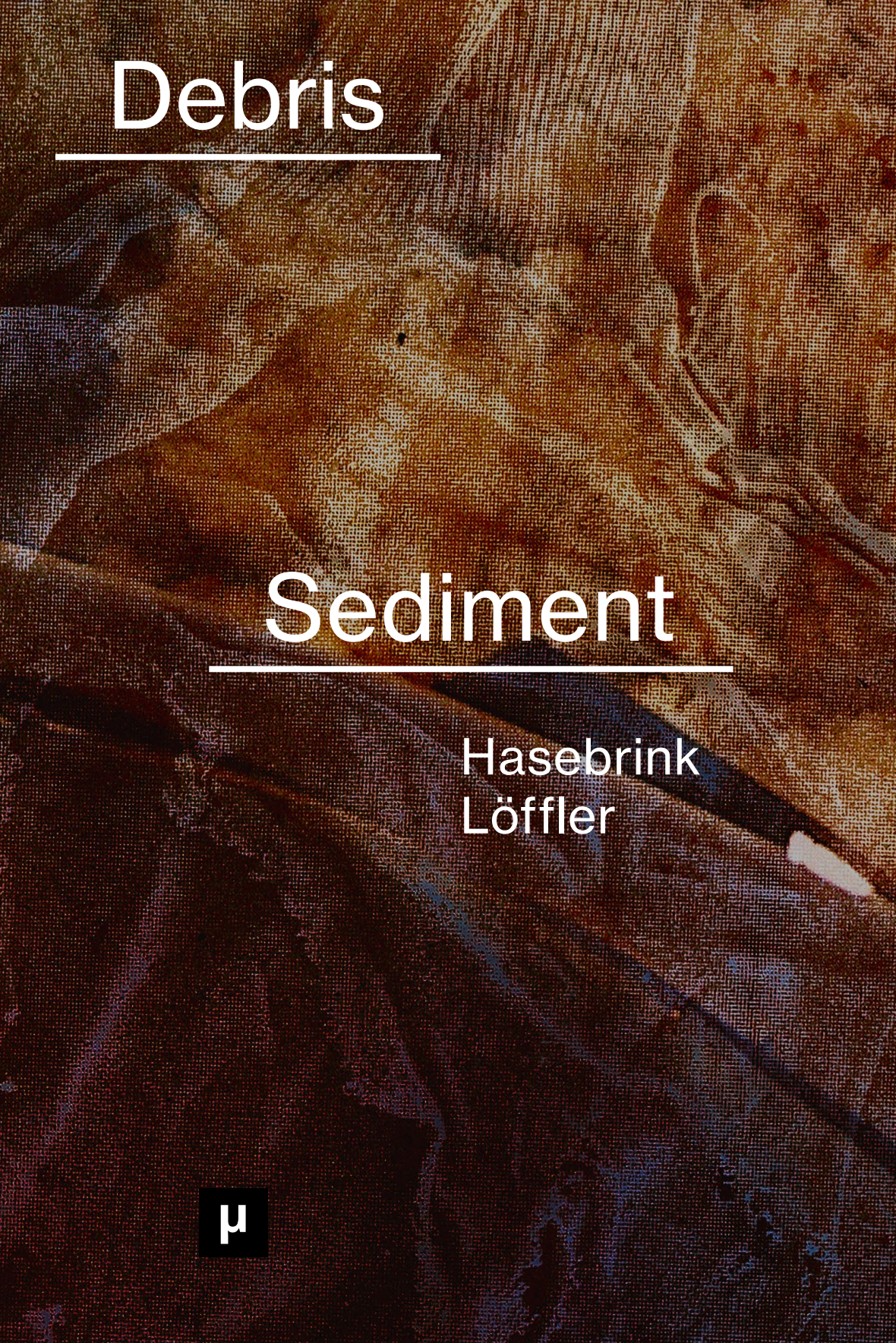
Debris
Sediment
Hasebrink
Löffler

From Debris to Sediment: Unearthing Imperial Geology

Future Ecologies Series
Edited by Petra Löffler, Claudia Mareis
and Florian Sprenger

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Felix Hasebrink and
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Series Foreword: Future Ecologies

Petra Löffler, Claudia Mareis, and Florian Sprenger

The future of life on Earth has generated ongoing debates in academia, through which the concept of ecology has gained status by being able to connect disciplines across the natural sciences, humanities, arts, design and architecture. Criticism of the effects of climate change, which exacerbate existing inequalities in our global population, has spread from academia to the political and public spheres. At a time when the future of life on this planet is more uncertain than ever, the urgency of exploring other ways of thinking, acting and dwelling together is evident. This book series investigates emerging ecologies in uncertain worlds – ecologies that are open to the interests of other-than-humans and that care for plural modes of existence. By providing a platform for these topics and debates, we hope to contribute to a nature contract with the Earth as the shared common ground of water and minerals, air and birds, earth and woods, living and non-living, active and passive matter.

Future Ecologies is about a "time-space-mattering" that calls into question common knowledges about the relationship between space, place, territory, and the linearity of time in light of the circulation of matter, energies, and affect. It also questions the meaning of past ecologies and unsustainable futures for emergent ecologies, while problematizing the ambivalent histories of environmental knowledge, especially in the interplay of modernity and coloniality. Reading research in the *Future Ecologies* series allows you to take the many facets of past ecological thinking into account, to reveal its differentiated and often contradictory political implications and effects – and to criticize its, sometimes, naïve promises. Studying *Future Ecologies* means not taking for granted what ecology means.

The series promotes a relational thinking that is aware of the environmental, economic, social, and individual complexities of such a pluriverse driven by equally complex technologies and infrastructures. As Donna J. Haraway said, in a shared world "nothing is connected to everything, but everything is connected to something". This connection generates and discloses different scales of responsibility. We dedicate this book series to all earthly critters who want to invent and try out new forms of life and styles of cohabitation, who ask which risks we want to and are able to take, and which futures we dream of. We invite contributions that address the geopolitical inequalities of climate change and capitalist extractivism, that deal with politics of (un)sustainability and (de)futuring, technologies of recycling and environing, non-anthropocentric epistemologies and practices of world-making.

The *Future Ecologies* series advocates for interdisciplinary approaches towards the numerous aspects of ecology. We invite junior and senior scholars from various disciplines in media, cultural and literary studies, anthropology, design, architecture, and the arts to build collaborations between different voices, practices and knowledges – that is: heterogeneous communities of practice. By endorsing open access publishing, the series also aims to partake in the current transformation of the ecologies and economies of knowledge production.

Introduction

Petra Löffler and Felix Hasebrink

The sediments are a sort of epic poem of the earth. When we are wise enough, perhaps we can read in them all of past history.
Rachel Carson

Matter is not only circulated and transformed by air, water, earth, and fire. It gathers in material assemblages, metamorphosing in space and through time. In geology, such accumulated deposits of organic or mineral matter are called sediments. However, the category not only applies to the rather slow transformations of the Earth's crust across vast geohistorical timescales. Today, new material assemblages are emerging that challenge traditional notions of geophysical sediments.

So-called plastiglomerates are a prime example. Plastiglomerates are hard lumps, formed by sedimentary particles of basaltic lava, beach sand, and organic debris such as wood or shells, but glued together by melted plastic (fig. 1). First discovered along the shorelines of Hawaii, plastiglomerates reveal the massive global spread of plastic waste in all shapes and sizes, from larger objects to microscopic fragments. Geologist Patricia Corcoran, oceanographer Charles J. Moore, and visual artist Kelly Jazvac (2014) suggest that this new type of "rock," an offspring of petromodernity's "synthetic worlds" (Leslie 2005) and its extractivist economies (LeMenager 2014), could be considered a possible marker of the Anthropocene. Atmospheric chemist Paul Crutzen and biologist Eugene Stoermer (2000) coined this term to designate a new geological era in which layers of artificial substances, man-made infrastructures,

1 Kelly Jazvac, Patricia Corcoran, and Charles Moore: Plastiglomerates (2016, an art/science research investigation, © the artists, photo by Jeff Elstone)

and other stuff emerge on the surface of the Earth (including the seafloor) as new geologic entities.[1]

Besides plastiglomerates, other anthropogenic deposits are currently becoming increasingly relevant as quasi-geological formations and thick layers of anthropogenic refuse: the pollution of soils and waters with cumulative toxins, decaying cityscapes and former infrastructures of industrial manufacture, nuclear waste (and the challenges regarding its long-term disposal), the rising concentration of carbon dioxide in the atmosphere, or the growing amount of space debris orbiting the Earth. The rapidly expanding deposits of residue are the result of capitalist extraction predominantly conducted by modern industrial societies and former colonial powers in the Global North. In this volume, we take them as an opportunity to reexamine geological, cultural, and political concepts of sediments, to discuss their aesthetics and explore their epistemological potential.

In the face of hybrid entities such as plastiglomerates (Nova and DISNOVATION. ORG 2020, 20–21), reconsidering geological processes seems to be an urgent task of the present. Accordingly, various scientific projects currently revolve around "plastic as sediment" (Russel, Pohl, and Fernández 2025).[2] Contemplations on the physical impacts of modern industrial societies, however, date back as far as the nineteenth century. In his book *Man and Nature or Physical Geography as Modified by Human Action*, published in 1864, polymath scholar and diplomat George P. Marsh (1864, iii) already warned of "the extent of the changes produced by human action in the physical condition of the globe we inhabit." While regarding "geological agencies" explicitly "as powers beyond human guidance or resistance," he advocated for "the restoration of disturbed harmonies and the material improvement of waste and exhausted regions" (ibid., 542, iii).

The essays in this collection aim to update this line of thinking for the early twenty-first century. They present different accounts of contemporary sediments that expand "geological agencies" and testify to new entanglements between geophysical deposits, anthropogenic waste products, and different forms of cultural remains. Adopting a geo-philosophical perspective (Deleuze and Guattari 1994), sediments become instructive starting points to tackle a fundamental question of the current ecological crisis: Are human beings able to install and practice non-violent and sustainable relations with the Earth and its many diverse co-inhabitants? Would they be able to perceive "other geologic lives" and invent "a new language

1 In 2024, the International Commission on Stratigraphy (ICS) approved the vote of its Subcommission on Quaternary Stratigraphy (SQS) to reject the proposal for an "Anthropocene epoch" as a new unit of the Geological Time Scale. Nevertheless, they state that the concept will "remain an invaluable descriptor of human impact on the Earth system." (International Commission on Stratigraphy 2013–2023)

2 See, among others, the ongoing projects PLASTICAL at MARUM and the University of Bremen and the research center "Mikroplastik" at the University of Bayreuth.

of geologic relations," as geographer Kathryn Yusoff (2024, unpag., 23) proposes?

Anthropogenic Deposits as Future Fossils

As environmental physicist Alexandra Klemme shows in her contribution, the term "sedimentation" can take on different meanings depending on the specific lens of the discipline. Processes of sedimentation can span different time scales, spaces, and velocities. In considering the many phases of sediment – transport, suspension, and deposition – she looks into the movement of both inorganic matter (the rock cycle) and organic substances (the carbon cycle) by presenting two case studies on the biogeochemistry in peat-draining rivers and the flux of sediment in peat soils. In environmental physics, however, anthropogenic sediments become increasingly evident not only through altered erosion patterns, but most significantly through entirely new material assemblages such as microplastics or industrial residues. The question of what these sediments will tell future observers – be they human or not (Zalasiewicz 2008) – lies at the heart of our interest in the transition from debris to sediment, material processes of sedimentation and erosion, and their impact on future ecologies.

Today, anthropogenic deposits deeply affect both local ecologies and global cycles of matter because, as waste researcher Myra Hird (2013, 105) states, "waste doesn't really go away – it flows over time and through space" and has a geologically relevant lifespan. In geoscience, plastic waste is used as a "scaling device" (Westermann 2020, 125) to measure human impact on the Earth system. Waste deposits form new geological entities, of which plastiglomerates are a key example, albeit not the only one. Paleobiologist Jan Zalasiewicz and geologists Colin Waters and Mark Williams (2014) propose the term "technofossils" to describe human-made artifacts that are now proliferating on an unprecedented scale on land, in rivers, and in the ocean, and which are likely to become part of the Earth's future geological make-up. Analyzing the geological cycles of plastics, Zalasiewicz and colleagues (2016, 7) found that the "dense hybrid plastic-sediment materials have good potential for burial and long-term preservation."

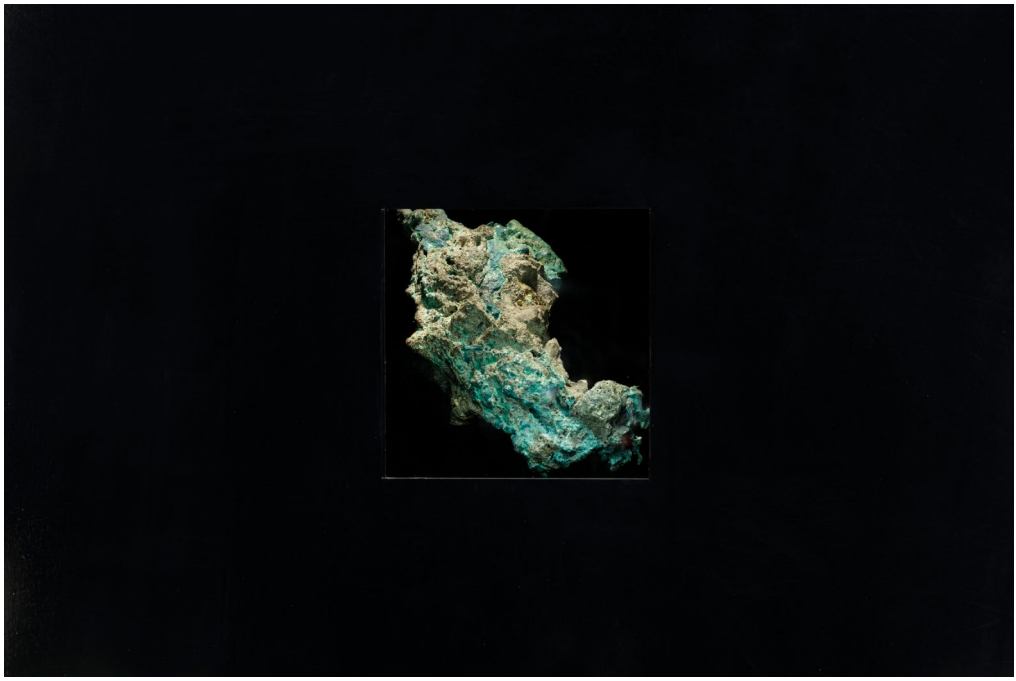
Anthropogenic refuse may aggregate in rocks, but it can also gather in other material constellations. One such constellation is the presence of ocean garbage patches floating on the water surface. Some of these patches, containing

mostly non-biodegradable plastic waste, can be perceived from passing ships and by ocean inhabitants. In order to calculate their actual volumes and track their movements, however, researchers resort to satellite images and sensory data collected from drifting barriers and buoys (Vehlken 2020). Garbage patches also expand less visibly into the water column, and sediment as scattered tiny pieces on the seafloor. The sheer immensity of these garbage patches and their transition from visibility to opacity qualify them as "hyper-objects" (Morton 2013) that lie beyond human apprehension. Yet, these hard-to-grasp, geologically relevant materialities share qualities with more solid ones, as described by media scholar Jussi Parikka. In *A Geology of Media*, he proposed a "different sort of temporal and spatial materialism of media culture" (Parikka 2015, 3), referring to the many metals, minerals, and synthetic materials media devices are made of and that remain after these devices are discarded, end up at landfills, and perhaps enter new material cycles. Picking up on the idea of imagining these electronic rejects as "fossils," he asks: "What is the layer of dead matter residue that we are producing as future fossils?" (ibid., 110). From a media ecology viewpoint, however, matter is very much alive, since geological processes of erosion, decay, and sedimentation play an important part in all media environments – especially for socio-technical infrastructures that must be permanently maintained (Schabacher 2022).

In her contribution to this volume, human geographer Amelia Hine takes a closer look at the entanglement of advanced diving technologies to explore the deep sea with narratives of scientific progress and masculine heroism, such as the discovery and extraction of new species. Using archival material and film documentaries, Hine analyses the remnants of deep sea-expeditions on the sea floor such as metal piles that were originally not considered waste, and the turbulence deep sea-submersibles bring about for inhabitants of the hadal zone, that is, the whirling up of sediment. And yet, it is image-producing media technologies involved in extraction practices that fuel both the public's desire for spectacular "frontier" images and scientists' desire not only to visualize the abyss, but also to obtain records from it.[3] This complicity of image (and other sensor-based) technologies with the logic and logistics of capturing the world ready for domination and extraction is a predicament in media studies, demanding an expanded "ecology of images" (Sontag 1979, 180; Ross 1992) that takes the impact of these images on ecosystems seriously.

3 See the British Oceanic Data Center's (BODC) huge collection of images from the seabed taken by ROVs, for instance 2023 in the Clarion-Clipperton Zone in the Pacific Ocean at: https://data.ceda.ac.uk/bodc/deposits01/soc240571/JC241_SMARTEX_ROV_imagery (accessed July 7, 2025).

2 Julian Charrière: Metamorphism XX (2016, Installation View, Into the Hollow, Dittrich & Schlechtriem, Berlin, © the artist/VG Bild-Kunst, Bonn, Germany, photo by Jens Ziehe)



The extraction of metals and minerals as well as the sedimentation of synthetic materials and man-made litter as a global phenomenon is studied across the natural sciences and the humanities. It has also sparked the interest of artists and designers. Artists like Ignazio Acosta, Julian Charrière, Susanne Kriemann, or Otobong Nkanga work with hybrid material aggregations and toxic sites to sensitize exhibition visitors to the many contradictory potentials of sedimented materials.[4] Charrière has centered his artistic projects around material processes like melting ice with a blowtorch or sanding outdated terrestrial globes using sandpaper made of mineral samples from the artist's work *Monument – Sedimentation of Floating Worlds* (2013) that represent the 195 countries recognized by the UN (Charrière 2014, 14–15). His exhibition *Future Fossil Spaces* (Musée cantonal des Beaux-Arts, Lausanne, October 31, 2014 to January 11, 2015) is a good example of the growing interest in geological processes

4 See also the chapter "Geological Records" (Fowkes and Fowkes 2022, 14–23), including artworks by Anca Benera and Arnold Estefán, Armin Linke, Sasha Litvintseva and Daniel Mann, Nicholas Mangan, Emilija Škarnulyté, and Tabita Rezaire.

of sedimentation beyond the natural sciences.[5] In his 2016 exhibition *Into the Hollow*, aggregations of molten computer waste and artificial lava sandstone were displayed in vitrines like geological specimen (fig. 2) – artificial twins to their plastiglomerate counterparts.

5 The term "fossil" in the title refers to its Latin etymology, which literally translates as "obtained from digging" (Bugada and Cargnel n.d.; see also Rudwick 1985).

In her 2020 project, *Mngrv (Polymersday), (Nylonsmoon)*, Kriemann transformed plastic waste that has been washed ashore on the coasts of Indonesia and Sri Lanka, where it accumulates in the mangrove forests and damages the biosphere, into a black substance. She used this highly toxic substance as a printing ink for large lithographs – as a gesture to bring the waste back to the Global North, where it mostly originated. In her visual essay for this volume, Kriemann turns her attention to another site of anthropogenic sedimentation: the desert. In her recent artistic project *Datadust, skin of sand* (2024), she tracks contemporary consumer waste found at archaeological research sites in AlUla and Tayma in the northern Arabian desert. The project asks how (micro)plastics and other anthropogenic waste relate to the ancient artifacts found at these sites. Collected scraps such as packages or a pullover are turned into silk prints using date syrup and microplastic-rich make-up, and are then coated with sand. For Kriemann, sand is a geologic agent containing data from past millennia. Her visual essay, together with a poem co-authored with curator Lisa Rosendahl, reveals the surprising entanglements and cycles of hybrid matter in the desert (Kriemann 2025).

Unearthing Imperial Geology

The increase in man-made waste, which is concentrated in the air, deposited in the earth and the seabed, has a considerable ecological impact. It also has cultural, social, and political significance that the contributions to this volume seek to address. What does it mean, for instance, to live in the growing "debrisphere," a term coined by artists Anca Benera and Arnold Estefán (2019), this "supra-stratum of the Lithosphere" (Voinea 2019, 9) formed by mounting layers of industrial modernity's refuse? These new environments are characterized by geopolitical power imbalances, the slow violence of ecocides, and the "imperial debris," as historian Ann Laura Stoler calls "*the uneven temporal sedimentations* in which imperial formations leave their marks" (2012, 2). In a similar vein, anthropologist Elizabeth Povinelli (2016) connects the concept of biopower to geological assumptions about the distinction of life and non-life to approach the "geoontopower"

of settler colonialism and its violent legacies. Colonial implications of geological constellations are by no means a thing of the past. Waste researcher Max Liboiron (2021, 5–6) shows how the actual places where the global waste streams end up perpetuate colonial relations to land. Waste deposition and pollution are, according to Liboiron, themselves a form of colonialism, not just its byproduct or aftereffect.

What is at stake in the new sedimentary layers are the relationships between geological entities and political conditions of life. These relations have increasingly been coming to the fore with the proliferation of new forms of sediments, but they are not a recent phenomenon as such. Geographer Nigel Clark (2017, 214) argues that "interactions with the stratified composition of the earth's crust have long played a constitutive role in social and political formations," and that "all social and political formations are implicated with specific geological formations." Clark is interested in the "historical longevity of 'stratal' issues" (ibid., 215), regarding the history of territorial governance and their links to different forms of political power (exercised on the surface as well as below). A crucial moment in his historical account is the growing awareness of the Earth's own age. In the eighteenth century, Enlightenment philosophers tentatively began to imagine a past of the Earth beyond the traditional biblical timeframe. These speculations were triggered, as Clark (ibid., 217–19) argues, by deeper rock strata exposed through advanced mining operations, as well as the Lisbon earthquake of 1755, the first major geological catastrophe widely perceived as such. 250 years later, the legacies of intersecting geological strata and social constellations have become a pressing political issue again. They not only appear in new research on how to govern and protect the Earth subsystems that Clark (ibid., 223–27) summarizes. Historical interchanges between geology and social life also feature prominently in popular political discussions – for instance in the context of correlations between geological features and voting preferences, highlighted in a *Forbes* article by US geologist David Bressan (2020).

In her recent book *Geologic Life: Inhuman Intimacies and the Geophysics of Race*, Kathryn Yusoff also examines possible connections between geology and social life, but broadens the scope of analysis considerably. Like Clark, she refers to epistemic shifts in the conceptualization of the underground that started in the second half of the eighteenth century. In her view, events like the Lisbon earthquake gave rise to geology as a new scientific discipline, and to new social regimes connected to this discipline that had particularly repressive

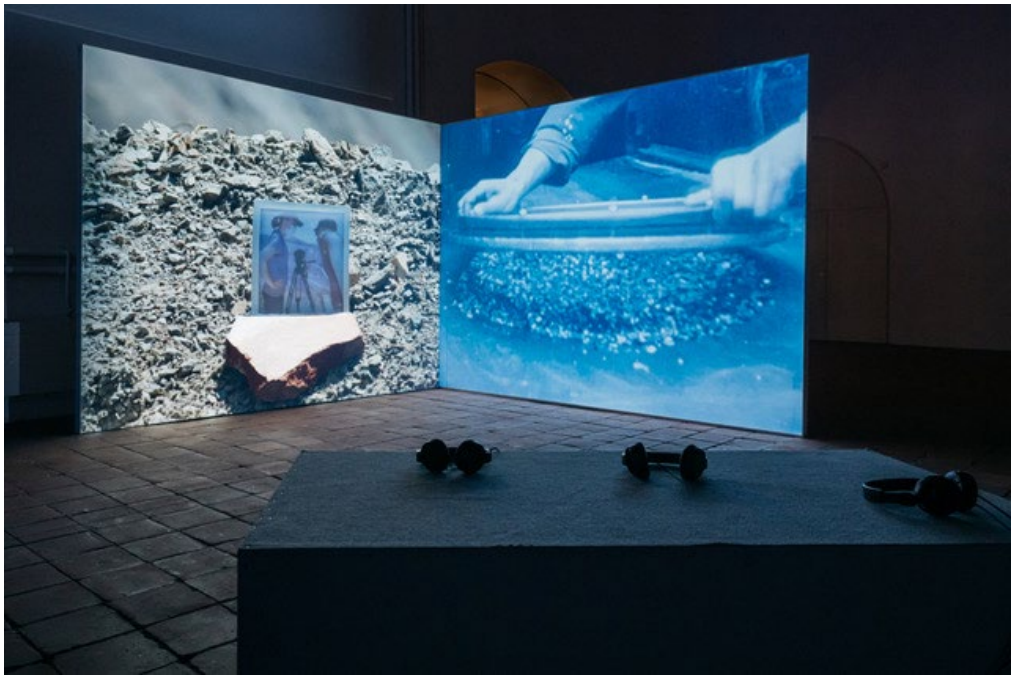
and discriminatory consequences. Yusoff (2024, 1) aims to uncover the complicity of geology with colonialism and imperialism, tracing geology's "systemic racism in the building of colonial worlds and the destruction of existing earths." For Yusoff, it is not simply "human history" that "is infused in geological time," as Parikka (2015, 6) claimed, but rather, and more precisely, the history of slavery and the reification of Black and Brown lives as inhuman. What she calls "white geology" is "a historical system of material power that used geologic minerals, metals, and fuels, combined with the epistemic violence of the category of the inhuman to shape regimes of value and forms of subjective life" (Yusoff 2024, 2). Yusoff reconstructs how the idea of the Earth as an apolitical, inanimate, and inhuman "ground" – a founding stone of the natural sciences emerging from the European Enlightenment – produced a binary racist regime, in which the "ground" – the "geos" in "geology" – was specifically associated with non-white life. Geology thus gave legitimacy to the dispossession and exploitation of land and human labor on a global scale.[6]

6 Other geologists are currently unpacking the entanglements of geological research, colonialism, and racism as well. See, among others, Rogers et al. (2022) and Luciano (2024).

For Yusoff, sediments have a particular methodological value. They are more than records of subjugated histories, but draw attention to "rifts," meaning the manifold cracks and fissures in alternative epistemologies of the Earth that "white geology" has smoothed over to create a uniform "plateau" (ibid., 77). Rifts, for Yusoff, are connected to "an aesthetics of the underground" (ibid., 116) that favors "disarray" or "disassembly" over "resolution" (ibid.) and can be understood as a "durational sense of brokenness" and "noncoherence" that "*un*works the enclose of the colonial earth" (ibid., 117). Yusoff's turn to aesthetics implies media as well: maps, surveys, photographic images, or sound recordings that both advanced the colonial projects of nineteenth-century geology, but can also be employed as visual practices to further investigate specific sites and spaces where historical entanglements of geos and bios, of "earth" and "life," become manifest – especially in new forms of sedimentary structures.

