Hadal Debris: Narrativizing Submersible Waste on the Deepest Seafloor

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This chapter focuses on the production, storage, disposal and finding of waste material, such as “shot” or ballast – matter that settles to the seabed as part of submersible dives. Taking on this example, alongside a discussion of the politics of anthropogenic waste at depth, it both widens the remit of how we might think of oceanic sediment and in doing so opens discussion of the matter that comes to shape a seabed of exclusion and discard. The chapter hones in on contemporary and historical dives to Challenger Deep in the Mariana Trench, the deepest known area of seafloor in the world, considering the material evidence of “frontier exploration” left as waste in perpetuity on the seabed, while also attending to human waste disposal politics, and the stratification of access to seabed (where wealth and gender have historically acted as barriers to partaking in expeditions). Together, it interrogates how narratives of exploration, technology and masculinity are materialised through sedimentary relations.

Keywords: Hadal Zones, Seabed Sediment, Frontier Environment, Politics of Access, Ballast

Ballast as More-than-Matter

In 2012, the film director James Cameron surfaced from his dive to Challenger Deep in the Mariana Trench, the deepest known point in the oceans. As he climbed out of the submersible he shook the hand of Don Walsh, who was a member of the two-man crew (together with Jacques Piccard) that first reached the seafloor of Challenger Deep in 1960. Cameron was the third person and piloted the second submersible to have ever made the journey. In Andrew Wight, John Bruno and Ray Quint's documentary *James Cameron's Deepsea Challenge* (2014) Walsh asks Cameron: "Did you see my shot? Did you find my shot piles down there?" (TC 01:19:49). Shot refers to small pellets of usually iron, steel or lead. It is one form of ballast used in submersibles, adding weight that allows the vehicle to sink through the water. Accordingly, shot is then dropped from the submersible to increase its buoyancy and to allow it to rise up through the water column during an expedition.

Shot piles, as material discards, may not seem the most important part of what was only the second "manned" mission to the deepest known space on the planet. But material discards – this earthly ballast adding to the seabed sediment – reveals a variety of relations, between people, matter and access to material worlds, the politics of waste, and how they link together in efforts of "discovery" and "conquest." For example, in asking whether Cameron found his shot piles, Walsh was reinforcing the idea that Cameron was following in his footsteps and that he, Walsh, had left material evidence of his claim to being "first" to the Challenger Deep seafloor. What does it mean to leave such waste in the planet's remotest zone? As self-titled "deep ocean explorer" and private equity investor Victor Vescovo (2025) has emphasized, these material remnants are *not* an environmental hazard when they are iron or steel because they can become part of the ocean itself:

> Now don't think it's pollution, they're made out of steel, raw steel. So over time the bacteria in the ocean break them down just like they do any steel wreck and they actually use it as food; takes a long time but it's – it is biodegradable. (Vescovo 2024, TC 00:10:14)

Drawing from this justification of negating the impacts of human endeavor, the central point of this chapter is to consider how waste disposal and its accumulation on the deepest point of the seafloor becomes *more-than-matter* and help us to think

through “sedimentary relations” (Hine et al. 2024) anew: the entanglements between people, practice and materials. Indeed, as the iron or steel slowly biodegrades on the surface of deep-sea ooze, it is bound up in complex meaning-making practices, opening a discussion on how matter – the very matter of shot – comes to shape a seabed of exclusion and discard.

Who is in a position to leave “shot piles” in Challenger Deep? What is their motivation for doing so? What are the impacts and implications? What narratives are produced? Through the course of this chapter, I will investigate the role that the intentional disposal of anthropogenic debris plays in crafting and maintaining narratives of frontier exploration, technological advancement, human achievement, and masculinities. After setting the scene for the chapter in the sections to follow, I sit with the aforementioned themes to explore how waste matter – shot and ballast – might be thought of as a kind of sediment, and how it undertakes the act of “sedimenting” particular socio-environmental relations of discovery and mastery, of access to the extreme. Thinking with the disposal and finding of waste matter within the context of private, deep-diving submersibles, this chapter considers how wastes and waste politics are central to the stratification and indeed *sedimentation* of seabed access, as well as how these relations rework sediments and stratigraphic archives.

