of grasping and articulating the island's materialities, and the spatio-temporalities they express' (2014, p. 2573). This entails an affective relationship with its surfaces and topologies, manifest in the Gothic narrative form they adopt. Easily overlooked in the midst of this body horror is Lavery et al'.s deployment of Walter Benjamin's allegorical ruminations on Troglodytic kingdoms to situate the colliery-riddled island, and which provide a sly subtext to the Romantic fairytales and mythologising of Japan's contract Geologists.

[9] We draw on materials located at the Nagasaki Prefectural Museum, the Nagasaki City Takashima Coal Museum, the Gunkanjima Museum, and conversations with staff at the regional offices of the UNESCO World Heritage Group in Kagoshima.

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