With this volume, we follow this nexus and pay close attention to the power-political and ecological entanglements of geological sedimentation. To this end, approaches from media and cultural studies enter a dialog with geoscientific research, philosophical concepts, and artistic positions. We are concerned with the imperial and colonial undercurrents of "Western" science, its institutions, methodologies, and research agendas, and are aware of the imperial and colonial violence implicated – not only, but especially in contexts shaped by extractivist economies. In doing so, we acknowledge

3 doplgenger: *Record of the Termite Landscape* (two-channel video installation, 2025, The Kunsthalle Osnabrück, © the artists, photo by Daniel Sadrowski)



the neo-imperial efforts of globally acting mining and other resource extraction companies, and of superpowers such as China, Russia, and the USA, to claim and to exploit territories on land as well as in the sea as a means of exercising and securing political dominance. Unearthing these ongoing geopolitics of imperial geology means for us revealing the legacy and continuity of imperial power relations and the ideology of resource extraction beyond colonialism as, for instance, Belgrade-based artist duo Doplgenger demonstrate with their two-channel video installation *Record of the Termite Landscape* (2024). In this installation, Isidora Ilić and Boško Prostran combine archival and newly filmed material to constellate the mining activities under socialist rule and their continuation under liberal capitalism in present-day Serbia. By juxtaposing images from different timescales and resources, they address the many strata of an extractivist geopolitics in the history of

Southeast Europe and, at the same time, excavate political and poetic acts of resistance (fig. 3).

Extractive Zones and Their Counterparts

In her contribution to this volume, Henriette Gunkel examines the remains of former diamond mining sites in the Namib desert between Lüderitz and Walvis Bay. Scattered across the desert are an old railway line, dilapidated settlements, and old mining equipment, dating back to the period of German colonialism and the genocide against the OvaHerero and Nama. Near the remnants of diamond extraction, Gunkel encounters an open grave site of workers who died when the mines were still active. The extreme weather conditions target infrastructural and human remains alike. Given that the dunes of the Namib desert are constantly moving, they may eventually cover up the remains and prevent them from scattering and decomposing any further. Yet Gunkel also pays close attention to counter-movements: the dunes uncover and expose the remains as well, thereby letting colonial and genocidal histories resurface in a very literal sense. Gunkel's contribution is invested in examining this dynamic of covering and uncovering, a temporary "holding" and further scattering of remains. The remains in the Namib desert demonstrate that geophysical conditions have not only facilitated colonial exploitation and the racist biopolitics sustaining it. Exploitation has also left tangible marks in (and on) the ground.

In Namibia as well as in other former colonies, land grab and resource extraction form the eminent economic basis of colonial and imperial power. Extensive mining, harvesting, and other practices of material removal leave behind devastated landscapes and ruined ecosystems as demonstrated, for instance, by Ignazio Acosta's (2018) artistic research project *Copper Geographies* (2012–16). But the violence does not stop there. Once extracted from the soil, parts of the earth materials stay on site as slag heaps. Other (toxic) parts migrate into the atmosphere and travel around the globe before they finally accumulate in specific places. With our interest in such processes of sedimentation, we focus on the aftermaths, counterparts, and "other ends" of colonial extraction and the logics of capitalist extractivism.

While current research has exposed the ruinous effects of extractivism as a pervasive economic logic and ideology (Acosta 2013; Mersmann and Ohls 2024), sedimentation brings a complementary dynamic into view: not the removal of raw

materials, but the deposition of *residual* materials that are set in motion by natural carriers or man-made means of transportation and accumulate again at different places. Processes of deposition can be observed in extensive, not clearly delimited areas (soils, waters, glaciers, etc.), but also take place at officially designated sites (such as above-ground or underground landfills) or in illegal dumping grounds, which can significantly pollute ecosystems. Consequently, the "extractive zone" (Gómez-Barris 2017) corresponds to various sedimentation sites and "discardscapes" (Lepawsky 2018, 131) that mark the counterpart of global resource flows.

Sites for the proper disposal of hazardous waste must fulfill special requirements. Studies can help identify locations with suitable geological conditions so that the resulting "discardscape" does not contaminate any surrounding environments. In her contribution, sociologist Christiane Schürkmann examines how scientists are currently investigating potential "host rocks" for underground nuclear waste repositories. A promising rock for the construction of such long-term storage facilities is clay. Schürkmann unravels the narratives and hopes projected onto this rock in public science communication and connects these discourses to experimental set-ups in which scientists hope to produce further knowledge about it. Following scientists through their above-ground and underground laboratories, Schürkmann discovers that the experiments are designed in such a way that the rock formations can "perform" what she terms "geological agency." This agency is made to appear in laboratory settings but cannot be fully controlled. Nevertheless, scientists must calculate with the agential capacities of rocks to determine how waste may be stored underground for millennia to come.

In contrast to comprehensively monitored waste repositories, other discardscapes are far more uncontrolled and almost impossible to remediate. One of the most extreme and widely debated forms are so-called "sacrifice zones" (Lerner 2012), territories that have been heavily contaminated by radioactivity, industrial waste, and related toxic leftovers.[7] Cleanup is usually considered futile because it would be far too expensive, too complex, or simply not feasible from a technical viewpoint. The concept of sacrifice zones alludes to peripheral regions that are somewhere "out there." However, man-made residue accumulates in all kinds of places, not always safely removed from habitats and dwellings. Sacrifice zones proliferate in the extractive zones of the Global South as well as in former and ongoing areas of heavy industry in the Global North.

7 For the shifting meanings of "sacrifice zone" from livestock and land management in the early 1970s through critical energy discourses and indigenous political ecology in the 1980s, see Juskus (2023).

Sedimentation as Thought Figure

In a strictly geophysical sense, sedimentation refers to processes of crushing, liquefaction, layering, and hardening, as well as enrichment and compaction. However, sediments also condense temporal structures. For geologists, they serve as natural records or documents, which make it possible to look back into past geological epochs and to form hypotheses about future changes in the lithosphere, hydrosphere, cryosphere, atmosphere, and biosphere. As geologist Marcia Bjornerud (2018, 22) claims, "to think geologically is to hold in the mind's eye not only what is visible at the surface but also present in the subsurface, what has been and will be." Comparing the studying of sedimentary rocks with reading a multilayered palimpsest, she regards her discipline as "akin to an optical device for seeing the Earth text in all its dimensions" (ibid.).

Bjornerud's analogy between the Earth and the written text is telling in applying humanities methods such as hermeneutics to geoscience. It demonstrates that sediments are not simply matter and that sedimentation is not just a geophysical process. In the humanities, sedimentation has become a theoretical model, a philosophical concept, and an epistemological figure of thought. Various authors have deployed the term "sedimentation" over the course of the twentieth century as an analytical tool beyond the discipline of geology, establishing connections between natural and cultural sciences.

In particular, sediments and sedimentation have been used to describe historical and cultural movements of accretion, accumulation, and grouping. For instance, philosophers such as Edmund Husserl (1939) and Maurice Merleau-Ponty (2012, 131–32) used sediment as a concept to describe historically evolved layers of meaning or accumulated experiences of the world. Michel Foucault (1972, 3–4) demonstrates on the opening pages of *Archeology of Knowledge* how layers and strata have long served as potent figures of thought for traditional historiography. More recently, historian Reinhart Koselleck (2018) draws on geology with his notion of "Zeitschichten" ("sediments of time") in a collection of essays of the same title.

In a more comprehensive way – and by no means just as a metaphor for historical periods and temporal non/simultaneities – Gilles Deleuze and Félix Guattari used sedimentation and stratigraphy to revise structuralist semiotics in their seminal book *A Thousand Plateaus: Capitalism and*

Schizophrenia (1987). They connect geology and human civilization by adding to the geologic (inorganic) and biological (organic) strata a third "alloplastic stratum" of human culture and language (Yusoff 2017). For Deleuze and Guattari, thinking alongside geologic strata becomes a starting point for examining events in which matter takes on form by means of layering or "stratification" taking place *between* two strata of rock formations, bodies, language, or in other modes of signification. For them, processes of sedimentation are followed by a "'folding' that sets up a functional structure and affects the passage from sediment to sedimentary rock" (Deleuze and Guattari 1987, 41). Building on Deleuze and Guattari's thinking, philosopher Manuel DeLanda (2000, 55) compares geologic processes with societal and historical dynamics again, taking "the geological" in history much more literally than conventional historians: "From the point of view of energetic and catalytic flows, societies are very much like lava flows; and human-made structures (mineralized cities and institutions) are very much like mountains and rocks accumulations of materials hardened and shaped by historical processes."

Against the backdrop of the climate crisis and the Anthropocene, an emerging "geological turn" in the humanities brings together sedimentation as a geophysical process and an historiographical and epistemological figure of thought. Our volume continues these complementary lines of inquiry by focusing on the contemporary ontological and critical potentials of sediments and sedimentation. This includes connections to earlier conceptualizations of the terms. Besides philosophy and historiography, artistic practices were referring to geological concepts as early as the 1960s. In 1968, artist Robert Smithson published an influential article in *Artforum*, the leading journal of Western art criticism at the time, entitled "A Sedimentation of the Mind: Earth Projects," in which he drew a connection between the "earth's surface" and the "figments of the mind," stating that "slump, debris slides, avalanches all take place within the cracking limits of the brain" (Smithson 1968, 82). Until his early death in 1973, Smithson created a series of "Earth Projects" on specific sites of the American landscape which altered the material composition of these sites by extracting amounts of rock or other materials and distributing and accumulating them elsewhere (such as, for instance, in *Asphalt Rundown* and *Spiral Jetty*). Smithson also brought rocky earth material into the gallery space where it became a "non-site." By calling such projects an "abstract geology" or "muddy thinking" (Smithson 1968, 82), he argued against established art theories and criticism. Moreover,

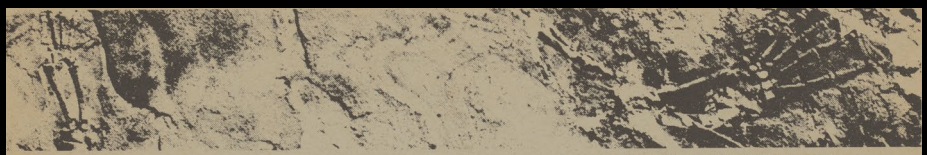
Smithson was very much concerned with the technology of his time and criticized media theorist Marshall McLuhan for calling media "extensions of man." Instead, he suggested that media "are aggregates of elements" because "even the most advanced tools and machines are made of the raw matter of the earth" (Smithson 1968, 82).

In a contribution to the eighth issue of the experimental art journal *Aspen* (edited by Dan Graham), Smithson explicitly plays with the geologic term "strata." Like a geohistorical timeline starting with the Cretaceous he connects layers – or "strata" – of words and images from palaeontologic backgrounds, namely titles of scientific books and photographs of fossils, and weaves them into a highly associative "geophotographic fiction" (Smithson 1970–71). This stratification of images and words points to the "alloplastic stratum" of culture and language proposed by Deleuze and Guattari (fig. 4). Again, visual media play a crucial part in the composition and representation of geologic timescales and the evolution of life.

It comes as no surprise that Smithson's pioneering thinking of "earth media arts" (Parikka 2015, 5) emerged at a time when ecology and environmental activism were increasingly influencing geopolitics in the USA and beyond. Taking the influence of geological thought figures on media theory into account, we are asking today: How can layering and accumulation in sediments be understood in media theory, regarding media functions like recording, processing, and storing, or its relation to objects, actions, and bodies (Schneider 2018)? What openness and simultaneous "grounding" does the concept of (de)sedimentation offer for scientific and artistic research? And finally, what different timescales are at work when natural and human history collide in processes of sedimentation?

Ulrike Gerhardt's contribution to this volume is concerned with contemporary artistic research on landscapes altered by human intervention and their connections to "sedimented" histories. At the center of her essay are recent audiovisual works by Anna Zett, Larisa Crunțeanu and Sonja Hornung, and Mareike Bernien and Alex Gerbaulet. All of these artists deal with the legacy of mining in the former GDR through practices that Gerhardt calls "aesthetic aftercare." Approaching the specific "sacrifice zones" of socialist resource extraction, the video works revolve around rock piles, uranium ore deposits, and open-cast mining landscapes, in addition to other man-made landmarks such as slag heaps or artificial lakes. The works approach these formations as allegories for buried

4 Robert Smithson: Strata: A Geophotographic Fiction (Aspen no. 8, 1970-71, part 8, © the artist, photo by Dietmar Katz)



CRETACEOUS

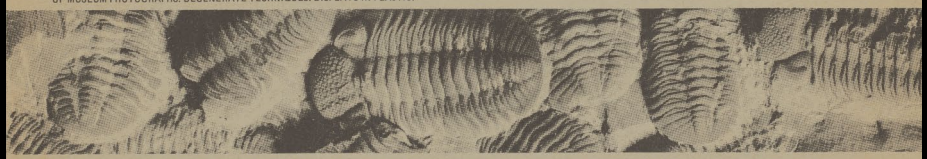
GLOBIGERINA OOZE AND THE BLUISH MUDS. *CRETA* THE LATIN WORD FOR CHALK (THE CHALK AGE). AN ARTICLE CALLED **GROTTOES, GEOLOGY AND THE GOTHIC REVIVAL. PHILOSOPHIC ROMANCES.** GREENSANDS ACCUMULATED OVER WIDE AREAS IN SHALLOW WATER. UPRAISED PLATEAUX IN AUSTRALIA. SEDIMENT SAMPLES. CONIFERS. REMAINS OF A FLIGHTLESS BIRD DISCOVERED IN A CHALK PIT. CAUSES OF EXTINCTION UNKNOWN. THE FABULOUS SEA-SERPENT. THE CLASSICAL ATTITUDE TOWARD MOUNTAINS IS GLOOMY. A DISPLAY OF PLASTER TRICERATOPS EGGS IN A GLASS CASE. THE ROCKS OF MONTANA. GLIBIGERINA CRETACEA ENLARGED 30 TIMES IN A BOOK. THE WEARING PROCESS CONTINUES. A CONSTANT GRINDING DOWN OF ROUGH TERRAINS. SOMETHING HAD FANGS 6 INCHES LONG. KILLED BY THE HEAT OF THE SUN. **THE SACRED THEORY OF THE EARTH** CAUSES BEWILDERMENT. SOME BOOKS CONCERNING THE DELUGE BRING CHAOS TO MANY. GRAY MISTS AND MUCH HEAT. PERPLEXED BY PEBBLE DEPOSITS. COLUMNS OF BASALT ILLUSTRATED IN **DE RERUM FOSSILIUM.** PAINTINGS OF CRETACEOUS PERIOD SHOWN AS *ARTIST'S CONCEPTIONS* ON LARGE PANELS. FROM 135 TO 70 MILLION YEARS AGO. **TRAITE DE PETRIFICATIONS.** WOODCUT SHOWING TWO STONES FALLING FROM THE HEAVENS DURING A STORM. A DEAD TORTOISE. IN THE ZONE OF AIR—THUNDERBOLTS, E.G. *CERANUNUS*, BELEMNITE, ETC. CERTAIN BEDS OF THE KEOKUK IN THE CENTRAL MISSISSIPPI VALLEY. THE *FLAMING RAMPARTS OF THE WORLD* (LUCRETIUS). **DE MINERALIBUS** BY ALBERTUS MAGNUS. FEATHER IMPRESSIONS EXHIBITED IN A PALEONTOLOGICAL MUSEUM. FOSSILIZED VENOM. THE TREE ONICA WHOSE TEARS HARDEN INTO THE MINERAL ONYX. (FROM THE HORTUS SANITATIS). SOME GRAINS OF SAND WERE SQUARE AND OTHERS PYRAMIDAL. CAMERAS LOST IN SHELLS AND SKELETONS.

JURASSIC

A LABEL UNDER A STEGOSAURUS SKELETON. BONY PLATES. THREE OUNCES OF BRAIN. 45,000,000. NO WORDS COULD DESCRIBE IT. CRAGGY CLIFFS, INDEPENDENT OF LIFE. EXTENSIVE LAKES OR INLAND SEAS MARKED AS BLUE STRIPES ON AN OVAL MAP. PLASTIC SEAWEEDS IN THE MUSEUM. A GREAT COLLECTION OF FOSSILS IN THE ASHMOLEAN MUSEUM AT OXFORD. **MUNDUS SUBTERRANEUS,** KIRCHER AMSTERDAM 1678. STONE PLANTS. JOHN CLEVELAND'S **NEWS FROM NEWCASTLE OR NEWCASTLE COAL PITS** PUBLISHED IN 1659. AGE OF CYCADS. A FINE CHALKY DEPOSIT (PERHAPS DUST BLOWN FROM RAISED CORAL REEFS). MONO LAKE—THE DEAD SEA OF THE WEST. BELEMNITES SWARMED IN THE MUDDY SEAS. POETS CELEBRATING GROTTOES. THE RECENT MONKEY-PUZZLE HAS NOTHING TO DO WITH THE JURASSIC PERIOD. WELL-PRESERVED PTERODACTYLS. THE BURNET CONTROVERSY. MANY CRAWLED ON THE OCEAN FLOOR. DELTAIC SANDSTONES OUTCROPPING IN YORKSHIRE. A MODEL OF A BRYOZOA ONE MILLION TIMES LIFE SIZE. MEANDERING RIVERS. *GO MY SONS, BUY STOUT SHOES, CLIMB THE MOUNTAINS, SEARCH THE VALLEYS, DESERTS, THE SEA SHORES, AND THE DEEP RECESSES OF THE EARTH* (SEVERINUS). IN BRITAIN THE JURASSIC CONSISTS MAINLY OF OOLITES AND CLAYS. RHAETIC BEDS. SEVERAL LAND-MASSES NOT SHOWN ON A MAP. LUXURIANT VEGETATION. **PARADISE LOST.** INVASION OF THE OCEAN. ARCHAEOPTERYX. FLESH-EATERS WALKED ON THEIR HIND LEGS USING THEIR FORE LIMBS FOR GRABBING PREY. BONES WITH AIR CAVITIES SHOWN IN LINE DRAWING. LOW TIDE. DEAD JELLY-FISH IN A LAGOON. PAINTING OF FERN FOREST. POST CARDS OF ZION CANYON. A BOOK ON URANIUM. AN *ARTIST'S CONCEPTION* OF DINOSAURS IN A SWAMP. CHART TELLS OF THE EVOLUTION OF WASTE. OVER-EXPOSED PHOTOGRAPHS OF THE SUNDANCE SEA. A NOVEL ABOUT THE LIFE OF AN ICHTHYOSAUR. NO ICE SHEETS MARKED THE POLES. INFRA-RED PHOTOGRAPHS OF THE GULF OF GEOSYNCLINE.

TRIASSIC

OBSCURE VALLEYS. DATA FROM DRILLED HOLES. *HE MAY EVEN NOW—IF I MAY USE THE PHRASE—BE WANDERING ON SOME PLESIOSAURUS-HAUNTED OLLITIC CORAL REEF, OR BESIDE THE LONELY SALINE LAKES OF THE TRIASSIC AGE* (H.G. WELLS). TRACKS OF DINOSAURS DISCOVERED AT TURNERS FALLS, ON THE CONNECTICUT RIVER IN MASSACHUSETTS. THE COLUMNAR JOININGS OF THE PALISADES. INERT, ALL SLIDES INTO A LOST MOMENT. A CLIFF BELOW THE WEST END OF THE GEORGE WASHINGTON BRIDGE. VOLCANIC VAPORS. AT THE CHILLED ZONE. A RESTORED SECTION OF A TRIASSIC FAULT BLOCK SHOWING LAVA DIKES. A BOOK IS A PAPER STRATA. A COLORED PHOTOGRAPH OF THE PETRIFIED FOREST, ARIZONA. A LANDSLIDE OF MAPS. ECLIPSE OF THE MOON. GYPSUM. AN ILLUSTRATION FROM THE PALESTECTONIC ATLAS. DYING IN THE YUKON AMID THE PLUTONIC ROCKS. TECTONIC ISLANDS SURROUNDED BY GREEN FOAM. *....NOTHING CAN APPEAR MORE LIFELESS THAN THE CHAOS OF ROCKS....* (DARWIN). SOUTHERN ELLESMERELAND. ABUNDANT QUANTITIES OF GRANULAR MINERALS. THE EXHUMED PRE-LATE TRIASSIC PENEPLANE CAN BE SEEN NEAR THE GEORGE WASHINGTON BRIDGE. A GENERALIZED GEOLOGIC CROSS SECTION SHOWING MAGMA OFFSHOOTS. A DIAGRAM SHOWING A FAULT ZONE. WEDGES OF SEDIMENTARY STRATA. A PHOTOGRAPH OF *ROTTEN* DIABASE. RAPID HEAT LOSS. A RESTORATION OF A ICAROSAURUS. FALL ZONE. SWASH. 600,000 CUBIC YARDS OF SOMETHING. A BLOCK DIAGRAM SHOWING DRIFT. BARRIERS OF MUD. *THE EARLIEST OF THE THREE GEOLOGICAL PERIODS COMPRISED IN THE MESOZOIC ERA* (**DICTIONARY OF GEOLOGICAL TERMS**). *BLACK HEATHS, WILD ROCKS, BLACK CRAGS, AND NAKED HILLS* (CHARLES COTTON). IN THE WAKE OF LAVA FLOWS. CHOMATIC EMULSIONS OF NAMELESS ROCKS. A NARROW RANGE OF GREY TONALITIES. THE ANONYMOUS SURFACE UNIFORMITY OF MUSEUM PHOTOGRAPHS. DEGENERATE TECHNIQUES. DISPLAYS IN PLASTIC.



PERMIAN

THE PROVINCE OF PERM IN RUSSIA. EVAPORATION CAUSES LAND TO SHRINK. CONTINENTAL DRIFT. A DRAWING OF THE SKULL OF THE REPTILE ELGINIA (RELATED TO PAREIASAURUS, FROM PERMIAN SANDSTONE IN ELGIN, N.E. SCOTLAND, DRAWN TO ONE-QUARTER NATURAL SIZE). THROUGH THE EYES OF DIMETRODON. PERMIAN ICE AGE. *THUS, THE PULSATING MOVEMENT OF GLACIERS IS DUE TO THE PROPERTIES OF ICE ITSELF AND IS ASSOCIATED WITH THE PERIODIC ACCUMULATION AND REMOVAL OF ELASTIC STRESS IN POLYCRYSTALLINE AGGREGATE* (P.A. SHUMSKI). HOT DESERT CONDITIONS. NOTES REGARDING FORAMINIFERA. REMAINS OF SLOW WADDLING CREATURES FOUND IN RUSSIA AND SOUTH AFRICA. SEAS WERE CUT-OFF FROM THE OCEAN, UNTIL THEY BECAME INCREASINGLY SALINE. DRASTIC CHANGES OF THE LANDSCAPE TAKE PLACE. A VOLCANO ACCORDING TO HUTTON IS A SPIRACLE TO A SUBTERRANEAN FURNACE. FANTASTIC IDEAS WERE LATER CAST ASIDE BY THE PLUTONISTS. SOLIDIFIES IN GRANITE. FAUST SAYS, *SET ROCK TO ROCK....* THE NEPTUNIAN THEORY. THE SYMMETRY OF THE EARTH WAS THOUGHT TO BE SPOILED. MODERN ORDERS OF INSECTS EMERGE. A SPIRALLY COILED BAND OF TEETH BELONGED TO HELICOPRION. DWARF FAUNA. ONE SENTENCE DEVOTED TO INSECTS IN A CHAPTER ON THE PERMIAN PERIOD. STEREOSCOPIC VIEWS OF THE GUADALOUPE SEA. NUANCES OF CHANGING LIGHT OVER RECONSTRUCTIONS OF DECIDUOUS TREES. SNAPSHOTS OF POISON GAS. DIORAMA OF ASH HEAPS. DAGUERREOTYPE SHOWING VAST DEPOSITS OF SALT AND GYPSUM. EQUATOR IN OKLAHOMA. SPOILED PHOTOGRAPHS OF SAND DUNES. PHOTOMICROGRAPHIC STUDIES OF FOSSIL FROST. AERIAL PHOTOGRAPHS OF GLACIATION. STRATIGRAPHIC MAP OF OIL DEPOSITS. MISPLACED BOUNDARIES. SHIFTS IN POLAR AXIS RECORDED. EVAPORATION OF SOUTHERN HEMISPHERE. MARATHON MOUNTAIN SKETCHED. JOURNALS DEVOTED TO RADIATION DAMAGE. UNDEVELOPED FILM OF DRY LAND MASS. NEGATIVES OF SHELLY ORGANISMS. A BOOK ON EDAPHOSAURUS. COLOR SLIDES OF PERMIAN PRAIRIES.

CARBONIFEROUS

THE COAL PERIOD. GEOGRAPHY OF THE LOWER CARBONIFEROUS PERIOD SHOWN ON AN OVAL MAP, WITH BLACK DOTS SYMBOLIZING *LAND PLANTS*. SLUG-LIKE CREATURES GLIDE OVER DEAD CALAMITES. TERRIGENOUS CLASTIC SEDIMENTS EXTENDED TO A LINE PASSING WEST OF MICHIGAN. EARTH WARPAGE. PHOTOGRAPH OF LIMESTONES NEAR BLOOMINGTON, INDIANA. NATURE IS NOT THE STARTING POINT. *ALL ROUND THE COAST THE LANGUID AIR DID SWOON...* (TENNYSON). PURELY STATIC SHAPES, CLUMPS GLIMPSED THROUGH THE EYES OF ERYOPS. THE BRITISH MUSEUM BUILT 1824. THE GLYPTOTHEK IN MUNICH 1816-1834. *AS DECAY AND DEATH OVERTOOK THESE FOREST GIANTS THEY EVENTUALLY CRASHED INTO THE MUD AND OOZE SURROUNDING THEM* (CHARLES R. KNIGHT). THE IMMUTABLE CALM IN THE STEAMING SWAMPS. THINGS FAIL TO APPEAR. WORDS SINKING INTO THE MUCK AND MIRE. *COLLECTING THE FOSSIL AND SENDING IT TO THE MUSEUM IS ONLY PART OF THE STORY* (EDWIN H. COLBERT). A CAMERA OBSCURA REPRODUCES A PALEOGEOLOGIC MAP. THE SPLITTING OF MARINE BEDS. ERODED OUT. DIAGRAM SHOWING EUSTATIC MOVEMENT—RISE AND FALL OF SEA LEVEL OF 100 FEET IN 400,000 YEARS. EPEIROGENIC SINKING. *IT IS IN THE MUSEUM-URGE THAT OUR LEARNING SHOWS A FACE TURNED TOWARDS THE THINGS OF DEATH* (ERNST JUNGER). A HEAP BETWEEN FORGETFULNESS AND MEMORY. A RECONSTRUCTION OF AN EARLY CARBONIFEROUS (MISSISSIPPIAN) SEA AS IN NORTHWESTERN INDIANA. (THE SMITHSONIAN INSTITUTION). *IN THESE NATURAL TRAPS THEY DIED, AND WERE EVENTUALLY BURIED...* (MARSHALL KAY AND EDWIN H. COLBERT). EFFLUVIUMS OF GEOLOGIC TIME. SLEEPING AMPHIBIANS DREAM NOTHING. A TECTONIC MAP OF THE CANADIAN APPALACHIAN REGION. UNSTABLE CONTINENTS. SEDIMENTS ON THE EAST SHORE OF THE BAY OF FUNDY AT JOGGINS, NOVA SCOTIA. SOUNDLESS WINDS. ARTIFICIAL LIGHT. AQUATINT ENGRAVINGS OF FOSSILS.