Setting the Extreme

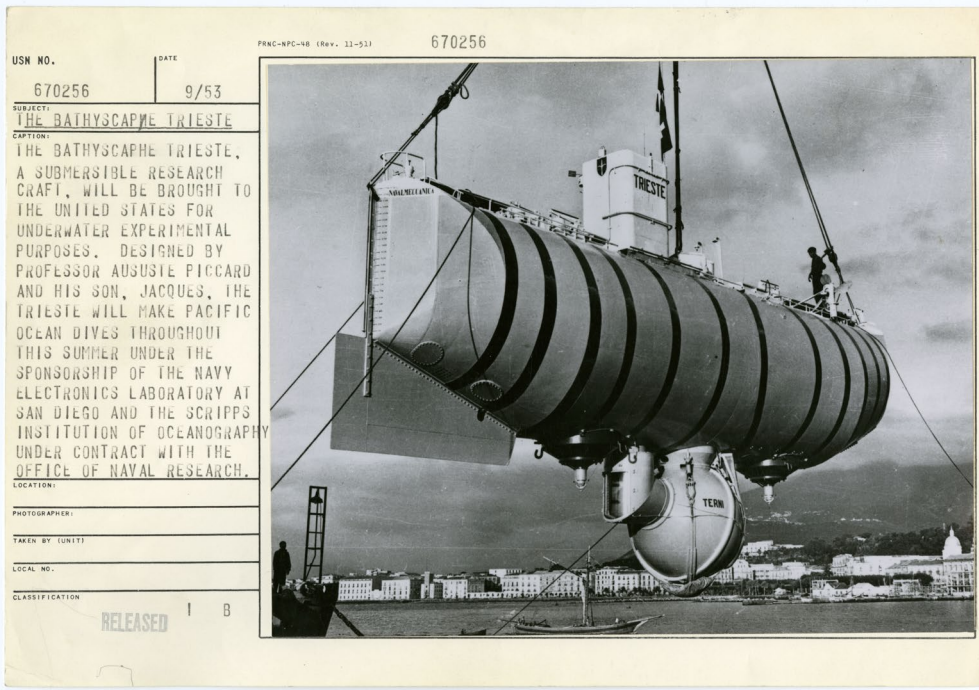
I focus enquiry for this chapter on the four crewed submersibles, and in particular the two privately owned submersibles, that have been to Challenger Deep in the Mariana Trench, drawing from the available documentation from their journeys (documentaries, published interviews, lectures, expedition websites, and archival material). Challenger Deep, located in the Pacific Ocean within the territory of the Federated States of Micronesia, is the deepest known point on Earth. This has been calculated to be 10,935m ±6m below mean sea level (Greenaway et al. 2021), and is squarely in the *Hadal zone*, that is a vertical depth below 6,000m where species become distinct from the abyssal zone that sits above it. The hadal zone largely occurs where fracture zones, faults, and basins dip below the abyssal plains, and Jamieson and Stewart (2021, 1) note that “the hadal zones of the world can be treated as large inverted islands bounded by the 6,000m contour.” It is characterized by extreme pressure, absolute darkness, and low temperatures at around 1.0°C to 2.5°C (Liu et al. 2018).

The first submersible to reach the seafloor of Challenger Deep was, as noted in the introduction, the *Trieste* in 1960 (fig. 1). It carried Don Walsh, a US Navy Lieutenant, and Jacques Piccard, a Swiss oceanic engineer who designed the "bathyscaphe" craft with his father (Britannica Educational Publishing Staff 2013). The US Navy bought and operated the *Trieste* during its dive to Challenger Deep, and it was later partially reused in the building of *Trieste II*, which now sits in the collection of the National Museum of the US Navy in Washington, D.C. (National Museum of the United States Navy n.d.). Some 52 years later in 2012, James Cameron piloted the single occupant submersible *Deepsea Challenger* to the Challenger Deep seafloor. The construction of this private craft cost around USD$10 million (Broad 2013) and was privately funded by Cameron. Cameron used the construction and testing of the submersible as well as the dive to Challenger Deep as material for the documentary film *James Cameron's Deepsea Challenge*, released in 2014.

Following Cameron, Victor Vescovo privately commissioned the two-person submersible *Limiting Factor* from company Triton Submarines and estimated in a 2025 interview that it cost "$50 million alone for the design and build … together with all support craft and systems" (Sims 2025). Vescovo piloted *Limiting Factor* to the seafloor of Challenger Deep in 2019, as one of a series of "deepest dives" where he piloted the craft to the deepest points in each of the five oceans. Like Cameron, the production company Atlantic Productions used these "five deeps" dives to gather footage (Triton Submarines 2019), and a docuseries titled *Expedition Deep Ocean* was released in 2021, with each episode featuring one dive. Vescovo has since dived to the Challenger Deep seafloor a total of 14 times, with each dive after the initial one with a different passenger on board. Wikipedia has helpfully compiled a list of these passengers (Wikipedia 2024), and they are notable in their diversity, as I will discuss further below.