DEVONIAN

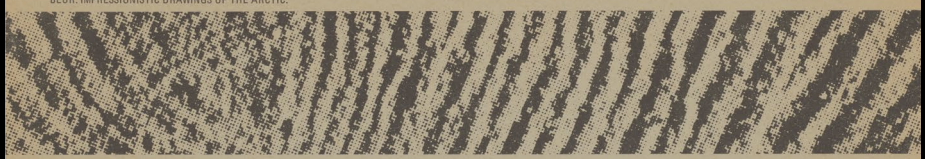
HUGE QUANTITIES OF PEBBLES, SAND AND MUD. DEVONSHIRE.... *APPARENTLY THE WRECK OF SOME GIGANTIC STRUCTURES OF ART*... (POE). THE WORLD THROUGH THE EYES OF A DEVONIAN LUNG FISH. POLISHED PIECES OF SILICA ROCK. FUNGAL THREADS AND RESTING SPORES. SUNSHINE ON THE PETRIFIED DEPOSITS. A LAKE LOST UNDER THE DEBRIS. SPIRAL SHELLS. FOSSIL FOREST EXHIBITED IN A DIORAMA IN THE NEW YORK STATE MUSEUM. EOSPERMATOPERIS IS PROMINENT. MOSS. ANTERIOR MEMORIES. LAYER UPON LAYER. *UNLESS THE INFORMATION GAINED FROM THE COLLECTING AND PREPARING OF FOSSILS IS MADE AVAILABLE THROUGH THE PRINTED PAGE, ASSEMBLAGE SPECIMENS IS ESSENTIALLY A PILE OF MEANINGLESS JUNK* (EDWIN H. COLBERT). A DOUBT WHICH TURNS TO NEGATION, BUT FEIGNED NEGATION. DENDROIDS AND GRAPTOLITES DISAPPEAR. MORE LIME ACCUMULATES. A MODEL SHOWING HOW A VOLCANO ERUPTS. TREE FERNS DECAY INTO FLORA CEMETERIES. RECONSTRUCTION OF LATE DEVONIAN SEA BOTTOM IN WESTERN NEW YORK; DIORAMA (CHICAGO NATURAL HISTORY MUSEUM), A FAINT ILLUSIONISTIC BACKDROP EXTENDS A FALSE UNDERSEA LANDSCAPE. JAWLESS FISHES IN GRAY WATER. A GAZE EQUAL TO SPACE. THE BURDEN OF MILLIONS OF YEARS. ONLY THE GREAT HORIZONS OF THE ABSENT WORLD REFLECT IN THE MIND. THE POTHOLES OF A WEAK IMAGINATION. MIRAGES ON THE VOLCANIC PLAINS. FOSSILIFEROUS ROCKS CRUMBLE IN MAINE. QUARTZ IN THE BRAIN. **ACADIAN DISTURBANCE**. THE AGE OF FISH. THE AGE OF SNAILS. THE AGE OF CALMS. MILLIONS OF YEARS PAST. A FAMOUS FOSSIL DELTA IN THE CATSKILLS. SPIDERS AND WINGLESS INSECTS ALSO ARRIVED. UPLIFT IN THE MIDST OF THE MOST COMPLETE BLINDNESS. AN UNKEMPT CEMETERY OF ANNULARIA. THE DEVONIAN PERIOD IS A SUCCESSION OF LOSSES. AT OUTSKIRTS OF MUD. SPASMODIC CHRONOLOGY. SUBSTRATA. EXHIBITION OF PLACODERMS.

SILURIAN

SEAWEEDS WITH LIMY SKELETONS. SUBMARINE TROUGHS DEEPEN. STONE-LILIES. BRIGHT COLORED POLYPS SPREAD. NEW MOUNTAIN RANGES APPEAR, THEIR NAMES ARE IMMATERIAL--DULL DESCRIPTIONS IN A BOOK. THESE SILURIAN TERRAINS EXIST BY CONCEALMENT. NOTHING BUT BLAND REFERENCES TO A VAGUE SET OF GEOLOGIC FORMATIONS. THE EARTH DIPS OUT OF SIGHT, ALL THE ACTIVITY IS LOST UNDER THE LIMPID OCEANS. ALL IS SEDIMENTATION AND AIMLESS EFFORT. THE SILURIAN NIGHT CASTS THE NINE FOOT SEA SCORPIONS INTO TOTAL DARKNESS, WHERE THEY LIVED MAINLY IN ESTUARIES AND COASTAL LAGOONS. SILENCE, DARKNESS, AND DISMAL PERFECTION. *I CANNOT DISCOVER THIS* OCEANIC *FEELING IN MYSELF* (FREUD). MASSIVE HEAPS OF SKELETONS CAPABLE OF WITHSTANDING BUFFETING IN ROUGH WATER. CORAL BREAKDOWN. FLOATING GRAPTOLITES, MANY SANK TO THE BOTTOM. SHALE. 400 MILLION YEARS AGO. PERIODIC ALTERNATION OF THE LEVEL OF LAND AND SEA. LESS VOLCANIC ACTIVITY THAN IN ORDOVICIAN TIMES. UNDERSEA MOUNTAINS, RAVINES AND VALLEYS. CRUSTAL MOVEMENT. TRAVERTINE. SWAMP TREASURE. DRAWINGS OF SINKHOLES AND CRATERS. THINKING OF THE TUNDRA NEAR HUDSON BAY. THE *MID-CONTINENT* IS A RELIEF OF FEATURELESS FEATURES. OVER THE SCAFFOLDING OF THE MARATHON TROUGH. SODIUM CHLORIDE IN THE EYES. ONLY TWO DIMENSIONS EXIST. HOURS AND DAYS ON LLANORIA. YESTERDAYS ARE DEFORMED. MONOCHROME MAPS. NO RECORD OF LIFE ON THE LAND. FUTURE TIME UNDER SALTY SEAS. RECREATING CRINOIDS. HAZE. PERIODS OF ABANDONMENT. THE LIMITS OF THE MICHIGAN BASIN. A VAST AND HIDEOUS CONTINENT.

ORDOVICIAN

ARENIG AND SKIDDAW SLATES. SPONGES WITH A FRAMEWORK OF SILICA, THROVE AT VARIOUS DEPTHS. VOLCANOES ERUPTED UNDER THE OCEAN, PAINTING SHOWING AN ORDOVICIAN SOUTH DAKOTA. THE MUD GROVELLING; AMPYX. FORGOTTEN PILES OF SANDSTONE. OCEAN FLOOR COLLAPSES. ROTTEN VEGETATION DECOMPOSES INTO ROTTEN ROCK. MAGNESIA. NO LONGER A FAITHFUL IMITATION OF ETERNITY, BUT A CONSTANT STATE OF EROSION. THREE STAGES IN THE DEVELOPMENT OF A THRUST FAULT, SHOWN IN A LINE DRAWING. DISLOCATED BY A MOLTEN CONDITION. THE BURIAL OF THE BRYOZOA. *FOR WHERE THINGS ARE DISCERNED AT INTERVALS OF TIME, THERE ARE FALSEHOODS; AND WHERE THINGS HAVE AN ORIGIN IN TIME, THERE ERRORS ARISE* (ASCLEPIUS). DECREPITUDE AND DELIQUESCENCE. BOTCHED FABRICATIONS ON THE FOGGY LANDSCAPE. PLANKTONIC CALCAREOUS ORGANISMS FALLING. CAREFULLY LABELED SPECIMENS ARE FILED AWAY. A TEDIOUS PART OF FOSSIL COLLECTING TAKES PLACE UNDER THE HOT SUN IN THE BAD LANDS. QUICKSAND. DIAGRAM WITH ORANGE BACKGROUND SHOWS HOW ROCK RESISTANCE INFLUENCES TOPOGRAPHY. A SORT OF JIGSAW PUZZLE FOR GEOLOGISTS. X-RAY VIEW OF AN OIL WELL. A LIGHT BLUE AND TAN MAP SHOWS ORDOVICIAN LAND SHAPES. OVERTURNED ANTICLINE IS A TYPE OF STRATA FOLD. WANDERING WATERS. **GEOLOGY** *EXEMPLIFIES A NEW IDEA IN PAPERBACK PUBLISHING--A SERIES OF OUTSTANDING BOOKS, ILLUSTRATED THROUGHOUT IN FULL COLOR.* LAKE BONNEVILLE HAS SHRUNK. VAST STRETCHES OF SALT FLATS. EVAPORATION. *OLD FAITHFUL*--YELLOWSTONE'S FAVORITE GEYSER. LOCCOLITHS. PROFILE OF A SHIELD VOLCANO: HAWAII'S MAUNA LOA. PTOLEMY GUESSED THAT THE EARTH IS A BALL. OUACHITA. BLUE INK ON TEXAS. CANADIAN SHIELD SINKS. THE OZARK DOME PAINTED ON A MAP AS A BLUR. IMPRESSIONISTIC DRAWINGS OF THE ARCTIC.



CAMBRIAN

GONDWANALAND? REEFS FORMED *CORALLINE SPONGES* (ARCHAEOCYATHINES). THE GREAT THICKNESS OF BLACK MUD. THE ROMAN NAME FOR WALES. BOTTOM LIVING FORMS WERE BLIND. PAXADOXIDES SHOWN IN A LINE-CUT ARE SAID TO BE *HALF NATURAL SIZE*. **MUNDUS SUBTERRANEUS**. PUTTING FACTS TOGETHER LIKE A JIGSAW PUZZLE. LANGUAGE AND SOIL BLOW AWAY. FLOODS. BILATERALLY SYMMETRICAL CREATURES. AN ILLUSTRATION OF THE AUSTRAL SEA (BLUE ON GRAY DOTS). A FRAGMENTARY THEORY. EXCAVATIONS AT DINOSAUR NATIONAL MONUMENT IN NORTHEASTERN UTAH. PALAEOZOIC ERA SHOWN ON AN OLD CHART. LITTLE IS KNOWN ABOUT THE LAND AREAS. THEY PLOUGHED THEIR WAY THROUGH THE MUD. WORMS AND MORE WORMS TURN INTO GAS. SEA BUTTERFLIES FALL INTO A NAMELESS OCEAN. PLASTER RESTORATIONS COLLECTING DUST IN THE MUSEUM OF NATURAL HISTORY. THE TRACKS OF TRILOBITES HARDEN INTO FOSSILS. ACCUMULATIONS OF WASTE ON THE SEA BOTTOMS. JELLY-FISH BAKING UNDER THE SUN. DIGESTIVE SYSTEMS SHOWN IN DIAGRAMS. *...A TENDENCY TO AMORPHOUSNESS...* (HEINRICH WOLFFLIN). *...SCABBY TOPOGRAPHY ON SOLFATARA PLATEAU* (C. MAX BAUER). MAY HAVE LOOKED LIKE THE PLANET VENUS. LIMP-LOOKING CRUSTACEANS, DYING BY THE MILLIONS. *WILL YOU FOLLOW ME AS FAR AS THE SARGASSO SEA?* (GIORGIO DE CHIRICO). CONGLOMERATE THOUGHTS. MOLLUSCA. BREAKING APART INTO PARTICLES. SOMETHING FLOWING BETWEEN THE CARIBBEAN AND NEWFOUNDLAND. THE EQUATOR OVER NEW MEXICO MADE OF DOTS AND DASHES. (PORIFERA). BELTS OF SCATTERED ISLANDS. LLANORIA SOUTH OF LOUISIANNA. MOUNTAINS OF JELLY FISH. THE DIMENSIONS OF AN UNKNOWN SLIME. LIME-SECRETING COLLENIA. A GLOBE SHOWING THE APPALACHIAN TROUGH. GALLERIES FULL OF ODD NAMES AND MODELS. CLOUDS MADE OF PAPER. A DRAWING OF CASCADIA DRAWN PARALLEL TO THE PACIFIC COAST. A GUIDE TO GRIT.

PRE CAMBRIAN

MEMORY AT THE CHTHONIC LEVEL. FLOATING ON SOFT MUDS NEAR THE BLIND RIVER. PINK FOSSILS. OBSCURE TRACES OF LIFE. HALF TONE PICTURES OF STRATIFIED ROCKS. RECONSTRUCTIONS OF SANDSTONES IN SQUARE GLASS CASES. HOT WATER. RIDDLE OF THE SEDIMENTS. LOST IN THE ENCYCLOPEDIA BRITANNICA. BEACHED. BOILING, BUBBLING CONTINENTS. PHOTOGRAPH OF BANDED RED CHERT OR JASPER IN THE SOUDAN MINNESOTA (MINNESOTA GEOLOGICAL SURVEY). A GRAFT SHOWING THE CORRELATION OF THE SUCCESSIONS OF ROCK UNITS IN SEVERAL DISTRICTS. *IGNEOUS* MEANING FIRE. *WE LIVE AMID THE WRECK OF FORMER WORLDS* (JEROME WYCHOFF, **OUR CHANGING EARTH THROUGH THE AGES**--FULLY ILLUSTRATED WITH PHOTOGRAPHS AND PAINTINGS). THIS PERIOD IS LOSING ITSELF IN SAND AND PAGES. THE REGION BEGINS TO DISSIPATE. AN AERIAL PHOTO SHOWING THE DRIFT OF LAVA. SOME THOUGHTS ARE SINKING INTO THE CONGLOMERATE. LOGAN PASS IN GLACIER NATIONAL PARK IS MADE OF CRUSTAL BLOCKS. THE AGE OF POTASSIUM-ARGON. GEOLOGICAL GHOSTS ON THE PAGES OF A BOOK ON VIRUSES. ANIMALS WITHOUT BACKBONES TURN INTO STONE. *IF ONLY THE GEOLOGISTS WOULD LET ME ALONE, I COULD DO VERY WELL, BUT THOSE DREADFUL HAMMERS* (JOHN RUSKIN). GRAPHITE (A CRYSTALLINE TYPE OF CARBON). SLIMY DAYS. STEAMING GEYSER BASINS (NOBODY'S YELLOWSTONE). COUNTERFEIT ALGAE IN THE MUSEUM. BURROWS IN A MOUNTAIN OF CORRUPTION. *...THE QUEER FLOATING BASKET-LIKE VARIETY...* (CHARLES R. KNIGHT). HEAPS OF CARBONATE LIME. POURING TONS OF MINERAL MATTER INTO A LAKE, IMITATION GRANITE. LAYERS OF OUT-DATED MAPS. XENUSION. PETRIFIED SCUM ON DISPLAY. MAP OF THE MISSING SEA. EXTINCT SPONGE-LIKE THINGS. STEAM. CHARTS SHOWING CLAY FORMATIONS. THE PILING UP OF DEBRIS. *...FUTILE AND STUPID STAGNATION...* (HENRY ADAMS). STALE TIME. ONE-CELLED NOTHINGS. ABSENCE OF OXYGEN.

STRATA A GEOPHOTOGRAPHIC FICTION BY ROBERT SMITHSON

layers of history, such as the environmental movement of the GDR. Not exactly solid ground, polluted areas and contaminated soils become places where official narratives erode, and sediments of time become slippery.

De/Sedimentation

Sedimentation implies the hardening and solidification of materials. However, theorists have also been interested in possible counter-movements. Sediments are productive figures of thought not just to describe the emergence of firm structures, but also to pursue the question of how such structures can dissolve, and how their constituents may be set in motion again. For instance, Jacques Derrida (1985, 2), explaining his concept of deconstruction, speaks of an "undoing, decomposing, and desedimenting of structures." Derrida's (1989, 50) use of geological figures of thought to illustrate a resolution or breaking up is striking – especially since he previously developed, in an extensive rereading of Husserl's *Origin of Geometry*, the idea of an inaugural, constitutive "desedimentation," necessary for any "phenomenology of the experience." In certain intellectual proximity to Derrida, feminist thinker Judith Butler (1988, 523) proposes understanding "the gendered body as the legacy of sedimented acts" in an early account on gender and performance theory, and locates the possibility of transforming dominant gender norms in "a different sort of repeating, in the breaking or subversive repetition" (ibid., 520). Similar to Derrida's "undoing" of existing structures, Butler's idea of a different "repeating" or "breaking up" would thus amount to a form of "desedimentation," if one follows Butler's geological semantics.[8]

8 Butler's "sedimented acts" are close to Merleau-Ponty's idea of experiences as "sedimentations," although Butler does not quote his use of the term directly. For a systematic overview of geological concepts in Butler's early theory of gender, see Pergadia (2018).

The idea that the undoing of rigid structures can be conceived in geological terms appears not only in Derrida's and Butler's writing. It constitutes a second, important strand in philosophical and political engagements with the concept of sedimentation. Again, this becomes particularly evident in Deleuze and Guattari's model of geological stratification as an alternative to linear, semantic structures. In *A Thousand Plateaus*, they not only refer to sedimentary layers, but also divide their concept of layer or "stratum" into "parastrata" and "epistrata." They introduce epistrata as "intermediaries and superpositions" (1987, 50) between different layers and further characterize them as sites of an "increasing deterritorialization" (ibid., 53). In Deleuze's and Guattari's understanding, such movements on the epistrata point towards an "outside," a possible dissolution of a given stratum's internal organization.

With this volume, we are interested in tracing comparable movements of dissolution, erosion or "desedimentation," and in exploring the question of whether these movements may also be located in and around the new geophysical deposits we are facing today. Various contributions explore how materials are not always deposited once and for all, but can sometimes be set in motion again, or can spark new cycles of matter. This "recycling" leads back to the geological implications of anthropogenic residues with which we opened this introduction. Hird and Yusoff, for example, regard dumping grounds as dynamic assemblages of living organisms and nonliving matter where microbes digest highly toxic minerals and thereby transform devastated environments. Through this "form of mineral-microbial heterogenesis" (Hird and Yusoff 2017, 265), new lifeforms can emerge. Such metabolic processes thus enable a change in perspective: Under which circumstances do sediments lose their stability and (re)gain mobility?

New metabolic cycles were – and still are – a promising exit route for the growing waste problem in the early twenty-first century (Bélanger 2007). Sociologists and waste studies researchers like Hird (2024), however, express strong reservations regarding the actual environmental benefits of recycling. Felix Hasebrink's closing contribution to this volume takes this growing skepticism as an invitation to devise a broader concept of recycling, in particular for the domain of moving image media. Film and media studies have recently developed a strong interest in the material "footprints" as well as the geological origins of photography and film (Levin, Ruelfs, and Beyerle 2022; Angus 2024), and are paying increasing attention to the ties between visual media and extractivism (Jacobson 2025). However, questions of recycling seldom figure in these discussions. Hasebrink proposes understanding recycling as a set of material practices that constitute a dynamic middle ground between material input and waste output. Recycling shows how physical materials are not always used up and discarded as waste, but can move in many directions within audiovisual media. This becomes apparent in the work of filmmakers that actively employ cinematic leftovers and remnants to create new works, as Hasebrink explains with the experimental film practice of burying strips of celluloid.

Artistic interest in cinematic residue and obsolete recording equipment adds to the fascination with media that has turned to waste, and waste that is slowly transforming into new geological entities. As the number of potential future technofossils continues to grow with every new digital device, digital technologies expand further and penetrate

environments more and more seamlessly. Writer and philosopher Daniel Falb (2019, 264) even speculates that the ever-increasing digital processing capabilities lead to "more and more data being fossilized into an interconnected techno-mineral system of a planetary scale," effectively producing a new, "vital" stratum composed of "unliving agents" (ibid., 265) such as Big Data applications, autonomous transportation, or globally operating intelligence services (today, one would certainly add all the different apps, networks, and research projects currently dubbed "AI"). Consequently, the ongoing "defossilization" of colossal amounts of minerals, fuels, biomass, and sediments is met by a "refossilization" of equally colossal amounts of data. In Falb's speculative account, the Internet of Things becomes all-encompassing, planetary, and essentially a new geological layer acting on its own. At the same time, earlier media materialities sink into the lower levels of industrial modernity's fossilized traces.

Contemporary media such as photography and film have their own part in the many forms of debris accumulating across the globe – from the beaches of Hawaii to river deltas in South Asia and desert landscapes of the Arabian Peninsula, from the deepest regions of the sea to the artificial landmarks of postindustrial sacrifice zones. The essays gathered in this volume explore how this debris may turn to new layers of sediment. Investigating various case studies and applying diverse methodological approaches, they expand previous understandings of sediments, demonstrating the epistemological richness of the concept for key ecological questions of the present. As the authors show, the new and proliferating sediments are not necessarily *faits accomplis*. They sometimes point to dialectical movements of stabilizing and destabilizing, solidification and erosion. What has turned to sediment can be "unearthed" through material processes or critical analysis alike. Scholarly and artistic approaches can illuminate, and actively counter, material movements of deposition, accumulation, or condensation – and the politics they imply.

The following contributions emerged from a workshop that took place in Oldenburg in March 2025. It was the latest installment in a series of workshops that started with the workshop "Records of Disaster: Media Infrastructures and Climate Change" in 2022 and continued in 2023 with "Sub(e)merging: Poetics, Temporalities, Epistemologies." Bringing international and interdisciplinary researchers as well as media artists into dialog, the overarching aim of the series is to examine the key material phenomena of the Anthropocene condition.

We would like to thank the Haus für Medienkunst, namely its directors Edit Molnár and Marcel Schwierin, for their steady interest in collaborating with students and scholars from the Carl von Ossietzky University Oldenburg, and in particular with our workshop series. Jakob Claus, our colleague at the Institute for Art and Visual Culture, supported us in organizing the workshop and helped us manage the workshop "backstage" together with Charlene Gerdes and Alwa Erythropel. Lisa Reuke and the team of Cine k kindly hosted a short film program that accompanied the workshop. Heartfelt thanks to all presenters, participants, and colleagues for sharing their thoughts, ideas, and insights with each other.

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Sediment as Earth's Archive: Insights from the Past and How They Shape Our Future

Alexandra Klemme

Sediments occupy a unique position in the natural sciences, acting both as archives of past environments and as agents in environmental transformations. Starting from the perspective of environmental sciences, this chapter explores how sediments provide essential insights into past environments and how their dynamics intersect with broader Earth system processes, especially the global carbon cycle and climate change. To do so, it separates sediments into three categories. At first, inorganic sediments are discussed through their role in the classical rock cycle and in the global carbon cycle. Second, organic sediments and their importance for global carbon dynamics and climate change are investigated. Third and finally, the concept of anthropogenic sediments is introduced.

Keywords: Sedimentation, Rock Cycle, Carbon Storage, Carbon Cycle, Climate Change

Within a few centuries we are returning to the atmosphere and oceans the concentrated organic carbon stored in sedimentary rocks over hundreds of millions of years.
Vaclav Smil

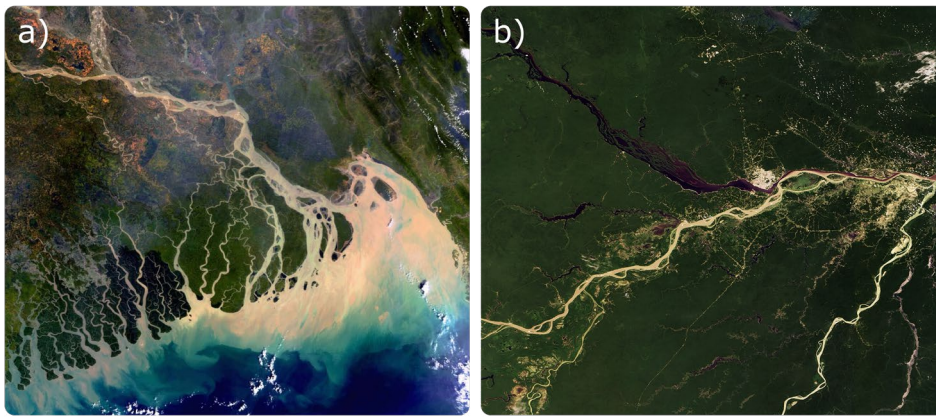
This chapter explores the processes and roles of sedimentation in Earth sciences through an environmental lens. My background is in environmental physics, with a particular focus on terrestrial aquatic systems, carbon cycling, and greenhouse gas emissions. As such, my engagement with sediments is primarily through rivers and aquatic systems, where sediment transport, composition, and interaction with biogeochemical processes are highly dynamic and ecologically relevant.

To illustrate what comes to mind when I think of sediment, consider the satellite image of the Bay of Bengal along the coast of Bangladesh (fig. 1a). Here, the Ganges-Brahmaputra-Meghna river system discharges vast sediment plumes into the ocean, forming one of the most expansive and dynamic sediment delivery systems on Earth. These plumes are not just impressive in scale, they embody the complex journey of eroded material from distant Himalayan headwaters, transported across thousands of kilometers through braided and meandering channels, before finally entering the ocean. These sediments shape coastal geomorphology, nourish deltaic wetlands, and influence nutrient cycles far beyond the river mouth.

As another example on a different continent, consider the striking aerial view of the dark waters of the Rio Negro River meeting the sediment-laden Solimões River near Manaus in the Amazon Basin (fig. 1b). The visible separation between the dark, organic-rich waters of the Rio Negro and the turbid, sediment-laden Solimões persists for kilometers and represents a striking manifestation of contrasting riverine geochemistry, sediment loads, as well as thermal and hydrodynamic properties. This boundary is not just aesthetic. It reflects fundamental differences in biogeochemical processes, such as organic matter decomposition, nutrient availability, and light penetration – factors that shape the ecological dynamics of the Amazon River system downstream.

These examples show sediments as dynamic participants in environmental change. In river systems, sediments are directly linked to biogeochemical cycling, land-use practices,

1 Satellite images from the European Space Agency's Envisat mission. (a) Sediment discharge from the Ganges River into the Bay of Bengal, captured on November 8, 2003. (b) Confluence of the Rio Negro (blackwater) and Solimões (whitewater) rivers forming the Amazon River near Manaus, captured on September 28, 2008 (Sources: ESA CC BY-SA 3.0 IGO)



ecosystem productivity, and climate feedbacks. As such, they are both a product and a driver of environmental processes, which will be further explored in this chapter.

What Counts as Sediment?

When I began preparing for the workshop that led to this publication, I was struck by a definition in the Cambridge Dictionary. It described sediment as "a soft substance that is like a wet powder and consists of very small pieces of a solid material that have fallen to the bottom of a liquid" (Cambridge University Press 2025). This felt limiting. According to that definition, the suspended particles that I study in rivers – constantly in motion, not yet "fallen to the bottom" – would not be considered sediment at all.

Another definition, offered by the Agricultural Research Service of the U.S. Department of Agriculture, felt more inclusive to me. It describes sediment as "solid material, both mineral and organic, that is in suspension, is being transported, or has been moved from its site of origin by air, water, gravity, or ice and has come to rest on the Earth's surface either above or below sea level" (U.S. National Agricultural Library 2025). This

broader definition includes the many phases of sediment: in transport, in suspension, and in deposition. It includes mineral and organic material form the conventional rock cycles and formed by biological processes. Yet there is no mention of synthetic substances and manmade debris.

Generally, definitions of the term sediment vary depending on the lens of the discipline. In ecology, sediment might be understood in terms of its effect on habitats. In geology, its mineral composition might be central. In the humanities and in the arts, sediment or debris might be symbolic of erosion – physical, cultural, or emotional – and, in a general sense, of layers of human history.[1]

1 See, for instance, the contributions by Ulrike Gerhardt, Felix Hasebrink, Amelia Hine, and Susanne Kriemann in this volume.

This chapter will distinguish between three broad categories of sediment: inorganic, organic, and anthropogenic. It begins with inorganic sediments, which are naturally eroded rock particles transported by rivers and deposited in lakes or oceans. Through these inorganic particles, the sediment's role in the classic rock cycle and their connection to carbon storage and fluxes will be described. From there, it will go on to broaden the perspective to organic sediments, which are formed through biological activity and are closely tied to the carbon cycle. These materials relate directly to questions at the heart of my environmental research in terrestrial aquatic systems, and I will look at two case studies on the biogeochemistry in peat-draining rivers and the sediment accumulation as well as its reversal in peat soils. Finally, I will touch on the question of anthropogenic sediments. The impact of human activities includes not only altered erosion patterns, but notably entirely new materials, such as microplastics or industrial residues. The classification of such materials as "sediment" is increasingly debated (Russell, Pohl, and Fernández 2025), but it reflects the need to account for human influence in both natural and altered depositional systems.

However, before diving into these specific types of sediment, I want to introduce why sediments are important to environmental sciences. For this, I will look at the general concept of sediments as environmental archives, and the methods of sediment analysis, ranging from detail views from small scale field campaigns to broad picture assessments from satellite missions.

Sediments as Archives of Environmental History

Sediments are constantly deposited in layers across the environment, whether in oceans, lakes, rivers, floodplains, or even urban catchments. These layers accumulate over time, from daily deposits to those spanning centuries or even millions of years, preserving a continuous, if complex, archive of Earth's surface conditions. Each sediment layer acts as a snapshot of the moment in which it was formed, capturing environmental signals that can later be interpreted through scientific analysis.

Some of these signals are striking and unambiguous. Volcanic ash layers preserved in lake sediments, for example, can be precisely dated and used as chronological markers not only of eruption events, but also to synchronize environmental records across regions (Singh and Khare 2024). Other clues are more subtle. Grain size and mineral composition might reveal the energy and character of transporting currents, offering evidence of ancient floods, shifting river regimes, or powerful storm events (Zheng et al. 2009). Pollen grains embedded in sediment layers record the composition of past vegetation, enabling reconstructions of long-term climate changes and biome transitions (Park et al. 2021). In dryland environments, layers of wind-blown dust point to the prevalence of glacial aridity (Kohfeld and Harrison 2003). In the deep sea, sediments enriched with microscopic foraminifera shells preserve isotope ratios that serve as proxies for past ocean temperatures and ice sheet dynamics (Lougheed et al. 2018).

Beyond recording natural processes, sediments also document human influence. Lead isotopes in lake sediments, for instance, trace the historical use of leaded gasoline and the rise of industrial pollution (Thevenon et al. 2011). In more recent layers, the appearance of microplastics and synthetic compounds provides a potential signal for the Anthropocene[2] (Simon-Sánchez et al. 2022) – a proposed epoch defined by human impact on the Earth system (Crutzen, Stoermer, and Steffen 2013). In urban riverbeds, alternating layers of coal ash, construction debris, and metal particulates reveal patterns of industrial development, economic change, and environmental degradation (Niu et al. 2023).

What makes sediment records so powerful is their global distribution and capacity to bridge natural and human timescales. Whether in remote peat bogs or bustling harbors, they allow researchers to study both gradual climate transitions and

2 The "Anthropocene" was proposed as a geological epoch characterized by human influences on Earth's geology and ecosystems. Although widely used in environmental and social sciences, the term has not been formally recognized by the International Commission on Stratigraphy (ICS) or its Subcommission on Quaternary Stratigraphy (SQS), which voted in 2024 against its formal adoption.

sudden events – such as tsunamis, deforestation, or mining operations. As such, sediments function not only as archives of Earth's environmental history but also as direct witnesses to environmental disruption and transformation.

Methods of Sediment Analysis

Sediment analysis is conducted across a range of spatial and temporal scales – from microscopic views of clay particles sampled in the field to satellite-based assessments of entire river basins. Three methodological approaches are central to this work:

1. In-situ methods: Techniques such as sediment coring, sediment traps, and direct sampling provide high-resolution data on physical and biogeochemical properties, including composition, density, porosity, and carbon content (Rothwell and Rack 2006). These methods can offer detailed insights into processes like annual layering, organic matter burial, and carbon storage.
2. Remote sensing: Satellite platforms such as Landsat, Sentinel, and MODIS estimate suspended sediment concentrations by detecting water turbidity (Marinho et al. 2021). Radar-based methods assess coastal sediment erosion by analyzing surface roughness (Kryniecka, Magnuszewski, and Radecki-Pawlik 2022). Gravity-sensing missions like GRACE-FO (Gravity Recovery and Climate Experiment – Follow-On) detect mass changes associated with sediment movement (Klemme et al. 2024).
3. Modeling: Physico-chemical models such as SWAT and HYPE simulate sediment transport using input data on land use, topography, precipitation, and soil type (Bonumá et al. 2014). These models are especially useful for scenario analyses like evaluating the impact of dam construction or deforestation, but must be calibrated and validated with field measurements.

Combining these methods enables the understanding of sedimentary processes across different regions and scales – from hilltops to river deltas and from carbon atoms to tectonic movements. A comparison of the earlier examples – the sediment discharge to the Bay of Bengal and the contrasting waters of the Rio Negro and Solimões Rivers – helps clarify the complementary strengths and limitations of satellite versus field-based data.

In the case of the Bay of Bengal, satellite observations from missions such as GRACE-FO have revealed that approximately one billion tons of sediment are transported annually from the Himalayas to the ocean (Mouyen et al. 2018). These large-scale sediment fluxes are detectable through subtle shifts in the Earth's gravity field, offering insight into erosional processes that would otherwise remain invisible at regional to continental scales. However, interpreting these gravity signals is complex. In erosion hotspots like the Himalayan foothills, up to three-quarters of the observed gravity decline can be attributed to sediment loss – an often-overlooked factor in GRACE-based groundwater studies (Klemme et al. 2024). Further downstream in the floodplains, by contrast, sediment-related mass changes account for less than two percent of the observed signal. These findings highlight both the power and the limits of satellite-based methods: while they capture large-scale fluxes, they can obscure sediment-specific contributions unless contextualized with ground-based data.

Further limitations become clear when examining sediment composition and biogeochemical function. Remote sensing can map sediment extent and movement but cannot resolve variables such as mineralogy, organic matter content, or microbial activity. This is where field-based studies become essential. In the Amazon basin, satellite imagery shows the striking visual contrast of the dark, humic-rich Rio Negro waters alongside the opaque, sediment-laden Solimões water before gradually mixing. Yet, this visual boundary tells us little about the underlying chemical gradients, carbon dynamics, or microbial processes that produce it. In my own research on peat-draining rivers in Southeast Asia, similar questions required detailed field investigations. In this case, on-site measurements made it possible to quantify dissolved organic carbon concentrations, oxygen demand, and degradation rates – parameters essential for evaluating the river system as a carbon source or sink (Klemme et al. 2022a). These biogeochemical properties remain invisible to satellite sensors.

Satellite and field methods thus serve complementary roles. Satellite observations offer spatial continuity and large-scale trend detection – especially valuable in remote or data-sparse regions. Field studies, by contrast, reveal the underlying chemistry, biological processes, and feedback that govern sediment behavior and its environmental impact. A comprehensive understanding of sediment systems therefore depends on bridging these two perspectives. Models offer a promising tool for this. By combining spatial reach with process-level detail, models can link patterns observed from space with

mechanisms studied in the field. Most current models, however, are still in early stages of development with regard to effectively resolving the full range of spatial and temporal scales involved. In particular, capturing the complex feedbacks between physical, chemical, and biological processes is a challenge. Thus, while models hold considerable potential to unify remote sensing and in-situ observations, their role is still emerging and should be viewed as complementary rather than conclusive.

Inorganic Sediments

Inorganic sediments – such as sand, silt, or clay – arise from the physical and chemical weathering of rocks. As such, they play a key role in the global rock cycle, which describes the continual transformation between the three major rock types: igneous, sedimentary, and metamorphic rocks.

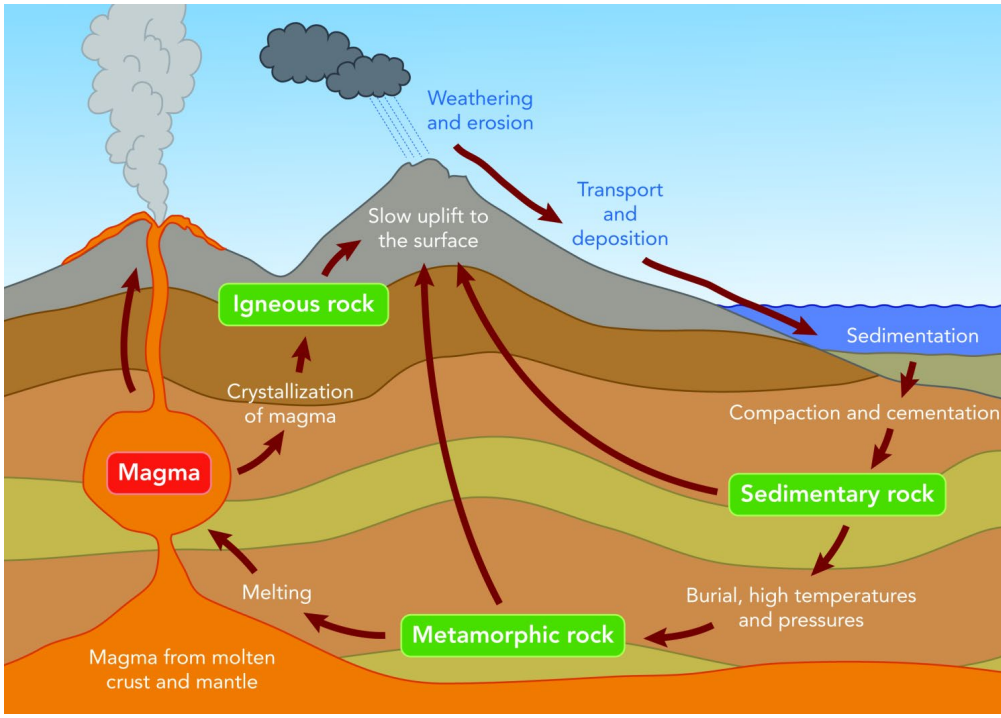
Sedimentary Rock Formation and the Rock Cycle
Despite their seeming permanence, rocks are not static. Over geological time periods, they undergo repeated cycles of transformation. In this cycle, sediments act as agents of renewal. After leaving the lithosphere – where rock processes unfold over millennia – they are exposed at the Earth's surface, where they interact with and are shaped by the atmosphere, biosphere, and hydrosphere, before they eventually re-enter the lithosphere, form new sedimentary rocks, and continue the rock cycle.

Here is a simplified outline of this process:

1. Weathering: Rocks at the surface break down into smaller particles through physical, chemical, or biological processes.
2. Erosion: These particles are picked up and moved as sediments by agents like water, wind, or ice.
3. Deposition: When the velocity of the transporting medium drops – such as at a river delta or lakebed – sediments settle and accumulate.
4. Compaction: Over time, layers build up. The weight of overlying material compresses the lower layers of sediment.
5. Cementation: Dissolved minerals precipitate between particles, cementing them into sedimentary rocks.

Sedimentary rocks can remain stable for hundreds of millions of years. However, if buried deep enough, they are transformed by heat and pressure into metamorphic rocks (fig. 2). If this process continues, the rocks may melt into magma, and upon cooling, crystallize into igneous rock. Unlike the fast-paced

2 Simplified illustration of the global rock cycle. Green boxes indicate the three major rock types. Arrows show transformative processes among them. Adapted from Siyavula Education (2014); https://www.flickr.com/photos/121935927@N06/13581730833.



cycles of the atmosphere or biosphere, the rock cycle unfolds over timescales of millions to billions of years. This slowness enables sediments to serve as long-term archives, providing a record of Earth's history and serving as a deep storage reservoir for materials like carbon.

The Role of Sediments in the Global Carbon Cycle

Carbon is one of the fundamental building blocks of life, but it is also central to the Earth's long-term climate regulation. In climate science, we often measure carbon amounts in petagrams of carbon (PgC), where 1 PgC = 1 billion metric tons of carbon. To visualize this amount, try to imagine 150 billion bags of charcoal. This amount is equal to a 14-meter-thick layer of charcoal – about the height of a four-story building covering, for instance, the entire city of Oldenburg, Germany.

Given the amount of carbon in the Earth system, we could cover more than 45 thousand of such cities, or about half of the area of Europe in such a 14-meter-thick layer.

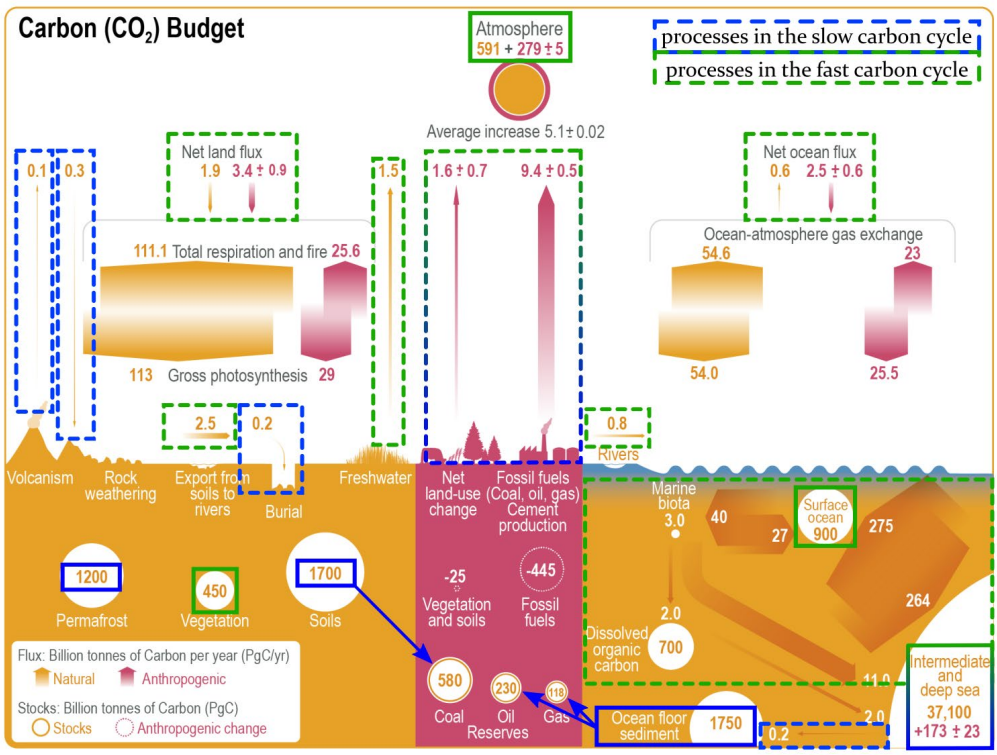
The global carbon cycle describes the movement of carbon between four main environmental reservoirs:

1. the atmosphere
2. the biosphere (plants, animals, and soils)
3. the hydrosphere (oceans and freshwater systems)
4. the lithosphere (Earth's crust, including sediments and sedimentary rocks)

One common way of separating the processes of such carbon movement in the global carbon cycle is by distinguishing between natural and anthropogenic components. This is often visualized in carbon budget diagrams, such as those provided by the Intergovernmental Panel on Climate Change (IPCC, fig. 3). Natural fluxes include processes like photosynthesis, respiration, volcanic activity, ocean-atmosphere gas exchange, and the burial of organic material in sediments (Canadell et al. 2023). Anthropogenic fluxes refer to human-made emissions of carbon dioxide and methane, for example from the burning of fossil fuels, land-use changes like deforestation, and industrial processes such as cement production (Canadell et al. 2023). These fluxes disrupt the natural carbon balance and enhance the impact of the greenhouse effect, causing global warming.

Another way of separating the global carbon cycle is by the speed of its processes, with the fast carbon cycle including processes that move carbon between the atmosphere, biosphere, and oceans over relatively short periods – from days to years, or a few centuries. In contrast, the slow carbon cycle operates on much longer timescales – thousands to millions of years – and involves the movement of carbon between the atmosphere and the lithosphere. Our current climate is mainly controlled by the processes in the fast carbon cycle, including photosynthesis, plant and microbial respiration, ocean-atmosphere gas exchange, and the decomposition of organic matter (fig. 3). The slow carbon cycle includes the processes discussed earlier in the global rock cycle: the weathering of silicate rocks, the transport of dissolved carbon to the oceans, the burial of organic material in sediments, and the eventual formation of sedimentary rocks. This process has stored vast amounts of carbon in the form of coal, oil, natural gas, and carbonate rocks (Berner 1998), but its workings are slow and only significant over larger geological timescales.

3 Visualization of the global carbon budget. Orange circles and arrows represent the natural carbon stocks and exchange fluxes, respectively. These are based on the pre-industrial global carbon cycle from 1750. Pink circles and arrows represent changes in carbon stocks and in exchange fluxes that have been introduced due to human influences since 1750. Green and blue boxes indicate fast and slow components of the global carbon cycle, respectively. Anthropogenic emissions constitute a conversion of carbon from the slow to the fast cycle. Adapted from Figure 5.12 in Canadell et al. (2023)



By extracting and burning these materials within just a few centuries, human activity transfers large amounts of carbon from the slow to the fast carbon cycle. This effectively short-circuits the slow carbon cycle. The result is a massive, one-way release of carbon into the atmosphere, far outpacing the natural rates of reabsorption and burial. Due to the vast difference in tempo between the natural carbon burial and drawdown in sediments and the carbon release by anthropogenic emissions, the Earth's natural systems cannot keep pace with the rate of change, leading to rising atmospheric carbon dioxide concentrations and accelerated climate change.

Organic Sediments

Organic sediments are formed from plant material, algae, zooplankton, or animal waste. These sediments play a crucial role in the fast carbon cycle, particularly within rivers and floodplains. Depending on the biogeochemical conditions, organic sediments can precipitate to the riverbed, discharge into the ocean, or be decomposed and potentially emitted into the atmosphere in the form of carbon dioxide or methane. As such, riverine sediments mediate atmospheric carbon flows in the fast carbon cycle and carbon burial in the slow carbon cycle (Canadell et al. 2023). In doing so, they are essential to how we understand the carbon-climate feedbacks of the twenty-first century.

Vast amounts of organic materials are stored in tropical peat soils. While peat layers themselves might not be considered sediment in the classic sense – since they form in-situ from the accumulation of plant material under anoxic, waterlogged conditions rather than from transported particles – they can still be understood as locally-formed organic sediments in a broader sense. From radioisotope compositions in peat layers, their age – and therewith the carbon accumulation rate – can be studied. Natural peatlands represent a greenhouse gas sink due to their waterlogged conditions that limit oxygen availability and thus decomposition (Page, Rieley, and Banks 2011). Dried peat soils on the other hand are a greenhouse gas source due to oxygen exposure.

For example, in Indonesia, several PgC are released annually through droughts and peat burning. These processes highlight the vulnerability of organic sediments and their central role in the climate system (Gaveau et al. 2014). Such conditions can also be viewed in the associated peat accumulation rates. In studies of peat cores from the Congo peat regions, scientists found that peat accumulation started about 17,500 years ago, with a declining trend starting around 5,000 years ago, reflecting a gradual drying from the Mid to Late Holocene (Garcin et al. 2022). By 2,000 years ago, there was no peat accumulation for an extended period, indicating a “ghost interval” of which no information is left in the environmental system due to peat erosion (ibid.).

Carbon eroded from peat soils and leached into rivers yield large concentrations of organic carbon sediments in those rivers (Rixen et al. 2016) and consequentially high carbon dioxide emissions after decomposition (Wit et al. 2015).

However, the unique biogeochemistry in peat-draining rivers impacts microbial decomposition, with emissions of carbon dioxide being limited by up to 85% due to the acidic water conditions. The addition of inorganic carbon sediments from weathering or liming practices in river catchments can alter the river chemistry and disrupt this pH limitation, which could more than quadruple emissions of carbon dioxide from these rivers (Klemme et al. 2022a). A similar outcome would result from the process of enhanced weathering – a carbon dioxide removal strategy based on the application of powdered rock particles (Klemme et al. 2022b).

These processes underscore how tightly coupled the biogeochemical behavior of organic sediments is with the broader chemical environment of the river system. While organic sediments originate from biological material, their fate and impact are often shaped by interactions with inorganic constituents. This interplay becomes especially important in the context of anthropogenic interventions in catchments – such as liming or enhanced weathering – which modify sediment composition and river chemistry. Such practices introduce fine-grained, mineral particles that function as anthropogenically introduced inorganic sediments that impact organic processes, blurring traditional boundaries and providing a conceptual link between inorganic, organic, and anthropogenic sediment classes.

Anthropogenic Sediments

Anthropogenic sediments are an emerging concept rooted in the recognition that human-made materials are becoming part of the geologic record. These so-called technofossils – including plastics, aluminum, synthetic fibers, and microelectronic components – have been documented in sediment layers from remote mountain lakes to deep-sea trenches (Zalasiewicz et al. 2014). Their presence challenges conventional definitions of what constitutes sediment. Should plastic particles that are suspended in rivers or buried in delta mud be considered as part of the sedimentary archive – or as pollution? What does it mean when erosion is no longer only a natural process, but one accelerated by mining, agriculture, and urbanization?

Microplastics, for instance, have been shown to mix with natural sediments, altering physical properties such as porosity, compaction, and water retention (Yang, Zhang, and Guo 2023). Discarded electronics, composed of metals, glass, and polymers, are embedded in urban riverbeds and coastal zones (Tao et al. 2022), at times forming composite materials

with natural sediments – hybrid "technosediments" that defy traditional classification. While these materials raise ecological concerns, particularly regarding leaching and ingestion by organisms, they also serve as markers of anthropogenic activity.

In a future where natural sedimentation processes are inseparable from human impact, new categories will be needed to describe sediment layers that are globally and irreversibly infused with anthropogenic material. Sediments thus become more than physical deposits – they reflect cultural and industrial processes. Cities emerge as sediment-producing landscapes, oceans accumulate waste, and smartphones may well become the fossils of the future (Zalasiewicz 2020). In this way, human activity leaves traces on Earth that are not only biological and climatic, but also sedimentological.

Conclusion

Sediments function as powerful environmental archives. Layer by layer, they accumulate traces of climate, ecosystems, and human activity, capturing change across space and time. From sediment cores collected during field campaigns to satellite-based observations of sediment plumes in large river deltas, sediments allow us to connect local biogeochemical processes to global patterns. These different scales of analysis – fine-grained and basin-wide – provide complementary perspectives that help us reconstruct the past and understand the dynamics of the present.

Inorganic sediments, derived from the weathering of rocks and transported by rivers, wind, or ice, hold deep-time insights into Earth's geological history. Their deposition in riverbeds, floodplains, and ocean basins preserves information about hydrological regimes, tectonic shifts, and long-term Earth surface processes. These sediments are also central to the slow carbon cycle, acting as vehicles for the transport of weathered carbon from land to ocean, and as precursors to the burial of inorganic carbon in sedimentary rocks such as carbonates. Through these processes, they contribute to the regulation of atmospheric carbon dioxide over millions of years, buffering climate change on geological timescales.

Organic sediments, formed from biological matter, play a key role in the fast carbon cycle. In wetlands and rivers, they act as both carbon sinks and sources, depending on environmental conditions. Their dynamic nature reflects the delicate

balance between storage and decomposition, accumulation and erosion. As shown in peatlands and tropical river systems, small changes in hydrology or chemistry can have major consequences for greenhouse gas emissions. These sediments offer insight into the contemporary biogeochemical feedbacks that are central to today's climate system.

Anthropogenic sediments reflect a new era in which human influence is embedded in Earth's sedimentary layers. Plastics, microfibers, industrial residues, and electronic waste are found from the deep sea to alpine lakes. These materials blur the line between sediment and pollution and challenge our definitions of what sediments are by introducing synthetic substances that were never before present in the Earth system. As cities produce new sediment types and oceans accumulate human-made waste, sediments no longer merely reflect natural processes – they also document human activity and the material legacy of industrial modernity.

As researchers of the Earth system, we understand sediments not just as silent witnesses to planetary change – but as participants in shaping our future. Whether it's the burial of ancient organic carbon or the deposition of microplastics, sediments reflect both the deep timescales of geology and the accelerated tempos of modern society. In the layers we leave behind, future beings – human or otherwise – may encounter natural pollen and organic fossils alongside plastic fragments and chemical dyes. Encoded in those deposits are the traces of today's decisions, preserved across landscapes and epochs. So, while we release anthropogenic debris into the environment, we should keep the question in mind:

What will sediments tell those who come after us about the choices we are making today?