After Vescovo, in 2020, the fourth and (so far) final submersible to reach the Challenger Deep seafloor was the three-person bathyscaphe *Fèndòuzhě* (奋斗者), translated to "Striver" (Zhang 2020). Built by the China State Shipbuilding Corporation in China, the submersible dived several times to Challenger Deep as part of its sea trials, with its first Challenger Deep dive crewed by scientists Zhao Yang, Zhang Wei, and Wang Zhiqiang (Yu 2021). It has since been deployed as a research vessel with the Chinese Academy of Sciences and as of 2021 had undertaken 21 dives over 10,000

1 The Bathyscaphe *Trieste* photographed in 1953, after its first tests but prior to purchase by the US Navy (Source: National Archives Still Pictures Branch 1953)



meters deep (Liu 2021). The *Fèndòuzhě*'s success has been domestically regarded as a national technological milestone:

> The feat shows that China now has the ability to conduct scientific exploration and research in the deepest parts of the ocean, which reflects the country's overall prowess in cutting-edge maritime technologies, Xi [Jinping, President] said. (Zhang 2020)

Indeed, the aim of each of the aforementioned vessels and their initial Challenger Deep dives was to achieve the act of physically reaching this extreme depth. Vescovo's team conducted scientific surveying of possible depth points to locate the absolute deepest point within Challenger Deep (Greenway et al. 2021, 1), ensuring that he achieved a dive to the *deepest possible depth*. For the other three vessels it

was sufficient to reach seafloor within Challenger Deep. As Cameron narrates in *Deepsea Challenge*, "for me it was all about trying to understand the world, understand the limits of possibility" (Wight, Bruno, and Quint 2014, TC 00:02:21).

The reaching of an extreme point – the highest, the deepest, the most remote – and also to be the first to do so are well-established "exploration" goals with extended historical trajectories. The "heroic era" of polar expeditions in the nineteenth and early twentieth centuries, for example, where all-male expeditions sought to reach one of the poles, were driven by a combination of "commercial, national and imperialist motives" (von Spreter 2021, 1), but were also closely tied to masculinity: "[t]o have the courage and strength to discover and conquest the supposedly uninhabited, frozen and dangerous place on earth was seen as an act of manliness deserving heroic merit" (ibid.) or "heroic masculinity" (Cicholewski 2023, 216). Exploration, with the mission goal of reaching a pole – indeed Amundsen, first to reach the South Pole, "returned to Antarctica largely because his initial goal of reaching the north pole had already been taken" (Dahl, Roberts, and van der Watt 2019, 327) – constituted an act of asserting control over nature and conquering a frontier. These values persisted through the Space Race and Cold War period, with an emphasis in the US political and social spheres on the domination of nature and a return to a combined masculine nationalism (Spiller 2015; Squire 2021). It was during this Space Race period that the *Trieste* undertook its Challenger Deep dive, and I posit that these themes have saturated the niche industry of "deepest dives" ever since.

Looking to Vescovo's invited passengers alongside his and Caladan Oceanic's – Vescovo's expedition company – articulation of their reasons for inviting them, it is clear that achieving "firsts" remains a central motivation, and that these firsts are related to conquering the depths and a need to be visibly making history. As he explains in a YouTube documentary published by his expedition company:

> One thing I was hoping to achieve for this dive series was continue to expand the number of people that have gone down to the bottom of the ocean because it is a very intense experience and it was shocking to me, you know, no woman had ever been down. And so, *I was looking for who is the best person to be the first woman down* and Dr. Kathy Sullivan definitely seems like the right person. She was the first American woman to spacewalk; she's been up in space three times; she was a former administrator

> of the National Oceanographic and Atmospheric Administration; she has a PhD in ocean related studies. So, she's just the right person and she's just a great person to be with 13 hours inside of a small submersible. What I'm most looking forward to is like, all the firsts that we've done with the *Limiting Factor* and on our dives, is just experiencing these things with someone else and *really being in history*. While I don't want to make too much of a big deal out of it, yeah, it'll be a historic event. Not just being with but piloting the first woman to the bottom of the ocean and seeing her experience as a trained oceanographer about what she's seeing and how it feels. (Caladan Oceanic 2021, TC 00:02:19, author emphasis)

In addition to the first woman, Vescovo has also piloted the "first person from the Asian continent," the "first Pacific Islander" amongst many other "firsts" to Challenger Deep: a procession of people whose significance to Vescovo is their status as "first" of a subcategory of people to achieve diving to the deepest point. In commenting on this I do not, of course, mean to undermine the integrity and value of any of the participants who have dived to Challenger Deep with Vescovo. However, significant in this quote is that Vescovo is the one doing the selecting, deciding on the "best" example of a woman to be the first. This is fundamentally reinscribing the dynamics of power from the Heroic Era onwards, where participation is dependent on being judged worthy by a white, extraordinarily wealthy North American man.

This is also not a standalone event. Notably, Jeff Bezos' company Blue Origin hand-picked six women to go into space in early 2025 as another "first": "...with New Shepard we're opening the- the- the- you know spaceflight experience for everybody and this one we've- we've been able to have so many historic flights but to be able to put six women on this launch in this capsule, the first time that has ever been done...," narrates Blue Origin Vice President of Commercial and International Sales, Ariane Cornell, in a live webcast of the flight (Blue Origin 2025). This flight garnered significant cultural backlash as it was perceived as an asinine exercise in optics; as Allen (2025) succinctly noted, "[t]he reality is that representation at 65 miles above Earth means little if women still lack influence over who designs the rockets, controls the funding or sets the agenda for space exploration."