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Hadal Debris: Narrativizing Submersible Waste on the Deepest Seafloor

Amelia Hine

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

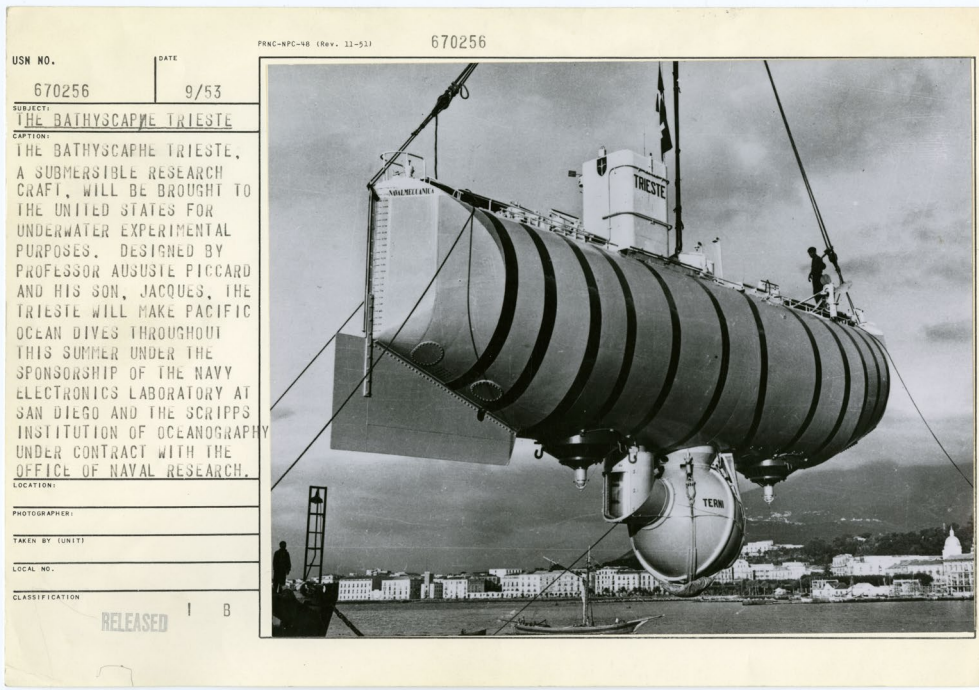
I focus enquiry for this chapter on the four crewed submersibles, and in particular the two privately owned submersibles, that have been to Challenger Deep in the Mariana Trench, drawing from the available documentation from their journeys (documentaries, published interviews, lectures, expedition websites, 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).

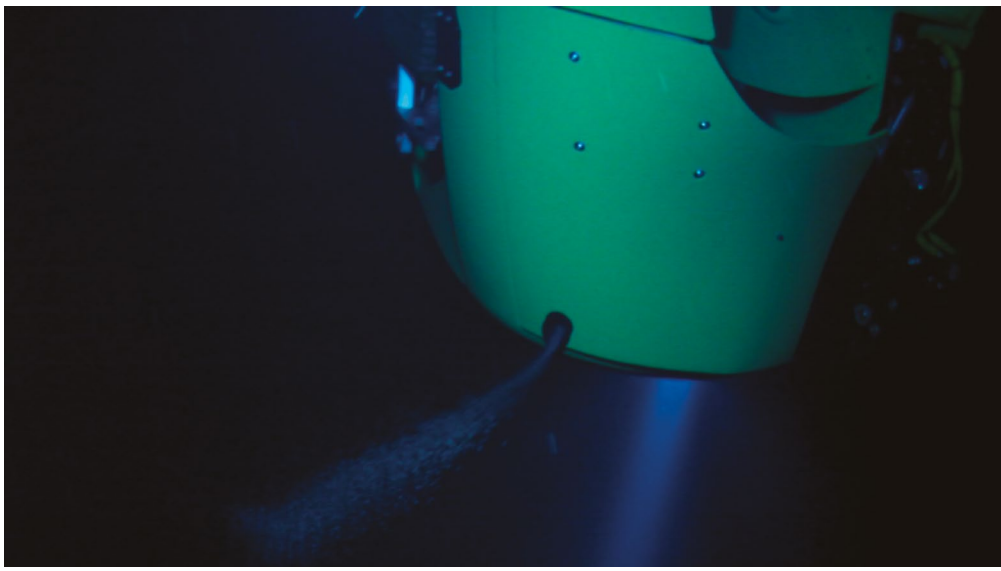
Indeed, the narrativizing of these forms of waste matter is a *matter of power*. To view the submersible ballast and shot piles as "intentional littering" (Vescovo et al. 2021, 3) would mean acknowledging a role in transforming "such an iconic and prestigious place" (ibid.) into a site degraded by visitation. 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.

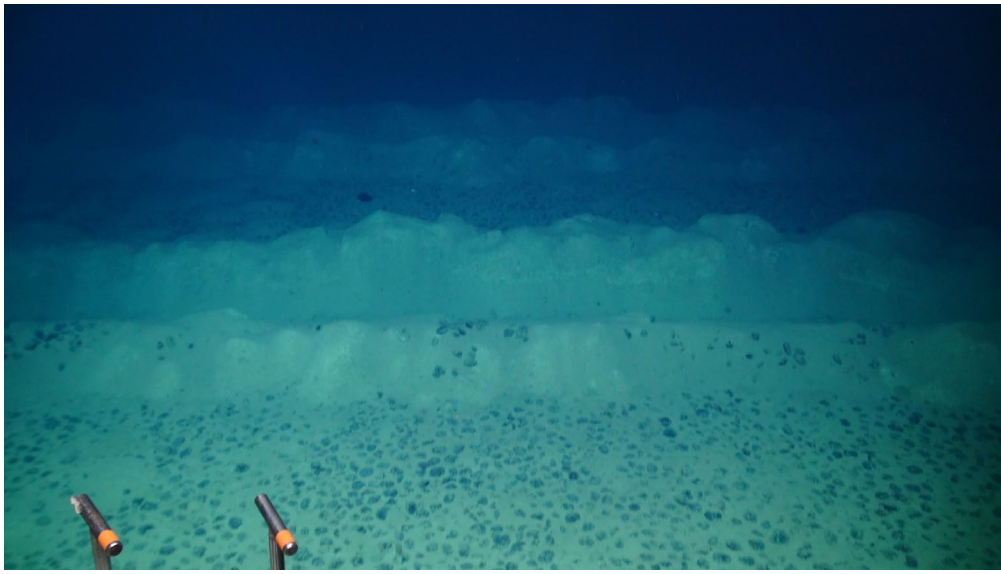
Stirring up a cloud of sediments, therefore, may not be as straightforward as it appears, with complex temporalities and dynamic forces intersecting with the act. It is not insignificant then, when these sediments enter new relations through deep exploration. This is not to say such clouds would have 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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Drift

Susanne Kriemann and Lisa Rosendahl

drift
a surreptitious sideways movement
barely perceptible
until a change in the horizon a landscape newly
arrived from nowhere

Sand displaced
into concrete walls and floors of buildings, into the glass of screens and windows, into asphalt and roads – what dreams are made of (or so the tale was told).

The evolution of image infrastructures – from photographic glass plates in the nineteenth century, to photographic film in the twentieth century, to the current dominance of digital images and screen-based culture and the possibility to encode great depositories of data in 5D glass – forms a circle, starting and closing with sand; as dream, as image, as data, as dust.

Each dune contains the seas and mountains of the past, ground down into more manageable bits of information. The desert is a vast data storage, a library of encoded images, an archive of fossilized visions.

When the sand first arrived it felt like amnesia, blowing through our dwellings like the great forgetting. Each grain obscured the sun, delayed the morning. We slept longer, woke up disoriented, fell out of step with time.

Slowly, it built up inside our homes. Each morning the sand had to be swept from the folds of the tent like sleep rubbed from our eyes upon wakening. It found its way into our clothes and bedding, settled like slopes of sugar at the bottom of our cups.

Before long, we knew our lives were being swallowed.

Every day the desert crept closer, hiding the hills, the well, the goats.
Dissolving their boundaries whenever it pleased.

The loss of vision was greater than night. The sand took our memories, erased everything we had known to be true. But the dreams it brought were vivid, pried loose from graves and temples, from prehistoric oceans now alive once more in the depths of our minds.

Only an archaeologist, a thousand years later, could see that we were still dreaming.

By that time, the world had been ground into pixels, mined, extracted, consumed, thrown away.

Our lives documented only in leftovers: rubber tires, wires, textiles

A hilly topography
seen from far, far away

several thousand burial structures
circular and square
made of sandstone blocks
entwined by water's transient being, named "wadi."

There
a pullover was left to gradually sink
over the course of two decennia
into its chosen bed of sand.
Disappearing to where no light could register its fade
until only a tiny bit of its knitted condition remained visible.
Polyester crunch
at the surface of an ancient burial site
Rujum Sa'sa.

A drone promised a view from above
a phone asked for transmission from below
in this noon of amazing discoveries
glistening light enveloping us, who came from rapidly growing cities
hoping to learn about an ancient landscape shaped by tombs over four thousand years old.
There was nothing to be seen on screen
hidden in plain sight
light versus light
inner heat and radiation.

Sand as spheres
powdery, shapeshifting
never reliable
may contain
CI 16035 (Red 40 Lake)
CI 19140 (Yellow 5 Lake)
iron oxides
VP/Hexadecene Copolymer.
A smile, a laugh, a blush.

In the middle of a place of intersecting timelines
fugitive cultural layers
folding into each other.
The value of each incomprehensible to the other
now intertwined
in eternity

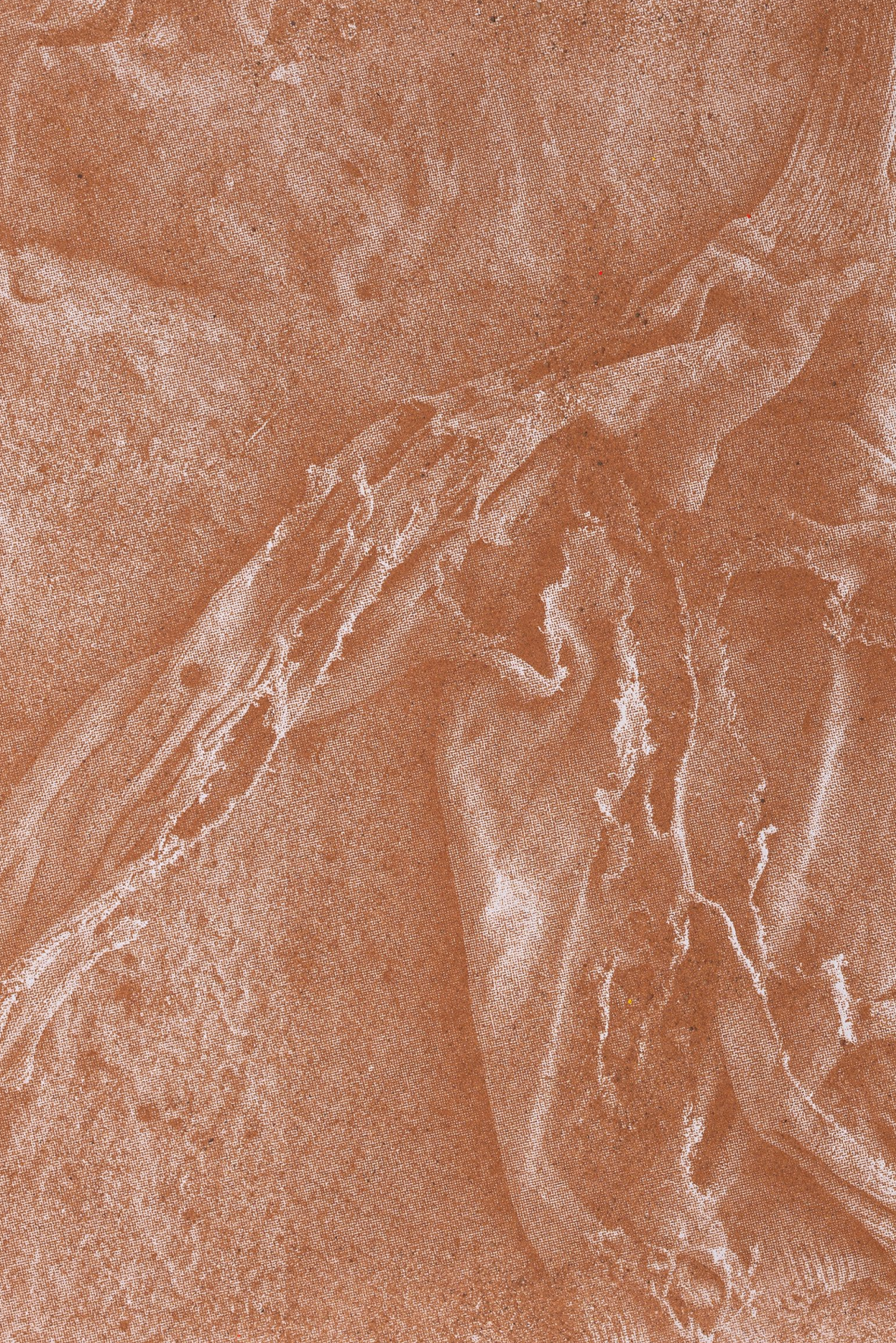
Six hundred years to come of plastic bottles
an accumulating necropolis facing the rising sun

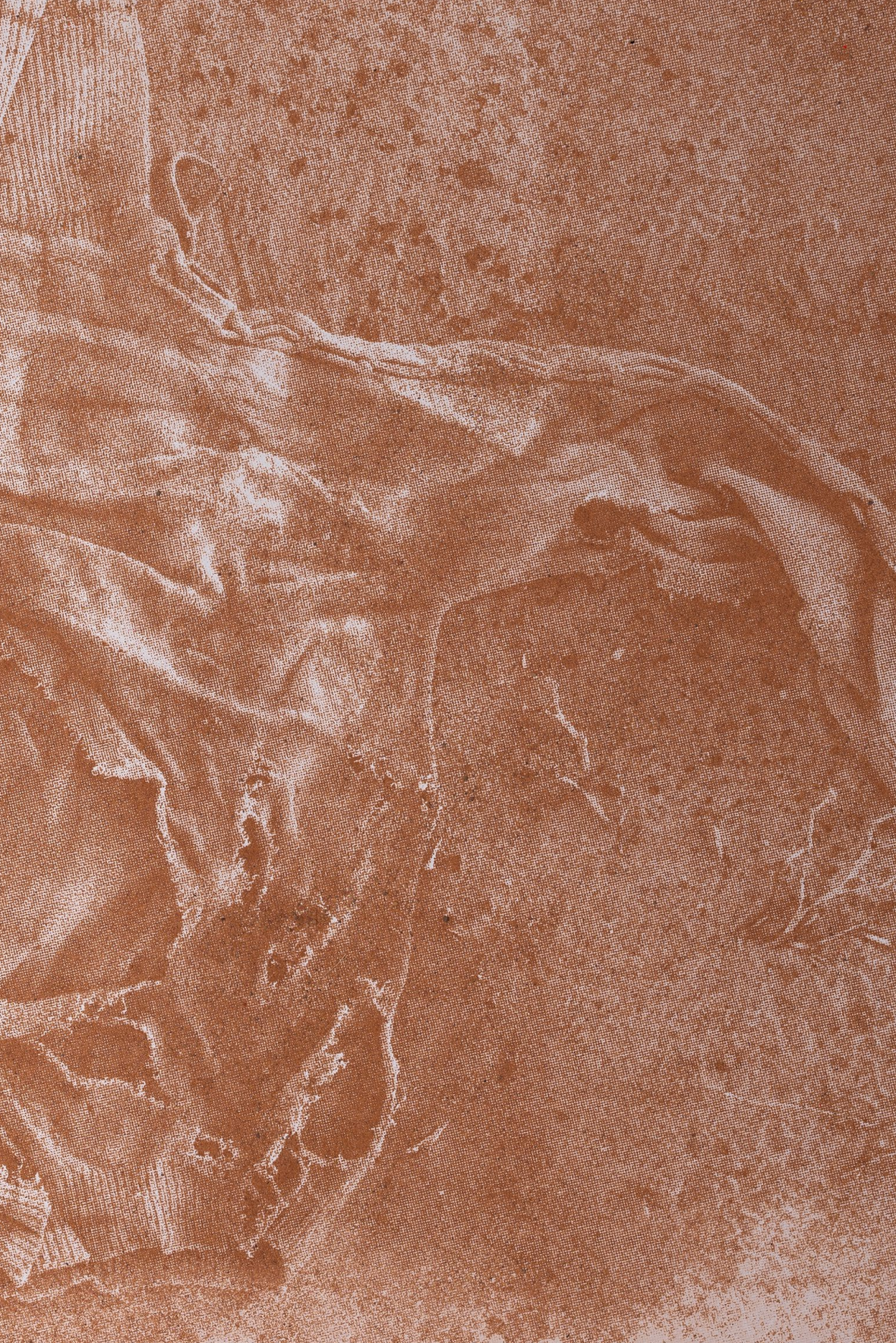
even after
the last person
has stopped looking.

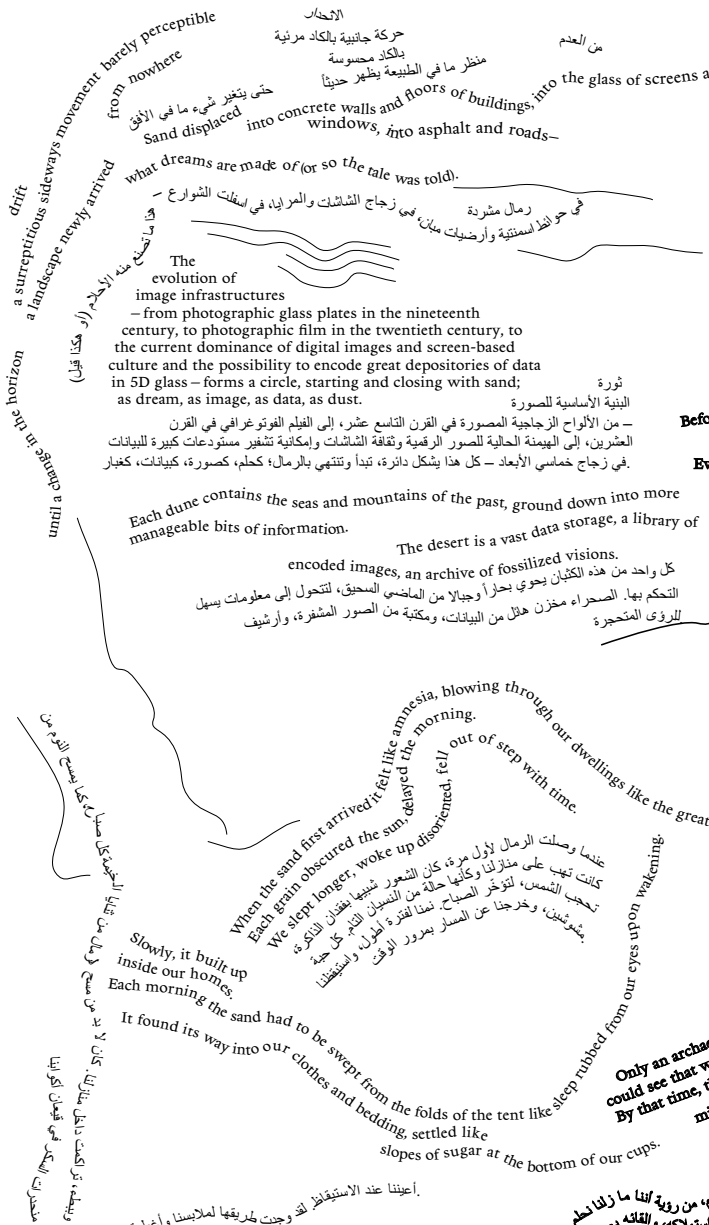
And the sand continues to escape from the images it has made
continuing to drift building other landscapes
elsewhere.

Sand as Dream, as Image, as Data, as Dust

Susanne Kriemann






الانجذاب
حركة جانبية بالكاد مرئية
بالكاد محسوسة
منظر ما في الطبيعة يظهر حديثاً
من العدم
drift
a surreptitious sideways movement barely perceptible
a landscape newly arrived
from nowhere
حتى يتغير شيء ما في الأفق
Sand displaced
into concrete walls and floors of buildings, into the glass of screens and
windows, into asphalt and roads–
what dreams are made of (or so the tale was told).
زجاج الشاشات والمرايا، في اسفلت الشوارع –
رمال مشردة
في حوائط اسمنتية وأرضيات ملاّنة، في
ما تصنع منه الأحلام (أو هكذا قيل)
The
evolution of
image infrastructures
– from photographic glass plates in the nineteenth
century, to photographic film in the twentieth century, to
the current dominance of digital images and screen-based
culture and the possibility to encode great depositories of data
in 5D glass – forms a circle, starting and closing with sand;
as dream, as image, as data, as dust.
ثورة
البنية الأساسية للصورة
– من الألواح الزجاجية المصورة في القرن التاسع عشر، إلى الفيلم الفوتوغرافي في القرن
العشرين، إلى الهيمنة الحالية للصور الرقمية وثقافة الشاشات وإمكانية تشفير مستودعات كبيرة للبيانات
في زجاج خماسي الأبعاد – كل هذا يشكل دائرة، تبدأ وتنتهي بالرمال؛ كحلم، كصورة، كبيانات، كغبار.
until a change in the horizon
Each dune contains the seas and mountains of the past, ground down into more
manageable bits of information.
The desert is a vast data storage, a library of
encoded images, an archive of fossilized visions.
كل واحد من هذه الكثبان يحوي بحراً وجبالا من الماضي السحيق، لتتحول إلى معلومات يسهل
التحكم بها. الصحراء مخزن هائل من البيانات، ومكتبة من الصور المشفرة، وأرشيف
للرؤى المتحجرة
Before long, we knew our lives were being swallowed.
حتى عرفنا أن حياتنا ابتلعت
Every day the desert crept closer, hiding the hills, the well,
Dissolving their boundaries whenever it plea
ب أكثر، لتخفي التلال، والآبار، والمناظر
The
loss of
vision was greater than night. The
sand took our memories, erased everything
we had known to be true. But the dreams
it brought were vivid, pried loose from
graves and temples, from prehistoric
oceans now alive once more in the
depths of our minds.
فقدان
رؤية كان أعظم من ظلام الليل.
ت الرمال ذاكرتنا، محت كل ما عرفناه.
لأحلام التي جلبتها كانت حقيقية، انتُزعت من القبور
د، من محيطات ما قبل التاريخ، التي دبت فيها الحياة مرة
أخرى في أعماق عقولنا.
When the sand first arrived it felt like amnesia, blowing through our dwellings like the great forgetting.
Each grain obscured the sun, delayed the morning.
We slept longer, woke up disoriented, fell out of step with time.
عندما وصلت الرمال لأول مرة، كان الشعور بفقدان الذاكرة
كانت تهب على منازلنا وكأنها حالة من النسيان التام. كل حبة
تحجب الشمس، لتؤخّر الصباح. نمنا لفترة أطول، واستيقظنا
بشوشين، وخرجنا عن المسار بمرور الوقت
Slowly, it built up
inside our homes.
Each morning the sand had to be swept from the folds of the tent like sleep rubbed from our eyes upon wakening.
It found its way into our clothes and bedding, settled like
slopes of sugar at the bottom of our cups.
Only an archaeologist, a thousand years later,
could see that we were still dreaming.
By that time, the world had been ground into pixels,
mined, extracted, consumed, thrown away.
Our lives documented only in leftovers: rubber tires, wires, tec
أعيننا عند الاستيقاظ.
لقد وجدت طريقها لملابسنا وأغطية فراشنا، واستقرت مثل منحدرات السكر في قيعان أكوابنا.
ذلك، تراكمت داخل بيوتنا. كان لا بد من مسح الرمال عن الخيمة كل صباح، كما يمسح النوم من
ذلك كان العالم قد تم مسحه إلى وحدات بكسل، وتم تعدينه، واستخراجه، واستهلاكه، والقائه بعيدا.
ولم يتمكن إلا عالم آثار، بعد مرور ألف عام، من رؤية أننا ما زلنا نحلم.
ت السطانية، والأسلاك، والمنسوجات

ولم يمض وقت طويل،
... the goats.
...sed.
كل يوم كانت الصحراء تقترب
كلما شاءت
وتمحي حدودهم.

طوبوغرافيا جبلية
تُرى من بعيد، بعيد جدا

A hilly topography
seen from far, far away

several thousand burial structures
circular and square
made of sandstone blocks
entwined by water's transient being, named "wadi."

عدة آلاف من هياكل الدفن
دائرية ومربعة
مصنوعة من كتل الرمل الحجري
مترابطة مع كينونة الماء، التي تسمى „الوادي"

There
a pullover was left
to gradually sink
over the course
of two decennia
into its chosen
bed of sand.
Disappearing
to where no
light could
register
its fade
until only a
tiny bit of its
knitted condition
remained visible.
Polyester crunch
at the surface of an
ancient burial site
Rujum Sa'sa.

هناك
تُركت الكنزة لتغرق
على مدى عقدين من الزمان
في سريرها التي اختارته من الرمال.
حيث لا يمكن للضوء أن يبرز تلاشيها لتختفي
حتى بقي جزء صغير فقط من خيوطها المحاكة مرئياً.
أزمة البوليستر
على سطح موقع دفن أثري
هو رجوم صعصع.

A drone promised a view from above
a phone asked for transmission from below
of amazing discoveries
in this noon light enveloping us, who came from rapidly growing cities
glistening to learn about an ancient landscape shaped by tombs over four thousand years old.
hoping to be seen on screen
There was nothing
hidden in plain sight
light versus light
inner heat and radiation.

وعدتنا طائرة الدرون بنظرة من الأعلى
وهاتف طلب الإرسال من الأسفل
على أمل التعرف على المناظر الأثرية التي شكلتها المقابر التي يزيد عمرها عن أربعة آلاف عام
وفي هذه الظهيرة الجلية بالاكتشافات العظيمة
غلفنا الضوءُ البرّاق، القادم من المدن النامية سريعا
لم يكن هناك ما يمكن مشاهدته على الشاشة
مخبأ على مرمى البصر
الضوء مقابل الضوء
الحرارة الداخلية والإشعاع

In the middle of a place of intersecting timelines
of intercultural layers, each incomprehensible to the other
fugitive cultures folding into each other.
The value of each now intertwined
in eternity

في منتصف مكان الطبقات المتقاطعة
الخطوط الزمنية
قيمة كل منها
مترابطة مع بعضها البعض غير مفهومة للآخر
في الخلود

Six hundred years to come of plastic bottles
an accumulating necropolis
facing the rising sun

ستمائة عام قادمة من الزجاجات البلاستيكية
مقبرة متكدسة
في مواجهة شروق الشمس

even after
the last person
has stopped looking.

حتى بعد
أن يتوقف آخر شخص
عن النظر

And the sand continues to escape from the images it has made
continuing to drift
elsewhere.
Building other landscapes

وتستمر الرمال في الهروب من الصور التي كونتها
في أماكن أخرى
لتبني مناظر
تستمر في الانجراف

Sand as spheres
powdery, shapeshifting
never reliable
(Red 40 Lake)
CI 16035 (Yellow 5 Lake)
CI 19140 Iron oxides
may contain
VP/Hexadecene Copolymer.
A smile, a laugh, a blush.

أكاسيد الحديد
١٦٠٣٥ (أحمر ٤٠) ١٩١٤٠ (أصفر ٥)
مادة الفينيل بيروليدون / هيكساديسين كوبوليمر.
ابتسامة، ثم ضحكة، عن استحياء.