Indeed, the flight succeeded in emphasizing the close networks of the wealthy, notably between Jeff Bezos and Katy Perry, and the power held by a very small number of

billionaires. As the four submersibles to Challenger Deep further demonstrate, access to wealth, either through private means or through state or navy funding, is crucial to access to the deepest seafloor. Even the *Trieste*'s construction and operations were only made possible through concentrated funding initiatives by the Piccard family in the city of Trieste, Italy, and later through the sale of the submersible to the US Navy (Martin 1964). As such, relations between people and planet, in this case to the deepest sediments on Earth, are *sedimented* through a politics of access – and as we shall come to see, are evidenced through a politics of waste.

Sedimenting Access: To the Moon, and Back

In conducting these dives, each of these vessels dropped iron or steel ballast on the very same seafloor, leaving traces of their journey *in situ* to become part of the sediment in Challenger Deep. Such material evidence of "frontier" journeys, which often take the form of rubbish, reveal sedimentary relations and can then be co-opted into or indeed help to form the narratives through which these journeys are framed and told.

Such is the case with the moon. Anthropologist and expert in space archaeology Beth Laura O'Leary (2015, 5) notes that "[t]he Moon today has over 100 metric tons of cultural materials from several nations, most of it clustered near the lunar equator." These can be categorized as scientific (landers, experimental equipment) or symbolic material (flags, memorial plaques), or waste: "96 bags of feces, urine and vomit" (Harris 2023, 38) were left on the moon surface after the Apollo 11 landing) – all of which paleontologist Ignazio Díaz-Martínez and colleagues (2021) note can be understood as "technofossils" (Zalasiewicz et al. 2014), a term coined by members of the Anthropocene Working Group. Likewise, material retrieved *from* the moon or indeed objects that undertook or symbolize the physical journey to the moon are valued culturally and monetarily for their role in such historic events. Christie's (2019) auction titled *One Giant Leap: Celebrating Space Exploration 50 Years after Apollo 11*, for example, sold 130 artifacts from the Mercury through to Apollo programs, ranging from sample collecting bags to a heat shield segment from the Apollo 8 mission, for a total of USD $9 million.

These objects – technofossils – carry with them the narrative of exploration and evidence of reaching the "frontier." The Christie's auction's star item, the Apollo 11 Lunar Module

Timeline Book, was billed as containing "the first human writing on another world" with "Eagle's landing coordinates written on page 10 by Aldrin" (Christie's 2019). The value of these objects is their bridging of humanity and an extreme environment and their ability to act as signifiers of significant events such as the moon landing.

A similar interest can be seen in the preservation of items *in situ on* the moon's surface. In 2010, for example, initiatives to protect the artefacts left at the lunar landing site of Apollo 11 resulted in these diverse objects being added to the California and New Mexico State Registers of Cultural Properties as a largely symbolic act (O'Leary 2014). Many of these objects were deliberately left *in situ*, and were carefully chosen for their symbolism. As historian and vexillologist Anne M. Platoff (1993, 2) points outs, the Committee on Symbolic Activities for the First Lunar Landing "was instructed to select symbolic activities that ... would 'signalize the first lunar landing as an historic forward step of all mankind that has been accomplished by the United States' and that would not give the impression that the United States was 'taking possession of the moon' in violation of the Outer Space Treaty." This mandate required a nuanced decision-making process and resulted in the choice to plant the US flag on the moon as "a symbolic gesture of national pride in achievement" (ibid., 6). Tracing this logic and historical evidence of the deliberate significance of remote objects and their placement, it follows that submersible ballast dropped to the deep ocean floor is not without symbolic meaning. The accumulation of ballast piles on the seafloor can be construed in the same vein as the flag and other cultural artefacts on the moon, that is, as a symbolic gesture of pride in achievement – albeit not the pride of a nation but of private capital – at the same time as it is a form of waste. Objects in both contexts are transformed into technofossils that reinscribe the values of heroic era expeditions, much the same as the objects in the Christie's auction that provide a bridge between people and extreme environments, signifying conquest and control of nature.

As the introductory quote from Vescovo (2024) emphasized, "[n]ow don't think it's pollution, they're made out of steel, raw steel." The rationale that steel ballast is not aligned with other discarded objects on the seabed such as plastic tethers is premised on temporalities and obstructions:

> ... we acknowledge that most scientific exploratory vehicles discard some sort of ballast weight at the end of each mission. These mild steel weights sink immediately into the

> sediment where they corrode over time and thus alteration of the habitat is minimal when compared with plastic-coated materials. They also offer no navigation risks to any manoeuvring subsea vehicles. (Vescovo et al. 2021, 3)

What Vescovo seems to be suggesting here is that his ballast will become a type of "artifactual-ecofactual matter," which ocean aesthetics scholar Killian Quigley (2022, 15) outlines as matter that "holds and conveys human meaning and memory while supplementing them, and sometimes rearranging them, through temporally, narratively, and ecologically unruly multi-species, animate-inanimate relations." The corrosion rates of steel in the hadal zone have not been studied as far as my search revealed, however, a study on steel corrosion left for 10 years on a seabed two kilometers deep did confirm generalized corrosion at ~100 µm/year, attributed to multiple factors including microbial activity (Rajala et al. 2022). For comparison, Harun Saricimen and colleagues' (2010, 992) test of mild steel corrosion found the average corrosion rates of "26.3, 208.7, and 493.2 µm/year in atmosphere, soil, and splash zone, respectively," so ~100 µm or 0.1 millimeter per year is slow-ish but higher than atmospheric corrosion. Rajala and colleagues (2022) point out that their study is one of the first to demonstrate that microbial communities actually play a part in deep seabed corrosion rates. The possible narratives of ecological and technological matter convergence have not yet been established. The impact of this influx of steel into the hadal environment *and* the specificities of hadal microbial communities and their interactions with steel are not yet understood. Yet, there is undoubtedly a set of new sedimentary relations that unfold.

As leading discard studies scholar Max Liboiron (2013) notes, "[i]n the cold, dark, still ocean deep, most waste survives perfectly intact for hundreds if not thousands of years like a vast cryogenic freezer, making the ocean the ultimate trash archive." Indeed, steel ballast falls under the category of "marine litter," as "any persistent, manufactured or processed solid material discarded, disposed of or abandoned in the marine and coastal environment" (Jeftic, Sheavly, and Adler 2009, 13). In insisting that ballast is not litter or pollution, Vescovo is attempting to write his own categories of matter – of marine litter – and in turn "disappears" his pollution and its implications for how we might view both the environmental impacts of manned submersible dives and Challenger Deep as a site marked by waste from (extreme) tourism (Liboiron and Lepawsky 2022, 87; Balayannis 2020).

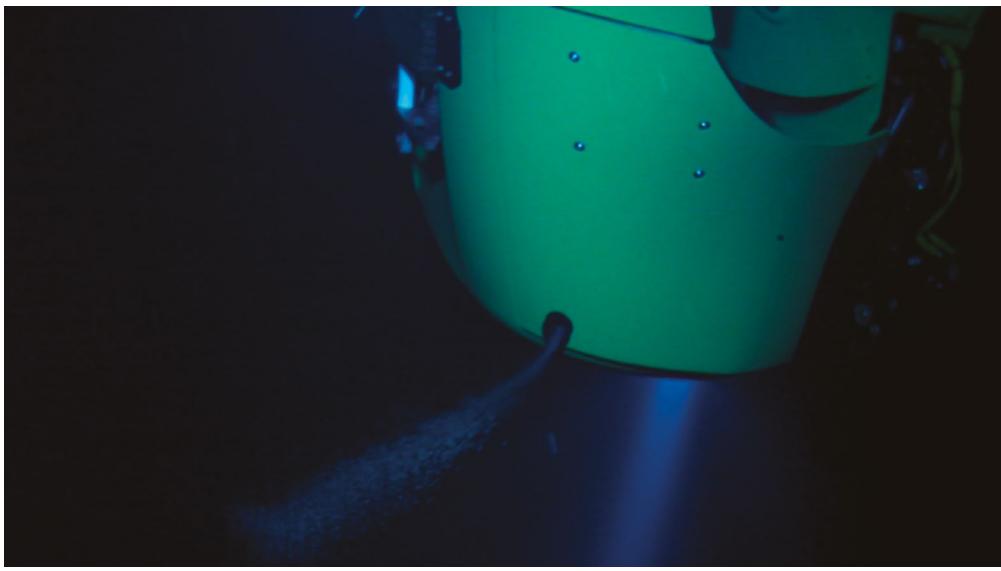
Indeed, the narrativizing of these forms of waste matter is a *matter of power*. To view the submersible ballast and shot piles as "intentional littering" (Vescovo et al. 2021, 3) would mean acknowledging a role in transforming "such an iconic and prestigious place" (ibid.) into a site degraded by visitation. Such a framing would fundamentally undermine the heroic nature of the expedition and the imaginary of Challenger Deep as a pristine, remote and dangerous place. It would instead render it into what amounts to a tourist destination. Similar management strategies have been identified within high-end tourist destinations such as the Maldives, where tourist imaginaries of "pristine, isolated and unpeopled island landscapes require ongoing and attentive management of space" (Kothari and Arnell 2017, 981). Management approaches that position the seabed as pristine are similarly required in relation to Challenger Deep, where a central technique deployed is silence – due to its inaccessibility and therefore the ease of controlling information from expeditions. These silences also render the reworking of sedimentary relations difficult to *unearth*, as the material and informational gaps in this chapter show.