Atmospheric (De-)Sedimentation in the Colonial Extractive Zone of the !Namib Desert

Henriette Gunkel

This contribution explores infrastructural remains of diamond extraction in the context of German colonialism and the genocide against the OvaHerero and Nama in Namibia's !Namib desert. While the desert is widely understood as to cover things over, to bury them, and to keep them buried, in this article I argue that the desert also exposes things and remains and can thus disrupt and detour processes of sedimentation. What are the conditions for the colonial and genocidal history to resurface? Expanding on the notion of remains as currently discussed in the context of restitution and reparation, I explore the question of what remains by reflecting on a fieldwork trip into the extractive zone between Lüderitz and Walvis Bay, commonly known as the Northern Fields of diamond extraction.

Keywords: Desert, Genocidal Remains, Saltation, Gathering

1 Unmarked burial ground in Swakopmund, Namibia with the !Namib desert in the background (Source: Henriette Gunkel 2021)

I want to begin this contribution with an image. This image shows the site of a large unmarked burial ground at the liminal space between the coastal town of Swakopmund and the Swakop riverbed with the vast !Namib desert[1] in the background (fig. 1). The town's name is derived from the Nama and Damara word "Tsoakhaub" which translates to "the movement of sediment and debris."[2] The mounds that are visible in the foreground reference the remains of thousands of Herero prisoners of war and genocide victims who died in one of the two concentration camps in Swakopmund and were buried there starting in 1904.[3]

Until 2016, that is, fairly recently, the gravesite was an open site, very different from the lush, walled-in, so-called "European" cemetery next to it. Some mounds are marked with stones and weather-beaten wooden crosses. The majority, however, are unmarked. The site has been demarcated in recent years after plans to build private houses on the site

1 !Namib is the indigenous name for the area in which the desert is situated. It is the Khoekhoegowab name for the landscape and means "vastness," "openness."

2 See, for example, Forensic Architecture's investigation *German Colonial Genocide in Namibia: Swakopmund* from 2024, available online: https://www.forensicarchitecture.org/investigation/swakopmund (accessed June 22, 2025).

were stopped. Until then, mainly white people would walk or drive their bikes straight across the gravesites to reach the dry riverbed and dunes. This constant movement brought splinters of human remains to the surface, exposing what had been buried.

3 The exact locations of the two concentration camps in Swakopmund are, to this day, not entirely known, and as such no monuments or markers refer to that history. There are indications, though. In 2024, Forensic Architecture's investigation into Swakopmund provided evidence of one camp's position.

A monument erected on the burial site by the local OvaHerero and Nama communities in 2007 reminds visitors of those who died during the genocide of their people under German colonial rule in 1904–1908; a genocide for which Germany has not paid reparations to this day, and which many in the German-Namibian community fail to acknowledge. In the last few years, I have spent quite a bit of time in Namibia, due to (newish) family ties – namely in this coastal town of Swakopmund, which appears to me as a time capsule from the white settler colonial period.

One way of dealing with the frustration about the lack of a radical break with the past, the genocidal afterlife, and the colonial continuities in the country and in this place in particular, is to work through it academically. In this contribution, I want to reflect on research that was initiated by this strong sense of walking on bones when moving through the Namibian landscape, as mass graves are still being found today.[4] As such, the Namibian landscape can be understood as a space of death, as what Jill H. Casid, in her discussion of the Anthropocene as a landscape of genocide, calls a "necrocene." For Casid, this is a move from death "as the opposite of life, to death as felt, material presence and active process by giving us death as a scene in which we are vulnerably situated" (2018, 239). Similarly, in her article "What the Sands Remember," Vanessa Agard-Jones asks us to "consider sand as a repository both of feeling and of experience, of affect and of history. Here sand links us unswervingly to place, to a particular landscape that bears traces of both connection and loss" (2012, 325).

4 Sometimes unknowingly, as for example, during a visit to the Independence Memorial Museum in Windhoek, which is built on the site of the Orumborombondi concentration camp. Even after Independence in 1990, no marker refers to this history.

I want to take up this affective and material presence of genocidal and colonial violence in relation to the Namibian landscape, particularly the !Namib desert, and follow the question of what sediments lie in the desert, and what remains. How do remains form part of the processes of geological sedimentation and as such enter into geological time or, rather, "residence time," a term developed by Christina Sharpe (2006) in her work on the ocean in the afterlife of slavery? Sharpe proposed the term to address deep geological time in the afterlife of slavery by re-conceptualizing the oceanic remains of those who died during the Middle Passage, arguing that

due to how "nutrients cycle through the ocean … the atoms of those people who were thrown overboard are out there in the ocean even today" (ibid., 40).[5] While the desert is widely understood as covering things over, burying them, and keeping them buried, in this contribution, I want to argue that the desert also preserves and exposes, and by doing so works – at least to a certain extent – against processes of sedimentation.

5 "Residence time" is also a scientific term commonly used to define the time spent by a fluid parcel in a defined volume, such as a human body in a lake. I was interested in exploring the residence time of the sand, in getting a sense of the unacknowledged traces that remain in the particular landscape of the !Namib desert.

What are the conditions for the colonial and genocidal history to resurface, resisting sedimentation? In the current discussion around reparations, remains are primarily discussed in relation to human remains brought to Germany for so-called scientific research that ended up in museum archives and private collections. I want to expand on this notion of remains by shifting to the materiality of the Namibian landscape and the geopolitical interface between colonial and genocidal violence, dispossession, land theft, ecology, and accountability as a form of representation. Specifically, I will turn to former sites of diamond extraction – spectral landscapes and infrastructures – situated in the !Namib desert and explore the relationship between "necrocene" and "extractive zone," a term set out by Macarena Gómez-Barris (2017). I will do so by focusing on a field trip in December 2021 to a former extractive zone between Lüderitz and Walvis Bay, commonly known as the Northern Fields of diamond extraction or Sperrgebiet II. Here I am particularly interested in the stretch between Meob Bay and Conception Bay, where in 1909 diamonds were discovered after the closing-off of the Sperrgebiet south of Lüderitz in 1908.

Deposition, Saltation, and Workings of the Sediment

To get access to the Northern Fields one needs a special permit, which is issued by the Namibian government to people experienced in navigating this area in their 4x4 vehicles. In my case that meant I needed to hire a tour guide to take me into the nature reserve.[6] We had to leave Walvis Bay early in the morning at low tide as it opened up a small corridor between the barchan dunes and the ocean the first kilometers after entering the nature reserve. From there it was about navigating the car across the dune belt before we hit the coastal saltpans and gravel fields where driving became easier.

6 As such, the field trip was a costly endeavor that was only possibly due to university funding. Access to the area is thus privileged.

The !Namib desert is said to be the oldest desert in the world. It's a littoral desert, its dunes run in most parts into the ocean. The cold, upwelling Benguela Current that flows

north from Antarctica along the African west coast to Angola is the reason for the aridity of the !Namib sand sea, as little evaporation takes place with rainfall rarely exceeding 10 mm annually. What sustains life in this desert is a thick fog coming in from the sea due to the colder sea air colliding with the sun-warmed overland air, reaching up to 100 km inland from the coast (Harris, Jones, and Schnitzer 2012, 125). The upwelling Benguela Current is also responsible for the expansion of the desert into the sea; sand is being deposited along the coast, turning it into "one of the most rapidly changing shorelines in the world," as Harris, Jones, and Schnitzer argue (ibid., 129). Shipwrecks, like the *Eduard Bohlen II*, which became stranded on a sandbank in 1909 while aiming to offload cargo for the mining sites, can be now found 600 meters inland with no ocean in sight, even though it is still audible. Not far from the shipwreck lies a whale carcass. I revisited the site in May 2023 and at that point the *Eduard Bohlen II* was only around 400m away from the shore, which means the ocean has reclaimed some parts of the coast.

The ocean's north-flowing, longshore currents also bring minerals with the sand into the desert. Subtle traces of mineral geology are visible on the desert surface such as iron and garnet. Diamonds reached the Atlantic Ocean from South Africa via the Orange River and were then deposited along the southern Atlantic coastline by the currents, a high-energy regime which, as Gabi Schneider (2008, 8) points out, "constantly reworks the sediments supplied by the Orange River." Diamonds initially deposited by the sea are further "upgraded" by southerly winds – this process of moving lighter material along the desert floor is called saltation. Or, as Schneider (ibid.) puts it: "In a high-energy aeolian environment, a very effective sorting of lighter and heavier material occurs; the heavier particles move slowly, while the lighter material is blown away... The sediments too coarse to be transported by this mechanism are winnowed and form wind-stable deflation surfaces."[7] Medium-sized soil particles that are light enough to be lifted off the sediment surface, but are too large to become suspended, move through a series of low bounces over the surface. The impact of a sand particle on the soil surfaces transfers energy onto the surrounding sand particles, which in turn bounce up and follow a parabolic arc. Through saltation, sand particles attack and grind down solid material and structures left behind (like the structure of corrugated iron sheets or the shipwrecks) in the deserted mining sites.

The fact that the diamonds were deposited in the !Namib desert from the ocean meant that in the extractive zone

7 And further: "When saltating particles continuously hit larger and heavier grains they can eventually be moved forward and therefore 'creep' across the desert floor. Heavy mineral particles transported by creep preferentially concentrate in the wind shadow of rocky obstacles" (Schneider 2008, 8).

between Conception Bay and Meob Bay the sediment was mined until the workers reached the old granite rock underneath the layer of sand.[8] Once the miners reached the grey granite, the search shifted sideways and eventually to the next "claim," demarcated by a pile of rocks. This distinction between the different geological strata – the diamond-infused sediment as distinct from the stratified composition of the Earth's crust – emerges as a politics of strata, as Nigel Clark (2017, 216) refers to it, when he argues that political and economic "territory emerges dripping from the watery dynamics of sedimentary geology." The mining of the sand was done by early practices of surface mining – large sieves were used to sift diamonds from the desert's sand. The visible indications of the history of mining are (alongside its infrastructure – water pipes, telegram wires, train tracks, boats, wagons, mining equipment, etc.), the "claims" as well as the sand mounds. The latter are larger than the ones in the Sperrgebiet (fig. 2) and as such less reminiscent of the burial mounds of the unmarked graves as seen, for example, in Swakopmund. The uncanny resemblance of the unmarked graves and the mounds produced through extraction serves as a reminder that the genocide was directly linked to colonial extraction and dispossession[9] and that the "colonial earth," as Kathryn Yusoff describes the product of the geologies of colonial worldbuilding, is intrinsically linked to the "epistemic violence of the category of the inhuman" (2024, 2).

8 Granite is widely distributed throughout the continental crust with an average chemical composition of around 72% silicon dioxide, which in turn is the major constituent of sand in many parts of the world.

9 See Press (2021) for a more detailed analysis of this.

During 1912/1913 a light railway ran from Conception Bay to Conception Water, and an 80km pipeline linking the settlements was built as part of a larger infrastructure of extraction in this area. Many prefabricated buildings were erected at several settlements, and some of these are still visible today. I visited the deserted German colonial mining settlements between Conception Bay and Meob Bay, named Holsazia (24° 10′ 00.01″ S and 14° 37′ 00.01″ E), Charlottenfelder (24° 13′ 00.01″ S and 14° 37′ 00.01″ E) and Grillenberger (24° 15’ 12″ S and 14° 37’ 19″ E). They were set up during the height of diamond mining. While Grillenberger provided more of an administrative site of the extractive zone and housing for the German contractors, Charlottenfelder and Holsazia mainly contained accommodations for the workers who sieved the sand for diamonds, and who were mainly Aawambo men from communities in north and north-eastern Namibia.[10] Wooden tent-like structures accommodated up to ten workers. By 1918, Schneider (2008, 122) argues, the "Luderitzbucher Minenkammer at Okaukueko station records list 2,800 workers that were recruited from the north." Once under contract, the workers had to walk by foot the approximately 130km from Walvis Bay to Conception Bay and

10 On the history and infrastructures of migrant labor in colonial Namibia, see, for example, Nampala (2023).

2 Mining sieves left behind in Charlottenfelder (Source: Henriette Gunkel 2021)

onwards. This meant that they had to walk for three days before reaching the diamond mining sites where they worked in groups of 30 to 50 per claim or expedition, supervised by one conductor. A list documented in Schneider's book *Treasures of the Diamond Coast: A Century of Diamond Mining in Namibia* (2008) states that between July 1912 and May 1913 a total of 119 arrived at the extractive zone – of which only eight returned home in good health while 24 died on the diamond fields and nine in hospitals either in Lüderitzbucht or Swakopmund.[11]

After taking me to visit the site and becoming aware of my interest in the working conditions of diamond extraction, Marius van Zyl, the tour guide, drove for about ten minutes off-route away from Holsazia to show me a site where scattered human remains lay on bare granite rock. Van Zyl explained that when he first came across the site in 2002, it was clearly identifiable as a grave site with the remains of approximately 20 workers still held together. He told me that it seemed as if the bodies had been wrapped in Sisal cloth[12] before they were loosely buried with sand, not far from a dune. Stones on

11 Similar in their work on the Tsumeb copper mine in northern Namibia, Noam Gramlich (2024) points to the intimate relationship between (what Yusoff would call white) geology, resource extraction, and coloniality.

12 The sisal cloth links German settler colonialism in German Southwest Africa to the former colony of German East Africa where sisal plantations existed, particularly in present-day Tanzania. Images of these plantations can be found, for example, in the Koloniales Bildarchiv at Goethe University Frankfurt am Main.

the plateau indicate that some form of burial seems to have taken place. Given the strong winds in this area, but also the roaming of animals such as hyenas and jackals, the remains are now broken apart and scattered on bare rock with the cloth no longer visible to the naked eye. The bare rock – grey granite – indicates that the area was first mined before the bodies were deposited, which unravels the ongoing genocidal violence of "racial capitalism" that Gómez-Barris (2017, xvii) understands as the "processes that historically subordinated African and Indigenous populations," while "extractivism references the dramatic material change to social and ecological life that underpin this arrangement." As she concludes, "extractive capitalism, then, violently reorganizes territories as well as continually perpetuates dramatic social and economic inequalities that delimit Indigenous sovereignty and national autonomy" (ibid., xviii).

During my visit to the site in December 2021, what remained visible were not the remains of 20 workers but less than half of them. It seems impossible to say exactly how many without forensic research. A dune that moves in from the south might have started gathering some of the skulls and bones and will eventually move over the site entirely. By doing so, the dune will, at least speculatively thinking, prevent further scattering, a further breaking apart of the remains, and provide some form of preservation, considering the dryness and the high level of salinity in this area. This movement over the human remains could be understood as one possibility to allow for sedimentation to eventually take place.

Together with colleagues from the Namibia University of Science and Technology (NUST) in Windhoek,[13] I am currently thinking through the notion of *scattering* as a colonial practice, which we understand in terms of people (like the workers in mining areas but also transnationally in terms of exile and diaspora) but also in terms of resources, ideas, objects, remains, knowledges. A decolonial response to the practice of scattering, we argue, cannot only be subsumed under the question of return, as currently discussed in the context of reparation and restitution. Instead, we propose the notion of *gathering* as ongoing, open-ended (with, again, less of an endpoint, as the question of return seems to imply) and what Fred Moten (2008, 182) understands "*as* contested matter, to linger in the break."

13 Namely Sarala Krishnamurthy and Phillip Lühl, together with Nashilongweshipwe Mushaandja and Maja Figge.

In the case of the human remains left behind in the extractive zone of early diamond mining, the gathering is not provided by the post-Independence government nor by the Owambo

communities that could claim the remains. Here, the gathering is performed by a dune, by the landscape itself, that started to move over the remains – referring to sand's capacity of holding together as a form of gathering, but also, at least partially, preserving – and eventually laying open what has been buried by moving over and beyond the site. The site thus becomes part of "ghost geologies," as Kathryn Yusoff (2024, 3) understands it, which for her is a testimony "to certain disorientation, a gathering of a series of ruptures" as a form of lingering in the break. By moving over the ancestral remains, the dunes provide a form of protection that they also offered in the context of the slave trade. For a long time, the dune belt along the Namibian coast made it impossible to dock ships, protecting the Indigenous population from being enslaved. In the afterlife of German colonialism and the genocide, the dunes perform another form of protection through their slow movements over remains, at least temporarily.

Sand, Atmosphere, and the Gathering of and around Remains

Aerial images are used to calculate the rates and directions of barchan dune movement. In her research south of Walvis Bay, in the Kuiseb Delta, Jessica Barnes (2001) concluded that between 1961 and 1999 the dunes moved on average at a mean rate of 13,15 m a″1, in an approximated northwards direction. Over this period, however, she argues "there has … been a substantial fluctuation in the rate of movement, from a minimum mean value of 4.24 m a″1 to a maximum of 18.9m a″1" (ibid., 283). As Barnes explains, barchan dunes form on solid surfaces – which in some parts of the !Namib desert are fossilized dunes, or, as in the case of the area I am interested in, bare granite rock – when there is little sand available. Barnes argues that the dune transport takes place in two processes. One is the movement of sand over the dune itself, through saltation, the other is "a 'rolling over' motion in which individual sand grains are cycled internally within the dune" (ibid., 286). What Barnes's study shows are the constant interaction and energy exchange between the atmosphere and the lithosphere in this area.

Satellite images captured by a planetary sensory network between 1984 and 2020 and animated by Google Earth Engine reveal the dynamic movement of the dunes in the area of the burial site. What becomes visible in this time-lapsed video is the speed with which the dune will eventually move over the remains.[14] It is the same movement of the dunes that covers

14 When watching the time lapse video, the term "sand sea," which is often used for the desert, becomes quite literal as the dunes move like waves north.

the corpses and contains further scattering that eventually allows them to resurface, to unearth.

Dunes also move in other parts of the extractive zone. Water pipes laid out between the freshwater sources near Conception Bay, named Conception Water, and Fischersbrunn, close to Meob Bay, seem partly untouched, unmoved. In other parts however, as at Conception Water itself, the pipe disappears into a dune and only resurfaces several kilometers further south. The dune obviously wasn't there when the pipes were initially placed but has moved in since. So, while sand saltation targets the infrastructure left behind, it also gathers around infrastructural remains. This is how new dunes are formed, as in the case of the *Edouard Bohlen II* shipwreck, where "prevailing winds … cause the formation movement of sand dunes around the wreck" (Harris, Jones, and Schnitzer 2012, 130), in addition to iron corrosion due to the wind, rapidly changing temperature, and humidity. In the former mining sites the decay is similarly visible, even though further away from the sea and hence surrounded by an atmosphere less salty.

The bodies that remain in the landscapes are hence different bodies – human and non-human: the bodies of workers who died while working in the Northern Fields as part of the colonial extractive industry, but also the ancestral remains that refer to ordinary Black life that preceded colonialism in this area. Human remains resurfaced close to Meob Bay, for example, but also south of Walvis Bay, the latter close to a heap of shells which indicate (at least temporary as in nomadic) community life, linking Black presence to the sands of this extractive zone. The remains of non-human bodies are equally visible in the barren landscape, that is, animal remains – cattle in the context of the mining sites, seals along the coastline, and whale carcasses in particular – as well as the shipwrecks, the body of the dune that moves over fossilized versions of itself. Attuning to the body that remains – the historical body, the geological body – thus means attending to the different elements and different temporalities they are made of. This way of "thinking through rather than about the earth" was already proposed in 2012 by Elizabeth Grosz, as Bremner (2021, 24) points out, and "affords political power to 'the elemental forcefulness of the earth itself.'" Attuning to the materialities of sediment and "sedimented acts" (Schneider 2019, 56) are embodied practices that address the body that enters the site and acts as a mediating conduit or connection.[15] Mediation thus happens through the body which is specifically positioned.

15 I am grateful for the ongoing conversations with Sam Nightingale, which shaped my understanding of the bodily practices of attunement. Similarly, Rebecca Schneider (2019) argues that bodies can themselves "mediate" and can extend physical media (not the other way around).

I am interested in this relationship between the material body of what remains and the processes of sedimentation as parts of the colonial infrastructure turn into spectral infrastructure and into a ghostly geology by the atmosphere and the weather/weathering. The desert is most commonly understood in meteorological terms by the distribution of rainfall and dry air masses (Weizman and Sheikh 2015). The weather is thus central to an understanding of the desert, which is generally described as a hostile environment and inhabitable. In the context of the Negev desert, Eyal Weizman and Fazal Sheikh (ibid., 38) argue that the aridity line is also the line of dispossession, as property rights south of the aridity line were and are not recognized. Their work indicates that weather thus refers to more than a meteorological phenomenon. It points to an understanding of the weather beyond a meteorological definition which would include "temperature, air pressure, humidity, visibility, clouds, and precipitation," as Jussi Parikka and Daphne Dragona (2022, 12–13) set out. Weather is also, as Christina Sharpe (2016, 104) has argued in the context of anti-Blackness, the "totality of the environments in which we struggle; the machines in which we live." Building on Sharpe's understanding of the weather, Astrida Neimanis and Jennifer Mae Hamilton (2018, 80–81) propose the notion of "weathering" – a term that becomes central in the process of how sand is formed – which for them is "a particular way of understanding how bodies, places and the weather are all inter-implicated in our climate-changing world. Weathering describes socially, culturally, politically, and materially differentiated bodies in relation to the materiality of place, across a thickness of historical, geological, and climatological times" (ibid.).

While a geomorphological understanding of weathering mostly acknowledges the chemical, physical, and biological processes at work in the formation of sand as consisting of material that resist dissolution, this scholarship situated in Black Studies points to a more complex relationship between bodies, place, and time that includes the social, political, material, and cultural. With sand bearing traces of different experiences and histories, it brings together the most recent history, with which Namibia is still coming to terms, and deep geological time. Here the remains in the desert refer to the wider ecology of remains – or, as Ioana B. Jucan (2019, ix) asks in the introduction to *Remain x Remain(s)*: "How are remains and remainders, and the process of remaining, to be understood, engaged, and entered into a relationship with?"

Importantly, and in a way building on Sharpe's idea of "residence time," remains are conceptualized in terms of

temporality – not necessarily in relation to past and present, as a sense of linear time, but more as a form of "polytemporality," as proposed by Tavia Nyong'o (2018, 155), which seems to do more justice or reflect on "the undecidable space between registers of what is live and what is passed" that one finds in the Namibian desert. To think remains outside of the binarized distinction between old and new, past and present but also outside of the binarized distinction between subject and object, the immaterial and material, between inorganic and organic, between life and non-life means to understand the atmosphere in the !Namib desert as one in which, I would argue, things are *held*, while the distinction between them has literally broken down. The easy distinction one might have made between the granite, the rock, human remains, and animal carcasses are, at least, eventually broken. The atmosphere in its interaction with the lithosphere and the hydrosphere is the breakdown of the distinction between things. Through the atmosphere, the distinction between rock, in this case granite rock, and sand breaks down, but also between the human remains that lay on the rock – they, too, break down (eventually) by the atmosphere that surrounds them, get carried by the sand, becomes part of the aeolian movement that surrounds us.

Conclusion

The constant high-energy exchange in the extractive zone between Conception Bay and Meob Bay – the sand blasting, the abrasive blasting in addition to extreme temperature fluctuations, and changes in humidity – targets not only rocks, but also other bodies, including human remains. By thinking through the Earth and attuning to the materialities produced when the desert ground and the different bodies embedded in it interact with and are transformed by the atmosphere, it seems as if the desert's atmosphere provides a dialectic of exposure and disruption to sedimentation processes. Larger, more solid elements of the bone structure will remain on site, covered by the moving barchan dune and thus buried, while entering the sedimentary cycle. The latter is a very slow process due to the dryness and high salinity of the Earth's surface in the desert. However, through the movement of the barchan dune over the remains, the ancestral remains will be released again until the next dune arrives. This movement by the dune exposes the remains and interrupts the sedimentary process.

Other bone particles, which are much smaller but potentially larger than the average grain of sand in this area, will be taken up through saltation and carried forward as part of the dune movement and beyond. These particles may enter the sedimentary cycle more quickly than larger particles, but they do so removed from the initial burial site.

The human remains thus "become part of the matter and mattering of landscaping as processes of inhumation" (Casid 2018, 239–40) and participate in processes of abrasion. As Agard-Jones (2012, 325) argues, just to repeat, sand "exists along" and "be/side us"; it "surrounds us." She also reminds us that it is not only the water and the wind that carry remains in the desert, but also us as we move through the space. The sense of walking on bones that initiated this research is thus only one way of understanding how the genocidal violence and its afterlife remains part of the Namibian landscape and how we, the sand, and the air interact with these remains.

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Rocks in Action: Disposing of Nuclear Waste in Dance with Geological Agency

Christiane Schürkmann

A repository designed to contain radioactive materials for a million years, embedded in geological strata that have formed over hundreds of millions of years – how does that come together? From a material-sensitive perspective, this contribution explores how scientific knowledge and uncertainty are produced with and through geological formations that are being studied as potential host rocks in nuclear waste disposal projects. How do these subterranean materials come to possess geological agency in the task of containing our toxic radioactive legacy? As an ethnographer, I follow scientific research practices and narratives within the field of nuclear waste management to trace experimental investigations of underground processes in the context of exploring suitable host rocks.

Keywords: Geological Agency, Material Agency, Geology, Nuclear Waste Disposal, Layers

A rock is a rock is a rock.
Tim Ingold

As I write this article, I occasionally look at a fragment of clay on the table in front of me – a segment of a drill core, given to me as a gift at the Clay Conference in 2024 during a workshop at the *Federal Institute for Geosciences and Natural Resources* (BGR) in Hanover (fig. 1).[1] In this regard I am reminded of Tim Ingold's invitation to the humanities, as well as the cultural and social sciences, to return to the material, to engage with materials, to work "practically *with* materials" (Ingold 2007, see also 2012), rather than solely questioning the materiality of objects. This request seems helpful to me not only for research into the perception and practical use of everyday artifacts. Large-scale infrastructure projects in our time are also based on research into various materials in order to harness and integrate their properties, behaviors, activities, and potential. In this view, the fragment of clay in front of me is not only relevant in itself or as a geological witness to a subterranean sedimentary past millions of years old. In the context of the handover of this technically excavated "geological artifact" at the Clay Conference, it is framed as a rock that is considered durable, stable, and swellable, alongside other geological formations in the focus of a specific disposal project: the permanent disposal of radioactive and particularly highly radioactive waste.

To date, the "solution" for disposing of radioactive waste has been seen in scenarios of final storage or disposal in deep geological formations. This involves the long-term confinement of radionuclides and their isolation from humans and other living beings for a period of thousands of years. In Germany, the Site Selection Act Section 1, Paragraph 2 defines the duration of such a final storage or disposal as one million years.

Against this backdrop, the segment of a drill core raises questions such as: Who works *with* this material? Who handles, analyzes, examines, and evaluates it in the context of deep final disposal projects? These questions are embedded in an overall key question: How to tame toxic and hazardous waste – waste that challenges societies due to its long-lasting danger, its long-term efficacy, its half-life and toxic agency? In this way, material like the fragment in front of me might release further questions such as: What do geological formations do and what are they expected to do, what do they potentially contribute to shielding, keeping away, isolating highly radioactive waste from us, from our above-ground societies in the long term?

1 This article is written in the context of my research project funded by the Deutsche Forschungsgemeinschaft DFG (German Research Foundation)-522985105.