Deposition and Memory

Cameron, in describing the design of his submersible and during his candid dropping of shot during his dives – as depicted in his documentary (fig. 2) – is conspicuously silent on where his released shot landed and its relationship with the environment he is visiting. Yet the scale of the ballast sediments being dumped is not insignificant, and the impact of ballast touching sediment is also not insubstantial. Piccard (1960), writing in a time immediately prior to Rachael Carson's seminal 1962 book *Silent Spring* and the emergence of the environmental movement, had no such compunctions about controlling perceptions of Challenger Deep. He poetically narrated his personal experience of the *Trieste* dive and the deployment and impact of ballast played a significant role via its interactions with the seabed sediment:

> With my hand on the electric switch, I see through the porthole a stream of pellets pouring from one of the ballast silos and then sinking into sediment as soft as powdered talc. The impact produces an immense and shining cloud, first in front of us, then above us, and finally stretching out like a great spreading cumulus.

2 Screen still depicting James Cameron's Deepsea Challenger on its descent to Challenger Deep "shedding some shot," visible as a dark blue stream of shot leaving the base of the vessel on the bottom left side of the image (Source: Bruno et al. 2014, TC 01:09:28)



> As we ascend, we traverse the cloud, rising above it as it disappears into the night that we restore to the abyss. This dust, I am sure, is made of the siliceous skeletons of diatoms that have died in the upper stratum of the sea and fallen slowly to the bottom. It will be hours, perhaps days, before it all returns to the bottom where it has lain, doubtless for centuries. (Piccard 1960)

Indeed, the *Trieste* was equipped with 16 tons of ballast (Martin 1964) that could be partially dropped as shot to help the pilot navigate. As described in the research and development report of the *Trieste* diving program (US Navy Electronics Laboratory 1959, 4), "return to the surface is accomplished by jettisoning enough of the iron shot used as ballast to regain positive buoyancy," and that during their tests on the seafloor near Capri, "[d]ischarged ballast (iron pellets) remained on the sea-floor surface in volcano-shaped piles" (ibid., 19). Given the apparent scale of the shot piles, it is little wonder that Walsh asked Cameron if he could see those left by the *Trieste* during

his dive to Challenger Deep. In addition to shot, Cameron's own submersible carried with it 450 kilograms of steel plates that must be dropped for the sub to rise to the surface (National Geographic 2023).

Examples of the steel plates used by Cameron are, interestingly, held in the Powerhouse Museum collection in New South Wales, Australia. Here a second technique for image management comes into play, whereby – much like the objects in Christie's lunar auction – the plates take the form of would-be technofossils, directly memorializing Cameron's dive (Powerhouse Collection n.d.). These are not objects of potential pollution but evidence of access across the technological and territorial frontiers in the deep-sea (Yin Han 2024, 47-48). It is notable that the steel plates in the museum are unused examples, and do not bare the marks of corrosion from exposure to the Hadal environment itself. Instead, they carry traces of their industrial manufacture and testing, and on one the whorls of a fingerprint remain etched into the metal. They have not had to cede to the material and more-than-human agencies – the "marinal powers" (Quigley 2022, 6) – of a lively ocean (Anderson and Peters 2014). Yet they represent and support narratives of sedimentary access.

Indeed, Quigley (2022, 107) has pointed out that "an encounter with the concreted is never not haunted by an imagery of imperial forms being superseded by waters that overwhelm them, and by encrusters that remake them at the same time that they hold them." Here concreted means an "ambiguous" merging of human and nonhuman "matter, conduct, and history" (Quigley 2022, 98). By avoiding such merging and retaining only the human origins of the objects, the imperial and here also nationalist, commercial, and masculinist exploration motives are not covered over nor made ghostly. Separated from their context of use and the physical evidence of having been submerged within the Hadal environment, these weights nonetheless speak to relations between the seabed and society, sedimenting notions of technological achievement.

Technotraces Through Sedimentation

These piles of iron or steel may be understood as kinds of sediments themselves – deposited and disposed – and are significant in their scale and capacity to narrativize sedimentary relations with the seafloor. When they are dropped, however, a further notable aspect of their disturbance to the hadal seafloor is their displacement of existing sediments. Walsh, in

a 2012 interview, described how the *Trieste* itself landed on the seafloor and this act created a temporally indeterminate cloud:

> This idea of stirring up a sediment cloud, it happened in all the dives. But in a few moments, few minutes let's say it would drift away and then [you take] your pictures and whatever. But in this case it didn't happen. This cloud of very fine material boiled up and it was like looking into a bowl of milk. And after twenty minutes it there was no evidence it was dissipating, and we decided we'd better get it out to surface. (Strickland 2012)

It is possible to view an example of these sediment clouds that were stirred up by *Limiting Factor*'s touchdown and ascent from Challenger Deep, captured within Caladan Oceanic's documentary (fig. 3).

Indeed, sediments that characterize the seafloor of the Mariana Trench are typical of abyssal zones and largely composed of silt (Lai et al. 2023). Their origin is "submarine and island volcanic matter, terrestrial aeolian dust and authigenic mineral" (ibid., 7). Aeolian dust and volcanic ashes constitute particularly fine sediment, which moves extremely slowly through the water column toward the deep seabed, taking anywhere from several weeks (van der Does et al. 2021) to hundreds of years (Honjo, Manganini, and Poppe 1982) to reach the seafloor. The hadal zone is not a completely static zone either, despite its appearance. Turnewitsch and colleagues (2014) have, for example, posited several "mechanisms" operating within hadal trenches to move sediment toward particular points where scientists have found higher rates of nutrient rich particulates.

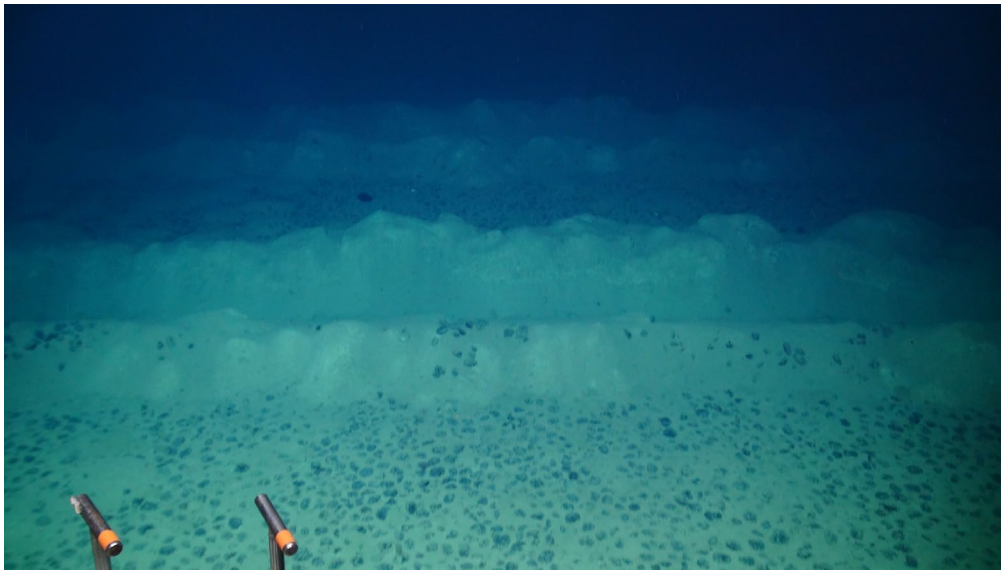
Stirring up a cloud of sediments, therefore, may not be as straightforward as it appears, with complex temporalities and dynamic forces intersecting with the act. It is not insignificant then, when these sediments enter new relations through deep exploration. This is not to say such clouds would have a major effect on a particular environment, but they do have *an* effect. Apart from the *Trieste*'s experience, there is little acknowledgement of the plumes of material displaced by the release of ballast or the movements of manned submersibles in the Mariana Trench (and plumes in general, see Saputra and Sammler 2024). Notably, in Caladan Oceanic's (2021) use of the sediment clouds footage (fig. 4), they are framed as a symbol of achievement, indicating success in reaching Challenger Deep.

3 Screen still depicting a sediment cloud on Challenger Deep caused by the start of *Limiting Factor*'s ascent and likely from the release of its ballast, viewable from a camera mounted on the exterior of the vessel and directed down toward the seabed (Source: Caladan Oceanic 2021, TC 00:15:39)

4 Screen still depicting a sediment cloud on Challenger Deep caused by the physical touchdown of *Limiting Factor* on the seabed, with the footage accompanied by Vescovo's live narration: "when we get to the bottom we're going to gently settle … and touch down" (Source: Caladan Oceanic 2021, TC 00:15:24)

Despite this, media scholar Lisa Yin Han (2024, 55) points out that "[t]urbulence precedes and conditions the possibility for a sedimentary archive," indicating that human-induced turbulence that disrupts the apparent linearity of sedimentation acts as a technotrace that can be preserved in the geologic record.

5 Photograph taken in 2023 by a camera mounted on an ROV during cruise JC241, depicting track marks that were left in the abyssal seabed 44 years prior by the *Hughes Glomar Explorer* (Source: Jones et al. 2025b)



It is technofossils and technotraces, that is, "traces produced by the manipulation of technical artefacts" (Díaz-Martínez et al. 2021, 4), in various guises that formed the basis for different arguments regarding the stratigraphic beginning and legitimacy of the Anthropocene as an era. Although it was decided in 2024 by the International Commission on Stratigraphy (ICS) and its Subcommission on Quaternary Stratigraphy (SQS) that the Anthropocene would not be recognized as a new geological era, for the better part of 15 years researchers have been collating and debating possible primary markers that would signify the era (International Union of Geological Sciences 2024).