1 **Fragment of clay rock from a drill core, interior view (Source: Christiane Schürkmann, 2024)**

Many scientists, mainly natural scientists, are investigating these questions worldwide. Through their eyes, clay is not only a dead sediment – rather, it is addressed as an active and capable material, a material with self-sealing properties that can retain radioactivity, and therefore a material that promises to guarantee something we call "safety." The following questions evolve around underground rock formations as a sedimented past that is investigated in order to *work with us* for a safer future: What expectations are placed on this material? How is scientific knowledge developed by working with underground materials and processes? What promises are derived from the use and properties of this material to envision a disposal that can retain radionuclides over a million years?

A Rock Acts Like a Rock? Some Thoughts on Geological Agency

Given the knowledge that clay is being researched and considered as a possible host rock for the final disposal of

radioactive waste, the fragment of clay in front of me turns into something active and capable, something that is confronted with expectations and hopes. The rock *is* not only a rock – in the context of such a large-scale project, it has turned into a material that is investigated by geologists and chemists to collaborate with us, to do something for us in order to keep our hazardous radioactive waste, our "toxic objects" (Schürkmann 2021), away from our habitat, from the surface, from the so-called biosphere. Such underground rocks come into the focus of contestations, politics of site selection, along with requirements for public participation, and scientific-technical controversies (see, for instance, Sundqvist 2002; Elam and Sundqvist 2006; Schröder 2016; Barthe, Elam, and Sundqvist 2019; Emmenegger 2025).

The discursive and political framing of deep geological disposal is particularly characterized by an attributed stability (Anshelm and Galis 2011). The inclusion of geological formations as a relatively stable and predictable "environment" or "nature" can be interpreted as a reaction to a central problem in disposing of radioactive waste. This problem consists in having to operate with temporalities beyond social orders, technical developments, and political legislative periods (Ialenti 2020; Kasperski and Storm 2020; Keating 2024). Or, put differently: Toxically effective radionuclides and their extremely long half-lives (from a human point of view) are to be countered by geologically grown rock strata that have evolved over millions of years in the history of the Earth. In this way, repositories become comprehensible as more than just human-technology-driven projects. An active nature (Haraway 2016) comes in as a kind of intervening and potentially collaborative but also self-dynamic agent in order to serve as a stabilizer and retainer. From such perspectives, geological formations are seen as a kind of nature that is supposed to make technologized society durable (Schürkmann 2024).

This leads me to the question of stressing a kind of *geological agency* – an agency that is presupposed in the rocky underground with its energy, behavior, processes, and activities. Such a heuristic notion of asking for the presence and relevance of geological agency ties in with theories and approaches that take material activity or agency into account (Latour 1993; Pickering 1995; Bennett 2011). Such approaches underline that human existence is no longer regarded as superior to a non-human world, but rather in dependence on material phenomena, co-existences, and activities (Coole and Frost 2010; Engert and Schürkmann 2021). As a result, things but also materials are not passive. They are doing something,

they act and unfold their agency. As Andrew Pickering (1995, 21–22) has convincingly pointed out, human and material agency are mangled in a "dance," or to put it differently: "The world responds to what we do to it and vice versa in a mutually transformative back-and-forth" (Pickering 2025, 3).

If we set the knowledge production of geologists, chemists, and engineers engaged in the field of nuclear waste disposal research into a speculative dialog with these material-related approaches, various "situated knowledges" (Haraway 1991) emphasize the following insight: Human based societies do not "manage" and control an active and hazardous waste in a technical single-sided way. Material agency co-directs the process of siting, developing, and operating repositories. Taking into consideration the attributions of a stable and enduring nature, geological agency can be characterized here as something that differs from technological agency, from technique and technology as something humans have produced, fabricated, and released to enhance, supplement, or improve their own possibilities of acting. In contrast to this, geological agency is considered something that has developed without humans and without human interventions. It can be seen as something that was there and active long before humans were, and even longer before highly technologized societies – and that will be there and active long after us.

Geological Agency on Stage: Performing Rocks in Public Communication

How is this geological agency publicly staged in the context of site selection procedures and disposal projects to finally store radioactive waste in deep undergrounds? The following statement by the Chairman of the Executive Board of Nagra (National Cooperative for the Disposal of Radioactive Waste) at a press conference on the announcement of the proposed site in 2022 might give a brief impression of how this agency is performed, presented, and communicated (see also Emmenegger 2025):

> The heart of the deep geological repository is this inconspicuous rock, the Opalinus Clay. It is around 175 million years old .... Knowing the exact history of this rock over the last 175 million years gives us the confidence that we can make good predictions for the distant future. Three relevant properties of this rock are important for the repository. Firstly, it is very dense. Secondly, it binds

> radioactive materials like a magnet. And thirdly, if it breaks, it heals itself again. (translated by the author)

If we follow this statement, it emerges that the assumed stability of a particular rock, "this inconspicuous rock, the Opalinus Clay," is also continued in the stability of a precise knowledge about an immensely long geological period – knowledge that is even profiled here as "exact" and that, at the same time, makes the future appear predictable and determinable. The rock is centralized here in a way – following the rhetoric used – that seems to make this predictability possible, that seems to reveal this knowledge about itself, a rock that also does something invaluably useful in terms of the deep storage of radioactive materials: "it binds radioactive materials like a magnet .... And if it breaks, it heals itself again" (ibid.). In this way, the properties of the material itself are made relevant, as well as the properties that the clay will contribute to this particular disposal project. The properties of the rock are converted into capabilities for deep geological disposal in clay. This marks the relational implications of what we call "properties," as Ingold (2007, 1) has emphasized: "The properties of materials, then, are not fixed attributes of matter but are processual and relational. To describe these properties means telling their stories." The story of the Swiss Opalinus Clay told by a Nagra representative here is a success story. From the point of view of those involved, this success can be measured by the fact that a site has been identified for the long-term storage of nuclear waste in Switzerland based on the tremendous long-lasting clay with self-healing capacities. In this case, a rock does not only act like a rock but rather as a capable host rock, a rock that should provide its outstanding geological agency for storing and retaining technologically produced toxic radionuclides in the long term.

Going Backstage: Making Geological Agency Tangible

The story of the Opalinus Clay can also be told and presented as one of research and experimentation. Beyond essentialist assumptions about stabilizing potentials and capabilities, we can observe that geological agency expected from particular rock formations *by us* are made tangible, observable, ascertainable, describable, visible, assessable, and therefore researchable – often by using technologies. In this way, I would like to shift the focus away from public statements on the quasi-political public front stage to the backstage of scientific knowledge production. Or, in other words: Let us look behind

the scenes and therefore into experimental practices situated both in above-ground and underground laboratories. In this context, underground rocks are addressed as "epistemic objects" in Hans-Jörg Rheinberger's (1998) sense, as Allison Macfarlane (2003, 784) has put it in the context of radioactive waste disposal in the USA and the Yucca Mountain project: "The processes to be analyzed and evaluated in a geological repository are complex and comprise a combination of scientific understanding of geological processes and engineering design." This is where I start my ethnographic engagement with the question: How do researchers investigate what particular rocks should do for us by serving as host rocks? In which ways are rocks turned into host rocks, and how is scientific knowledge produced in this context? As Bruno Latour has famously proclaimed in his 1987 published book *Science in Action: How to Follow Engineers through Society*, I follow science in action for the purpose of disposing of radioactive waste. Therefore, my ethnographic field is located in the so-called *radwaste community* including its laboratories, research practices, experimental systems, and political involvements. To refer again to Ingold: I follow those who work practically *with* these materials and who identify their properties, activities, behavior, and capabilities.

A look at the practices of researching and working, demonstrating and visualizing these underground rock formations allows geology to appear less as factual and unchangeable, but more as exploratory, experimental, and in a certain sense unpredictable. In 2023, in my role as an ethnographer, I was able to visit a rock laboratory in which research is conducted within the context of disposing radioactive waste. Rock laboratories allow us to imagine the possible "realization" of an underground site for the storage of radioactive waste. They therefore play an important role in developing and envisioning deep and final storage projects. They make the future possibility of realizing deep geological repositories "graspable" (Geysmans, Silvikko De Villafranca, and Meskens 2023, 314). In such a laboratory, the underground rock formation emerges as an "epistemic object" and, at the same time, as a "demonstration object" (Kim 2025). The following excerpt is from an ethnographic protocol that I wrote during my visit to the rock laboratory:

> The guide (T.), my colleague, and I get out of the car and stand in a seemingly endless tunnel. It smells of clay, the light is pale. T. works as a geologist in the rock laboratory and immediately starts talking about the laboratory, its geology, and the history of its creation. … "Above a certain

> amount of minerals, one speaks of Opalinus Clay." Clays, according to T., "can swell and what they can also do: They are electrically charged and so the radionuclides can then adhere" – he also speaks of the "retention capacity" (translated by the author) of the clay.

Entering the underground is experienced here as a journey into another world – an association with Jules Verne's famous 1864 novel *Voyage au centre de la terre* comes to mind. The subterranean sound formation surrounds us and unfolds its own atmosphere: Artificial light is needed to see anything, the accessible space extends in the form of tunnels, corridors, and niches, the air smells of clay. However, T.'s statements show that the Opalinus Clay is not an ontological fact. Moreover, it has to be characterized and defined based on geological knowledge about its properties and composition. As T. argues: "Above a certain amount of minerals, one speaks of Opalinus Clay." Similar to the front stage communication, the geologist highlights the special agencies of this geological material that "can swell" and mentions "what they can also do: they are electrically charged and so the radionuclides can then adhere." The clay can retain radionuclides, which qualifies Opalinus Clay in general to become a possible host rock in Switzerland and other countries with such a clay formation. Another extract from the ethnographic protocol draws attention to the properties of different types of Opalinus Clay:

> T. leads us into another gallery. … He explains that the Opalinus Clay is present in three different facies. On a map attached to the tunnel wall, T. points to three different facies: "So the clay has three different faces." He explains: "There are sandy facies, then clayey facies and, as a special case, carbon-rich sandy facies. This is the sandy facies, which is relatively stable. … In the early days, people relied on the clayey facies because they wanted to have these swelling properties of the clays and wanted to investigate and understand them and see: Hey, can we get a safety case that meets our requirements? In the knowledge that the stability of this clayey facies is not really good, so building a tunnel in clayey facies is not so good." (translated by the author)

Here we learn that clay is not a homogeneous material that is always the same, always does the same and can always do the same. It "has" various "faces," or, in a more geological way, various "facies." Metaphorically, the clay seems to have multiple characters with different properties, abilities, and modes. In the context of studying clay for planning and

developing repositories for nuclear waste, this knowledge is very important in relation to expectations and requirements. While in the past the ability to swell and therefore to seal the disposal was expected to be favorable in the clayey facies, the question of the stability in this particular clay was later recognized as a problem. In this way the geological rock should not only function as a barrier that retains radionuclides, it also has to work as a building element, in this case, a tunnel, that should be stable enough to last over thousands of years and more. Hereafter, geological agency is seen as complex and in relation to an engineered project and its requirements. In this way, in such disposal projects geological agency is not only considered as agency in itself but rather is made relevant as *agency in-itself-for-us* (Schürkmann and Anders 2024), for our safety. Therefore, geological formations, what they should do and what requirements they must fulfill, enter concepts of safety regulations and bases of calculation, as well as practices of modeling to make distant futures calculable, describable, and predictable.

Zooming In: Observing Geological Agency Under and Out of "Control"

While the experimental practice in rock laboratories exposes itself to the conditions in the sense of real-world experiments (see, for instance, Gross and Hoffman-Riem 2005; in the context of nuclear waste see Parotte 2017), in above-ground laboratories rock samples from the subsurface are used in experimental practices under so-called controlled conditions. These conditions are produced by humans and their technologies by setting up particular possibilities under which the geological material can unfold its limited potentials in the sense of samples. In such lab-based experiments within the realm of nuclear waste disposal research, geological materials such as clay or cement are prepared in small pieces to be investigated by using different methods and equipment such as mass spectrometry, for instance. What comes into the focus is material behavior, activity, and agency on a small scale (Schürkmann 2022). For example, geological material such as clay is put into contact with plutonium to measure and observe where dissolved and thus "migrating" radionuclides are retained. My ethnographic fieldwork also leads me to such above-ground laboratories where such experiments are developed. The following extract taken from an ethnographic interview with a researcher (K.) conducting such experiments might give brief insight into this observation and identification work in this field – and also into its challenges:

Host rocks are extremely heterogeneous materials. So the further you zoom in, the smaller structures you recognize … Clay is a layered sediment, so it's structured like slate, this means layers, and of course diffusion along this layer works much better and is faster than if … my radionuclide has to work against these layers. … These are experiments that would not work in reality because the layering is somehow more chaotic. (translated by the author)

The question of heterogeneity becomes a question of perspective. As K. points out, the focus in such experiments is not to gain generalized and typified knowledge about rocks and their capabilities, but rather on looking into the various layers and structures of geological material. Or, as he suggests: Let us "zoom" into the clay. This perspective is sensitized to micro and even nano levels to investigate questions such as: How and where are radionuclides such as plutonium retained in a core or sample that simulates a geological barrier? Or the other way around: How far and to what extent or distributions do radionuclides permeate a material after a certain time? To research such questions, prepared material cores are used in experiments in which, among other things, the capacity factors of the rocks (e.g. porosity), coefficients (e.g. diffusion coefficients), and activity (radioactivity) of materials in contact with radionuclides are determined over time (Schürkmann 2024, 136). Following K.'s statement, it is important for the experimental setup to control how the materials are brought into contact with the core or sample regarding its structures and layers. The position of the migrating radionuclides in relation to the layers plays a serious role in simulating a scenario that "is somehow more chaotic" in the reality out of the laboratory. In this way, questions about controllability arise combined with questions of representing and predicting long-term confinement of radionuclides, long-lasting barrier systems, and societies of distant futures. How to transfer such situated experiments to long-term processes, such small samples to large scale events, such controlled materials in the laboratory's simulation to the chaotic realities outside science and its precautions? Counter to this insight into chaotic layers, geological agency might be recognized as also being unruly, unpredictable, and "resistant" (Pickering 1995, 22) regarding scientists' assumptions and intentions but also societies' expectations and hopes.

2 Fragment of clay rock from a drill core – exterior view (Source: Christiane Schürkmann, 2024)

A Rock Acting Like a Host?

This article has tried to unfold some thoughts on what I called geological agency within the context of nuclear waste disposal. How does this agency enter onto the stage – and how is it performed backstage? Possible answers depend not only on the ethnographically gained insights into the field of repository research, but also on the respective conceptual perspective. Inspired by Ingold, we might say that geological material becomes relevant as a practical material with which scientists and engineers work in their everyday life. Seen through the lens of Latour's science studies perspective, geological material shows up as rocks in action that should stabilize technologized societies to shield them from their toxic fabrications; using Pickering's approach, geological agency can be understood as material performances or performing materials serving in a particular manner to host our unwanted hazardous waste. In a neo-materialistic view following Bennett, this agency opens as a kind of vibrant material that is included in a regime of long-term care and responsibility – long-term

care for the waste we produced, for the generations that will follow, for the environment as a contaminated one. The notion of geological agency might contribute to understanding a little more of what we call “Earth” (see for instance Bobette and Donovan 2019), which cannot be reduced to passive, dead matter. Rather it becomes relevant to us, to our technologies, to our active, radioactive waste products, to our thinking of futures even far beyond today.

In this way, the question of deep geological disposal for nuclear waste might enter into a dance not only with technological but also with geological agency. This dance can be characterized as supposedly controlled and disciplined in the laboratories above ground and, at the same time, as dynamic and self-expressive if we leave the scientific comfort zone above ground and move into the deep past and therefore into the depths. The question in this context now is not if the rock acts like a rock but rather if the rock will act like a host for up to a million years, a host that should treat the waste brought in as a guest that should not leave too soon. Therefore, the question is not only about the geological agency of the rock itself, geological agency in the context of deep disposal projects moreover relates to the agency of radionuclides, of humans and their political accounts and initiatives, expectations and attributions.

I look again at the fragment of clay. Its round shape bears witness to the drilling that brought it to the surface. Its fine layers testify to its long-term origin, the pink marking on it transforms it into an artifact of the material culture of geoscientific practice (fig. 2). At the same time, it is embedded in a social situation, it is also a gift. I received this piece of clay on the occasion of a workshop in which we were shown various drill cores, in which we tried to get in touch with a past before us, not least to think about and create futures that will outlast us.

I would like to thank the scientists who provided me with insight into their work and research activities. My heartfelt thanks also go to various colleagues with whom I have been able to work on this exciting topic over the past years and who have always been available for an exchange of ideas. I would also like to thank Petra Löffler and Felix Hasebrink for inviting me to a stimulating and varied workshop that contributed to the reflections written here.

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Postsocialist Video Art as Aesthetic Aftercare for the Extractivist GDR

Ulrike Gerhardt

This article explores how postsocialist video art enacts aesthetic aftercare for the devastated territories of the GDR's socialist extractivism. Focusing on works by Anna Zett, Mareike Bernien and Alex Gerbaulet, Larisa Crunțeanu, and Sonja Hornung, it examines how sedimented infrastructures and industrial residues become sites of artistic inquiry. Engaging with disposal, necropolitics, and radioactivity, these artists develop methods that confront toxic legacies through sustained practices of care. Aesthetic aftercare emerges here as an open-ended, situated response to ecological damage – where sediment becomes both material and metaphor for lingering, unfinished histories.

Keywords: Postsocialist Video Art, Socialist Extractivism, Disposal, Sedimented Infrastructures, Aftercare

Around 2010, artistic research investigating the connections between ecology, geology, and toxicity in social and political contexts entered into a fraught relationship with the concept of the Anthropocene (see, among others, Demos 2017; Romakin 2023; Fowkes and Fowkes 2022). This contribution focuses on three video works dealing with environmental history of the GDR, which highlight post-industrial landscapes and their difficult legacies as material agents to be coped with. This artistic research blurs the dividing lines between the human and the non-human, between nature and technology, the material and the cultural. Their subjective, exploratory, and interdisciplinary approaches challenge classical subject-object distinctions. Like many artistic practices of the recent years, they draw on the concept of the "Chthulucene," coined by biologist and historian of natural sciences Donna J. Haraway (2016), in the pursuit of an artistic practice that interweaves nature, culture, technology, and non-human entities.

In *Freiheit 3* (2020), a video work by artist and poet Anna Zett about the former landfill Freiheit III in Bitterfeld-Wolfen, locations of the "East German Anthropocene" (Heyne and Wagner 2024) become scenes of what this article calls an "aesthetic aftercare" of sedimented infrastructures. The second artistic position considered here approaches aftercare as a necropolitical séance. In *Untitled (to slip, to slide, to glitch)* (2024), Larisa Crunțeanu and Sonja Hornung invoke Achille Mbembe's (2019) notion of "necropolitics" to examine how "extractive zones" (Gómez-Barris 2017) have governed territories, resources, and lives in the lignite mining region in Lusatia, Germany.[1] At the heart of the third example, Mareike Bernien and Alex Gerbaulet's documentary essay *Sun Under Ground* (2022) about the former open-pit mines of Wismut SDAG, lies the experiment of giving radioactivity a material presence – of generating visual and acoustic material about an invisible source of radiation, conceived as a form of sediment.

1 The copper mining area in the Apuseni Mountains in Romania is also discussed in this work, but not mentioned here for reasons of geographical precision.

All three video works engage with the legacies of the extractive GDR industry, whose material residues are difficult to identify and articulate, yet form the starting point for the artists' research-based practices. Art historian and curator Bettina Knaup approaches this elusive waste from a performative-material perspective:

> As many have noted, waste is hard to grasp and to know. It resists – maybe by definition – classification and definition, as it seems to be their other: mutable and multiple; mingling qualities, states, beings, matters, temporalities;

> persisting and dispersing, accumulating and disappearing, sedimenting and evaporating. (Knaup 2021, 14)

Persistence and dissolution, accumulation and disappearance, sedimentation and (apparent) evaporation are processes connected with industrial waste unfolding on timescales that exceed human perception. This continual vanishing and re-emergence of matter shapes the artists' engagement with their research objects and their focus on the "devastated territories and poisoned soils" (disthene 2024) left behind by the GDR's as well as the Soviet Union's energy policies. The elusive and often incomprehensible nature of these research objects – especially given the growing historical distance and abstraction surrounding the chemical, raw materials, and fuel industries of the GDR – had a profound impact on each of the artistic methodologies. In attempting to relate themselves to these partly inaccessible histories, they turn to artistic strategies that oscillate between autofictional narratives, archival and documentary research, and performative embodiments. Finally, they tend to "produce artificial geoformations as environments" and "experiment with anthropogenic sedimentation processes" (Falb 2019, 266). Each of these methods seems to approach artificial geoformations, sediments, and eroding landscapes from a different angle, attempting to remember and relate to these landscapes, sites, and objects as neglected archives.

In recent years, archives have become increasingly permeable as they are confronted with curatorial, scholarly, and epistemic practices that challenge their foundations (Kuster, Lange, and Löffler 2019, 103–104). But how does waste intersect with the archive? Waste and archive merge in extractive landscapes where what has been discarded, buried, or forgotten is not overlooked (Hawkins 2006, 13), but endures as a sedimented trace – a material legacy of past regimes of extractive processes and environmental transformation, alongside cultural practices of valuation and classification.

Visiting landfills and attuning to neglected and intangible archival objects is not necessarily an easy task, even though they carry valuable knowledge about our relations with the material world. Anna Zett speaks of the unpleasant feelings she experienced during her research in the GDR Opposition Archive.[2] She had the impression of visiting a "contaminated place" that felt like a "burden" (Zett 2025, unpag.). It was only by accessing the history of the waste trade from West to East, which had been little researched so far, that Zett (ibid.) found an entry point into the topic through the term "disposal,"

2 The Archive of the GDR Opposition is the largest non-governmental archive of its kind, offering insights into alternative media practices and knowledge networks.

recognizing the intertwining of the political, material, and symbolic.

The paradigm of disposal and the associated rejection of planetary responsibility are reinterpreted within all three artistic works in the sense of a "planetary feminism" (Tsomou 2022) that addresses issues of speculative care and regeneration (Schütze and Leeker 2025; Gerhardt 2025) and understands categories such as nature, body, and woman not as biologically fixed entities, but as material relations in a historical context. With this background, Anna Zett, Larisa Crunțeanu and Sonja Hornung, Mareike Bernien and Alex Gerbaulet focus on sedimented inanimate matter, formations of orphaned, scarred landscapes, GDR industrial history, and costumed bodies in their video works. The artists turn to the "environmental, political and emotional wastelands" (Zett 2025, unpag.) of fossil socialism in a new way by tracing their material and historical genealogies. Zett (ibid.) looks back at the ruinous East German environments as follows: "In the 1990s huge heaps of GDR-built scrap were forming all over my childhood city – thrilling playgrounds, just like all the abandoned factories, rotten hotels and teardown houses that hosted my youth." Through their research methodologies, the artists practice a kind of aftercare by stirring up long-settled stories anew, revealing gaps, and retrieving little-known memories – an aesthetic aftercare that deals with the legacies, the scarred landscapes and bodies *after* the supposed end of extractivist violence.

This article develops a theory of aftercare marked by the (re)encounter with these historical places, in which care is understood as a situated, ongoing, and relational practice of recovering (Puig de la Bellacasa 2017, 161). Aftercare constitutes a physically situated practice and an ethics of care – one that takes the body seriously as a vulnerable, permeable, and relational site in the human sense, but also in its extensibility to more-than-human bodies such as soil, toxic rock, or architectural remains. Furthermore, the notion of aftercare enables a turn towards responsibility, in the sense of "response-ability" (Haraway 2016, 58; Puig de la Bellacasa 2017, 111), that is, the ability and obligation to respond to damaged ecologies and more-than-human others. In an artistic sense, aftercare could be understood as an expression of such co-constitutive responsiveness. This responsiveness is not necessarily linear or smooth but is often flanked by moments of disorientation and disquiet (Bartsch and Puffert 2023, 123; Zett 2025, unpag.).

A second important focus is the ethical endurance of damaged conditions, the anxious, continuous encounter with the wounds and legacies of the colonial, warlike, extractive, and nuclear practices of the "Socialist Anthropocene" (Fowkes and Fowkes 2025, 6), more specifically the "East German Anthropocene" (Heyne and Wagner 2024), and today's "Capitalocene" (Moore 2016). This includes the question of *how* to live together amid the debris of state socialism and capitalism (Tsing 2015; Gerhardt and Wolf 2024) within landscapes and architectures shaped by the "slow violence" (Nixon 2011) of climate change and ongoing resource extraction. In the following, I will examine how artistic practices address, embody, and mediate the sediments of extractivist practices.

Witnessing Damage: Ecological Artistic Inquiries

The approach to these sediments is by no means smooth. Being confronted with landscapes destroyed by extractions, cultural scientist Elisa T. Bertuzzo (2025, 7) describes "moments of disorientation and loss," "in which our perceptions but also our judgement are interrupted," as an emotional state of cluelessness that can also be observed in societal debates. Such a scene of cluelessness can be found in Larisa Crunțeanu and Sonja Hornung's two-channel video installation *Untitled (to slip, to slide, to glitch)* (2024). Crunțeanu and Hornung's practice is characterized by an overlap of historical-speculative, queer-feminist, and media-ecological influences. *Untitled (to slip, to slide, to glitch)* traces the disruption, destruction, and subsequent recultivation of landscapes in the Lusatian lignite mining region, among other sites.[3] In the first part of the video installation, the two artists wait in front of the disused pit of a Lusatian open-cast mine. They experience a moment of alienation from which they try to escape by using modern communication technologies. Still standing on toxic grounds, they call a guide who, due to network faults, never shows up. Describing themselves as partially disoriented cultural workers, the artists position themselves as "out of place" in this scene of helpless waiting – not out of compassion, but rather out of temporary confusion and disorientation in the face of the scarred Earth:

> Upon (re)visiting the sites in question, we became disoriented. We were overwhelmed by the vastness of the scars left behind by mining, the patchily covered-up displacement of villages and their cemeteries, of trees and their bones; the many fences; the glitching, unstable ground. (Crunțeanu and Hornung 2024)

3 The video installation *Untitled (to slip, to slide, to glitch)* (2024) was created as part of the exhibition *to slip, to slide, to glitch* at alpha nova & galerie futura, Berlin. The work traces the disruption, destruction, and recultivation of landscapes in the Lusatian lignite mining region, among other places.

This experience resonates with Donna J. Haraway's (2016, 39) emphasis on enduring trouble in the face of ecological destruction.

Through the reference to future fossils such as shards, stones, or even film reels, this initial helplessness gradually transforms into a practice of care, into a more attentive approach to what has been destroyed by exploitation but has not yet entirely disappeared. The artists observe the damaged landscape and its associated objects with meticulous care, recognizing them as both "material" (Schuppli 2020) and "planetary witnesses" (Gray and Sheikh 2018), within artistic practices that engage with the residues of socialist extractivism (Fowkes and Fowkes 2025, 10).