Like the Anthropocene marker discussion, there is a push and pull in the narrativization of Challenger Deep ballast, its sedimentary displacement, and its rates of corrosion. Cameron's steel plates held in the Powerhouse Museum readily symbolize human technological achievement, while Vescovo positions his ballast as being a biodegradable material in a

slow process of corrosion on the seabed – naturalized to its surroundings rather than exceptional to it. Regardless of their narrative framings, however, both discarded ballast and the technotraces formed of sediment movements from dropping many tons of steel onto the hadal seafloor will remain in the sedimentary archive of Challenger Deep alongside the plastic tethers, though presumably outlasted by the latter. Indeed, a recent visual survey of the seafloor where, in 1979, a mining vehicle, the *Hughes Glomar Explorer*, left exploration tracks showed in photographs (fig. 5) that 44 years later the tracks remain distinct with "very little visible sign of physical remediation" (Jones et al. 2025a, 6). Deep benthic environments are particularly slow moving, and have great potential to hold onto sedimentary technotraces for far longer periods than most other environments.

Conclusion: Needing to Go

One final intermingling of access and sedimentation that I would like to bring to the fore here is that of the production of internal waste within the submersible. This is a brief note as at present the data and indeed the documentation is lacking, and I point to it as a potential point of expansion for the topics that I have addressed within this chapter. Notably, Vescovo (2024) points out that a dive to Challenger Deep can take upwards of 14 hours in *Limiting Factor*. The *Trieste*'s descent took four hours and 47 minutes, it spent 20 minutes on the seabed, and its ascent took three hours and 15 minutes (Cox 2020). These time periods are significant when considering there are no toilet facilities on board. This is, of course, standard within both private and research submersibles. A Woods Hole Institute booklet on their long-lived *Alvin* research submersible explains that "[t]here is no bathroom. On a wall inside its support vessel, *Atlantis*, there is a sign that reads "PB4UGO." Experienced divers urge newcomers to take the sign seriously. If there is an emergency, divers have to use a bottle" (Woods Hole Oceanographic Institution 2019, 15). This lack of facilities is significant when considering how it might restrict certain types of bodies from participating in extended dives. Put frankly, peeing in a bottle is not an easy feat for anyone operating without a phallus. The extended time periods of deep dives similarly discourage certain types of bodies from participating. Studies have shown, for example, that women under 60 go to the bathroom with significantly higher frequency than men under 60 (see Mueller et al. 2005).

There is a broader history of bathroom-related restrictions underwater that has impacted who has been able to spend extended lengths of time below the ocean's surface. The US Navy lifted a ban on women serving on submarines in 2010, and the UK followed suit in 2011. While there were several reasons given for the US ban, one persistent discussion point was the high cost of retrofitting submarine bathroom and sleeping facilities (MacAskill 2010). Only in 2024 was the first consciously designed gender-neutral submarine commissioned (Mayer 2024). Indeed, as geographer Katherine Sammler (2024, 184) has noted, the porous, leaky body poses "a threat to the techno-modernist ideals of the highly engineered habitat." Future research may consider whether the lack of bathroom facilities on board research and private submersibles is truly placing unofficial anatomical restrictions on the types of bodies that feel confident or able to participate in extended dives. I speculate that the production of bodily waste may have a relationship not only with the politics of accessing the deep seabed, but also with the ability to deposit external waste *onto* the seabed: sedimenting relations both inside and outside the submersible.

As I have shown through the course of this chapter, dropped shot and ballast are more-than-matter, but can be thought of as tangible manifestations of particular ways of being in the world. The frontier narrative is alive and kicking, framed and supported not only by shot piles, but by a whole range of predominantly digital documentation largely self-produced by those with a vested interest in these manned expeditions to Challenger Deep. These narratives *appear* to be engaging with contemporary issues such as equity and inclusion through deliberately inviting "firsts" to participate in dives. In actuality, however, they are reestablishing existing framings of frontier expeditions, particularly its commercial underpinnings, with access to extreme wealth now a key factor in dictating who is worthy of visiting the "deepest deep." Representatives of marginalized communities are cherrypicked to participate as a demonstration of the generosity of the wealthy and to act iteratively as new forms of history-making. This is a particularly fitting reworking of the frontier narrative given the contemporary political climate, particularly in the US, where nationalist and imperialist values have thoroughly merged with commercial interests and the accelerated concentration of wealth in the most recent administration alongside the dismantling of diversity and inclusion measures. In inscribing manned submersible dives into the geological archives of the deep ocean through the dropping of ballast, traces of uneven access to the deep seabed are simultaneously being recorded through these

symbolic objects left *in situ* and through their effects on the seabed sediments and benthic microbial ecosystems.

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