In *Freiheit 3*, Anna Zett discovers a porcelain shard embedded in slag – an object stripped of clear historical reference due to the homogenizing process of waste incineration. Ultimately, after failing to guess about its concrete history, she lets the fragment fall again. Her interview partner remarks, with amusement: "Well, the coins are all already picked out. That's for sure" (TC 00:11:27–00:11:40). The scene gestures toward an absence – an archive emptied of its stories by extractivism and technological rationalization. Mareike Bernien and Alex Gerbaulet take a more invasive approach towards material witnessing in *Sun Under Ground*. They bury a roll of X-ray film in gravel, revealing uranium's own recording and imaging capacity (Angus 2024, 172–79) while simultaneously proposing a speculative kinship between image carrier and geological matter. They therefore seem to suggest a relationship between the film reel and the rock. The act of burial functions both as a refusal of visual evidence of a resource-driven history and as a gesture of making space for speculative futures.[4]

4 For practices of burying analog film as a form of cinematic recycling, see Felix Hasebrink's contribution in this volume.

The three artistic practices orbit around what media theorist Jussi Parikka (2015, 109) calls a "material monument": industrial and civilization residues that have become part of the Earth's body. In the hands of the artists, such remnants – porcelain shards, film rolls, or other technological artefacts – serve as testimonies from a damaged archive. Even if they offer no clearly legible or secured information, they practice a different mode of historical reflection: a material and media ecological search for traces between destruction and remembrance. In a similar vein, artist and media scholar Daniel Wolter argues that the discharge of production residues into surrounding ecosystems shows how media technologies are embedded in industrial processes and carry material consequences for the environment. The medium

thus materializes within the landscape or ecosystem itself. When such a landscape – for instance, its waters and soil – is approached as an "archive of media" (Wolter 2025, 36, translation by the author), waste is no longer a meaningless remnant but a layered inscription of media history and material culture. Understood in this way, waste becomes an active carrier of present and future meanings, calling for new forms of knowledge, (after)care, and response-ability.

In contrast to archaeology, which seeks to provide evidence and to construct fixed historical narratives, artistic research engaging with the industrial and environmental history of the GDR is conceived by artists as a situated and subjective practice. Found materials – such as overburden, dust, or residues – are treated as evidence, but also as active agents with which the artists establish subjective, relational encounters. This form of research continues the legacy of a "history from below" (Sharpe 1991), as it was practiced in the environmental activist contexts and milieus of the GDR, running along the lines between conformity and the informal boundaries of free expression (Halbrock 2012). Instead of recovering found objects with narrative power, however, the artists come across materials that seem to conceal their history due to socio-cultural, ecological, and media-experimental entanglements – through archiving in the mining museum (pitchblende in the museum), industrial heat processes (shard in the slag), and burial (film reel in the ground). The artistic works selected here do not feature speaking remains but rather devastated materials that have been rendered aesthetically mute through various processes.[5]

5 This void is not merely an absence, but rather part of a growing erasure of the collective memory of socialism (Gerhardt 2024b, 67–76).

Aesthetic Aftercare of Sedimented Infrastructures

Anna Zett's video work *Freiheit 3* (2020) focuses on the failed environmental policy of the GDR and the management of its material legacy after 1989. The title refers to the name of a landfill of the Bitterfeld Chemical Combine (CKB), the former center of the chemical industry, located about 50 km north of the city of Leipzig (Gerhardt 2024b, 139–61). *Freiheit 3* shows the artist during a detailed inspection and guided tour of the landfill site with Harald Rötschke, engineer and managing director of *Mitteldeutsche Sanierungs- und Entsorgungsgesellschaft mbH Bitterfeld* (MDSE). The dialogical tour of the landfill by Zett and Rötschke forms the "present" layer of the work. Visually superimposed on this present layer – and often covering it – is a "past" layer of documentary footage and filmed

activist material from the GDR's environmental movement, as well as from the end-time and liquidation period in the late 1980s and early 1990s, which was designed by the artist as a gray relief (fig. 1). These assembled documentary sequences are juxtaposed with footage of a writing performance the artist staged on a gravel hill in the Leipzig/Bitterfeld area in 2018.

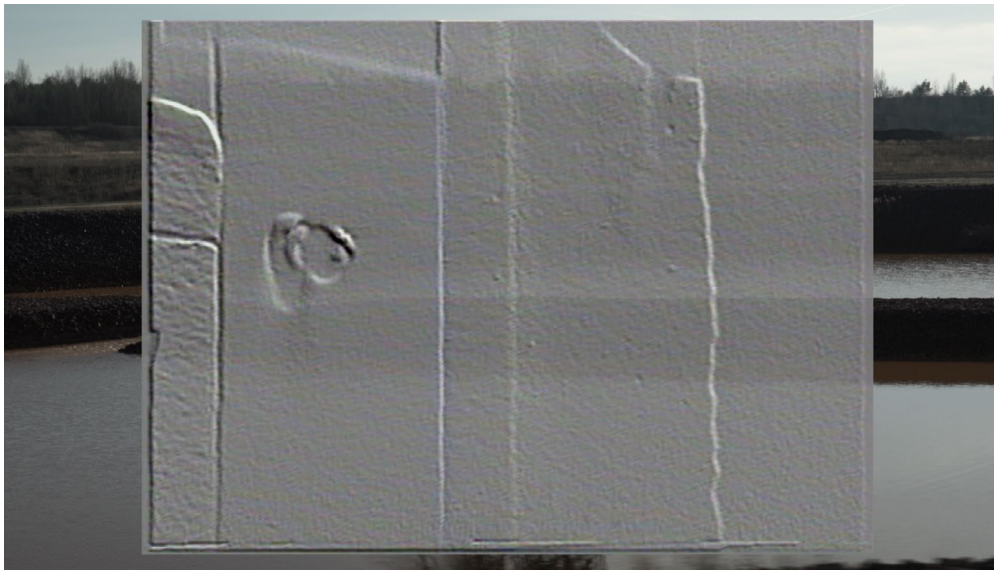
Through their inspection of the landfill and joint observation of the soil structure, a piece of industrial history is gradually reconstructed in the present layer. The chemical industry was one of the most significant branches of industry in the GDR.[6] Approximately 10% of industrial production was manufactured in the chemical combines of Bitterfeld-Wolfen, Buna, and Leuna, collectively known as the chemical triangle (Nieters, Faupel, and Derlien 2000, 2). In the GDR, the Bitterfeld-Wolfen landfills were a result of the lignite, oil, plastics, and chemical industries, a prominent example being the highly toxic wastewater from the VEB Filmfabrik Agfa Wolfen,[7] which was discharged into the so-called "Silbersee" (Barkowski 1992, 233), a toxic waste dump. Since the release of the documentary film *Bitteres aus Bitterfeld. Eine Bestandsaufnahme* (Bitter Things from Bitterfeld: An Inventory, 1988), Bitterfeld has been considered the most polluted town throughout Europe. In the words of journalist Margit Miosga (2019, 74), who co-directed the film, the film shows "never-before-seen images of everyday life under real existing socialism: chemically foaming waterfalls, poisonously glistening lakes and smoke-black streets." The "past" layer of *Freiheit 3* contains gray relief image material from *Bitteres aus Bitterfeld*, the GDR's environmental and citizens' movement, the occupation of Stasi offices in winter 1989, as well as private and television footage from the "Wende" period.

6 The GDR was also the world's largest producer of lignite. Lignite is a geologically relatively young sedimentary rock. Lignite and chemicals complemented each other in Bitterfeld and left behind some of the most contaminated groundwater and soil in the world (Schlaudt 2024, 13–30).

7 Formerly named Fotochemisches Kombinat, 1954–1964, from 1964 ORWO Orwocolor and Orwochrom films, from 1990 Filmfabrik Wolfen AG, from 2002 ORWO Net GmbH.

Dissident environmental activism in the late phase of the GDR had to face many obstacles: environmental data was considered a "confidential, classified matter" by the state from 1975 onwards and a "secret ministerial matter" from 1982, and environmental activist activities were persecuted as hostile to the state (Gundermann 1994, 29; Möller 2019). In the GDR, environmental campaigns and protests began in the late 1970s, primarily in the context of the Protestant church. Specific ecological protest activities included tree planting, action walks, bicycle parades, ecology seminars, and informational events. Historian Martin Stief (2019, 20) describes how the Ministry for State Security went to great lengths to monitor the opposition, that is, independent environmental groups and activists. Given the drastic nature of the ecological problems in the GDR in the 1980s, environmental policy became the

1 **Gray converted Stasi safe in *Freiheit 3* (Anna Zett, 2020, video still, TC 00:25:06)**



subject of various activities critical of the regime (Wolter 2025), which ultimately contributed to the downfall of the entire system.

The 125-year-old chemical region of Bitterfeld-Wolfen was taken over by the so-called "*Treuhand*," short for "*Treuhand-anstalt*" (trust company) in 1990, which was tasked by the new state with privatizing state-owned assets, preserving jobs, and supporting the development of sustainable corporate structures. The clean-up of contaminated sites and the modernization of the central German chemical triangle became by far the most expensive project undertaken by the Treuhand and took more than ten years to complete (Karlsch 2024). The Treuhand and its successor company, the Federal Agency for Special Unification-related Tasks (BvS), therefore opted for the partial privatization model (Nieters, Faupel, and Derlien 2000, 2). Currently, the remediation of contaminated sites is being carried out by *Mitteldeutsche Sanierungs- und Entsorgungs-gesellschaft*, one of the largest of its kind in the German-speaking world, with 64 landfills and an area of approximately

1,400 hectares, including a wide variety of measurements and protection projects that indicate the need for an "infinite aftercare" of the site.[8]

8 Zett's video work addresses the term and the task of aftercare at TC 00:18:50.

One of these projects is explained in Zett's video. It involves the continued filling of the "Silbersee" pit with incinerated household waste – slag – over the next 15 to 20 years. This slag consists of mineral waste mixed with sludge and is capable of binding toxic waste. Rötschke emphasizes: "You will hardly find any organic matter in there (in the waste, UG)" (TC 00:12:00). During the tour, Rötschke and Zett concentrate on the deposits at these contaminated sites: mineral waste, accessible rubble and shards from Saxony-Anhalt, post-1989 partial landfill privatization, and remediation strategies for toxic waste. In contrast to biographical or documentary-style artistic video works, the real historical moment of the remediation, disposal, and deep-time aftercare of the material legacy of an abandoned industrial site is negotiated here instead. The extent of contamination is such that it will persist for at least the next thousand years. Considering this deep temporal horizon, these cultural practices take on significance beyond the art context, as they engage in modes of "staying with the trouble" (Haraway 2016) – learning to endure and respond to what extractivist regimes have long refused to confront.

Zett's work does not simply exemplify silencing and forgetting; it also thematizes it. *Freiheit 3* ends with Zett's writing performance (fig. 2). This structural element of this layer of the work, which has not yet been discussed here, recurs at various points and forms part of the "contemporary" level of the work. Anna Zett uses red spray paint to write the sentence: "Dear environment / There is something / that I have to / get rid of" on the gravel hill close by a concrete factory in the Leipzig area. The steep mound of coarse gravel serves as a surface in constant flux – eroding, slipping, giving way. As she writes, Zett risks losing her footing. Her performative movements initiate a process of disintegration of her written words. The first sentence stands briefly, with the quality of a slogan; as she continues, her very gestures start the process of erosion. To write the next lines, she must shift the unstable terrain beneath her: "Dear environment / There is something / that is / left / over." Zett's self-penned lines of poetry all address the environment in a tone that resembles a confession ("Dear environment / There is something / that I have to get rid of"; "Dear environment / There is something / that is left / over"; "Dear environment / I bring / my / waste to / you"). Zett's verses also reflect motifs of turning away from one's responsibility ("Dear environment / The waste is / not

mine"; "Dear environment / I / did not / do it") and the helplessness and search for orientation mentioned above ("Dear environment / I / did not / do it / where / with it?").

The lettering is sprayed onto a pile of gravel – that is, onto sedimentary rocks. The materiality of the site is very revealing: the heaped gravel refers to the infrastructural after-effects of extractivism, specifically to dumping, regrouping, and relocation – processes in which economic interests, technology, and practices of political disposal intertwine.[9] The performative act marks the sediment not only as a physical carrier but also as an embodied topography of shifted responsibility. The sentence "I did not do it" denies a clear admission of guilt while simultaneously recalling the exculpatory rhetoric with which "Western" people have relativized their share of the ecological burden on "non-Western," colonized landscapes up to the present day. Similar to the following quote by media scholar Noam Gramlich (2021, 74, translation by the author), in my reading, the pile of gravel becomes a sedimented infrastructure into which extractivist history has inscribed itself materially and epistemically: "Human and non-human bodies, earth, water, and air are involuntary repositories that carry postcolonial violence … to this day, while this history of Europe's media infrastructures remains opaque."

9 While Zett sprays her poetry on the gravel, scenes in relief are shown that depict the painting of the Wall in November 1989 as an act of appropriation of this symbolic object of state terror. In other scenes, protest marches and painted banners become visible in the relief material. With her writing performance, Zett alludes to these resistant banners and wall paintings.

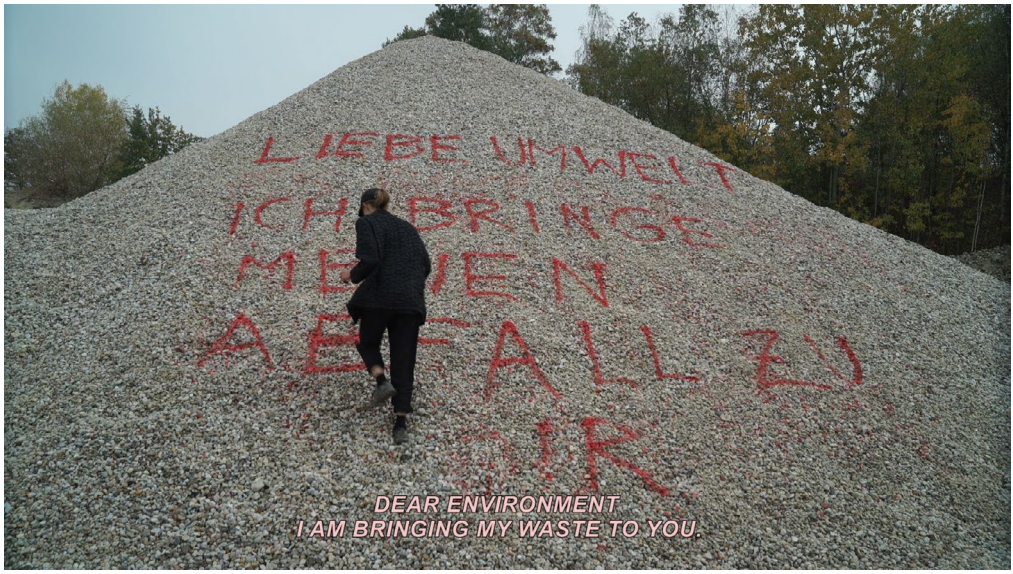
Zett's repeated, performative erasure of the spray-painted lettering stands out in particular. This erasure, initiated by trampling, addresses the problem of the gradual illegibility of the dissident and activist legacy of the transformation period. The trampling of the writing links the problem of illegibility with the main motif of the work: the sedimented industrial infrastructures of the GDR. The red spray paint of the illegible writing is still physically present in the gravel mound after the end of the performance, like the slag from the chemical industry in the Freiheit III landfill. In this way, the elements of stone and writing or language and landfill are brought together in Zett's work.[10]

10 Spraying and wall painting are presented in parallel at TC 00:07:31–00:08:02 and TC 00:10:55–00:11:25.

With regard to aesthetic aftercare, the work aims to unearth what has remained invisible or has often been overlooked. The performative setting makes the surface of the Earth porous for what is stored in the depths – not only materially but also in terms of the politics of memory. Here, aftercare becomes a political-poetic practice that does not evade the sediment but recognizes it as part of a shared present.[11] By focusing on the "naked" material signature of the toxic waste from the GDR regime, *Freiheit 3* addresses the question of the GDR's legacy in the present from a deeply temporal and decidedly "muddy"

11 In her conversation with Rötschke, Zett draws parallels between the long-term security of radioactive nuclear waste and that of the Bitterfeld toxins, see TC 00:16:29–00:16:48.

2 **Writing performance in *Freiheit 3* (Anna Zett, 2020, video still, TC 00:12:26)**



perspective (Randolph 2024). In the video work, the landscape is not treated as a neutral backdrop but as a slag-covered witness to an environmental history. The environmental activist images from the opposition archive and the piled-up masses of gravel refer to sedimentary landscapes as the musty storage media of extractivist history.

Aftercare as a Necropolitical Séance in the Extractivist Zone

In their search for ways to perceive the world's wounds Larisa Crunțeanu and Sonja Hornung turned to the 150-year history of lignite mining in Lusatia. Their artistic research opens up a broad range of methods, from autofictional narration to fragmented quotes, documentary film, and the fabrication of mythologies. These lead the viewer down convoluted paths across the complex field of mining in contexts shaped by state socialisms sustained by fossil and nuclear energy systems, as well as the turbulence of the post-socialist years. The question

I would like to ask in the following is: How do the artists parse research material that is both fact-based and politically sensitive?

Art historians Maja and Reuben Fowkes (2022, 24) address the complex interweaving of the colonial, military, and mining activities in "toxic extractivist zones," problematizing the increasingly invasive technologies and methods deployed to make the Earth's materials available for extractive processes. Given the often Sorbian villages dug up in Lusatia and the associated loss of language and culture, Crunțeanu and Hornung decided to focus on another special feature of the landscapes traumatized by extractivism: the scarred soil. At the beginning of the two-part video installation *Untitled (to slip, to slide, to glitch)* (2024), satellite images are used to show the cracks, furrows, and scars on the surface of the Earth caused by mining (fig. 3). The extent of these transformations is revealed here from a bird's-eye view. The artists describe the satellite images as compositions of self-produced disturbances. They not only point to the permanent changes in the open-cast mine but also to the resulting instability of the ground itself. We see a bleeding landscape divided by a control grid, crisscrossed by trenches and worked by machines. The satellite images evoke the sensation of acidity, bitterness, and the taste of the salt of a wounded Earth's surface (Gerhardt 2025, 47).

In their search for an audio-visual language to sketch the outlines of unspeakable loss, destruction, scarring, and embodiment of the physical landscape, the artists refer to neuralgic points in film and literary history. Moving through the formats of documentary and autofiction, the narrative directs the viewer to what feels like a distant future. Here, in the tradition of naturalistic science-fiction productions, Crunțeanu and Hornung enact scenes reminiscent of the special effects from silent cinema – the fin-de-siècle assembling and disassembling of skeleton bodies (as, for instance, in Louis Lumière's *The Merry Skeleton* (1898) and Georges Méliès's *The Merry Frolics of Satan* (1906)). Their slapstick garb seems to point to the constructed nature of (moving) images, the artificiality of the (post-)mining landscape, and the co-constitution of body and landscape, which, on such sites, can prove deadly due to sinkholes and swallow holes.

The environmental and cultural scientist Stacy Alaimo (2010) criticizes the frequent lack of thinking together of environmental forces and embodiments in cultural and literary studies (Teets 2022, 119). She develops a neo-materialist

3 Lusatia satellite image in *Untitled (to slip, to slide, to glitch)* (Larisa Crunțeanu and Sonja Hornung, 2024, TC 00:02:17)
4 Skeleton dance in *Untitled (to slip, to slide, to glitch)* (Larisa Crunțeanu and Sonja Hornung, 2024, video still, TC 00:18:44)

theory that emphasizes the intersections of social, economic, and political forces and their material effects on people. Her theory of transcorporeality addresses the interweaving of human and non-human bodies with desire, toxicity, death, and interconnection (Alaimo 2008, 260). Dressed in costumes, the artists Crunțeanu and Hornung dance like creatures raised by wolves in industrial architecture and concrete shafts. They evoke the howling of wolves, appear in industrial landscapes as

if risen from churned-up graves, and invoke local mythological narratives, which they fictionalize and recontextualize. Their highly artificial, atmospherically compressed voice-over narration blends together quotes from Margaret Atwood, Sarah Keenan, Bojana Pejić, and Legacy Russell.

Crunțeanu and Hornung also point to the similarities imposed by discourse history between the feminized body and damaged ecosystems, which also tend to be feminized and seen as something that needs to be protected. They rely on German landscape architect Otto Rindt (1906–1994) and his contemporaries, who claimed that "nature" has to be protected from the damage of industrialization and technology. In their view, the landscape architect should also embed industrialization and technology into the "natural" landscape, simultaneously producing and "repairing" it (Heuson 1929). This narrative – a product of the modern "Western" discourse on "nature" – and its associated attempts to repair and rehabilitate the yawning holes in the landscape left behind by mining, which usually only serve to justify ongoing extraction elsewhere, lead the artists to describe their impressions as follows:

> We were uneasy about the apparent feminization of the land present in historical discourses around mining, rehabilitation, and repair, and uncertain about how to address our alienation from it all as dwellers of cities, where the contents of most mines are deposited and consumed, apparently without at all considering the extent of the damage left behind "elsewhere." (Crunțeanu and Hornung 2024)

In *Untitled (to slip, to slide, to glitch)*, the artists experimentally use their bodies to make visible the discursively rehearsed feminization of the landscape in the context of mining, mining work, and the mining industry's self-fulfilling prophecy of rehabilitation and repair in particular. The artists' dance in skeleton costumes through the renaturalized brown coal region of Lusatia (fig. 4) can be read as a confrontational encounter of bodies read as female with fragmented, scarred, and re-greened landscapes. In them, the past traces of GDR extractivism are both clearly visible and – as a result of recultivation – have become difficult to read. In this work, aftercare is staged as a necropolitical séance. The extractive zone is not a neutral terrain but rather a necropolitical space in Mbembe's (2019) sense, in which the boundary between life and death proves to be permeable. It is a place where the exploitation of nature and labor went hand in hand with the

systematic depletion of resources, geologically, socially, and ecologically.

The sand mixed with coal dust from the open-cast mines is not merely an atmospheric by-product but a sediment of extractivist practices: the residue of a state that hollowed out landscapes and wore out bodies. The performative dance on this sandy soil thus becomes a physically bound gesture of return – to toxic soil, to the "material from below" (Husse and Rosenfeld 2019), to the material signatures of the regime. This séance seems like a corporeal, performative retrieval of what has been disposed of and repressed, which continues to circulate in the dust. In this context, aesthetic aftercare does not mean reparation but rather a visualizing responsibility towards that which has been brought to death by exploitation but has never completely disappeared. The landscape is not "repaired" but taken seriously as a damaged witness – in an artistic practice that does not reconcile itself with the ghosts of extractivism but questions them.

Radiation as "Invisible Sediment"

In *Sun Under Ground* (2022), artists Mareike Bernien and Alex Gerbaulet examine uranium as both a nuclear and a non-renewable energy source, particularly on a visual and acoustic level. Uranium has shaped the history of SDAG Wismut and its mining areas in Saxony and Thuringia from its inception to the present day. Due to its extraction from the Earth and its radiation, which is invisible without aids such as UV light or Geiger counters, this raw material has a special relationship to processes of invisible contamination (Gerhardt 2024a). A central focus of this video work is on techniques for presenting evidence of radioactive radiation, and the artists shift back and forth between mythical, technological, and corporeal approaches. Uranium as a limited nuclear fuel is interconnected, in Bernien and Gerbaulet's work, with the history of SDAG Wismut and its mining areas in Saxony and Thuringia from the time of its creation to the present day. *Sun Under Ground* follows the trail of this hidden radiation first horizontally – through today's Anthropocene landscapes – and vertically – through the ground as an archive (Berlinale 2022).

The GDR was the fourth-largest uranium producer in the world. Shortly after the end of the war, uranium ore mining began in 1946 at various locations in Thuringia and Saxony. Under the cover name "Wismut," the Soviet nuclear industry was supplied with more than 210,000 tons of the radioactive raw

material uranium for 44 years, sustaining 60 percent of the USSR's nuclear program. The Wismut company thus became the largest Soviet foreign operation. With SDAG Wismut, the Soviet occupying power pursued the goal of exploiting German uranium deposits – largely without regard for the well-being of people or the environment (Kunze 2021).

Since 2018, Bernien and Gerbaulet have been dealing with the uranium mining of Wismut as part of the project *Wild Recuperations. Material From Below. Artistic Research in the Archive of the GDR Opposition.* They conducted research at the Museum Uranbergbau Bad Schlema, the Ronneburg show mine, the Civic Movement Archive in Leipzig, and the Archive of the GDR Opposition of the Robert Havemann Society, among others. Part of the knowledge received by the artists comes from the GDR-wide anti-nuclear movement and local environmental initiatives. Bernien and Gerbaulet's artistic research spanned several years, and their findings are brought together in the video on both narrative and visual levels. Overall, they emphasize that the historical materials on "Wismut" in the archive of the GDR opposition are quite limited, referring to "Wismut" as a top-secret "state within a state" (Bernien and Gerbaulet 2019, 254). It was not until 1986 – after the Chernobyl reactor disaster – that the consequences of uranium mining began to receive more critical attention in literary and academic contexts (Krause 1987; Wolf 1987). The history of SDAG Wismut is an example of how the Anthropocene, in its socialist coloration (Fowkes and Fowkes 2025), inscribed itself into the landscape. It leads to the top-secret and, therefore, elusive practices of a centralized extractive energy economy. By staging at night and burying recording media such as the X-ray film, the use of UV light, and the images produced with an infrared camera, the video work extends to the edges of the visual spectrum available to the human eye. Through this focus on the barely recognizable, Bernien and Gerbaulet ultimately also undermine expected depictions of the environmental consequences of uranium mining and the non-renewable energy economy, such as moonscape-like soil erosion, abandoned villages, dead forests, slag heaps, sewage lakes, sludge dumps, or pollution of large swathes of land.

The history of SDAG Wismut can be understood as the cumulative effects of a toxic and unsettling material that acts on the human nervous system and cell structure like an unknown agent, without this process being perceptible to the senses (see, among others, Schwab 2020, 8). The preservation of evidence for the effects of nuclear radiation and the history of Wismut, which is kept under lock and key, is also portrayed

as highly unstable in *Sun Under Ground*. Jussi Parikka assumes that the twentieth century's new types of radiation are stuck in our bodies like sediments:

> New kinds of rays, but also the harnessing of old kinds of chemical reactions, have produced a new sort of time, that of a toxic era. We carry with us that time as a different type of archival memory, not one read by human eyes and written in the usual form of normal library content, but one that is measured by the rattle of the Geiger machine as much as by the sedimentation of various toxins of the 20th century, which our bodies literally carry with them. (Parikka 2016, 117)

Framing radiation as a bodily sediment highlights a field of tension within media and body theory. Its traces remain inaccessible to direct visual or corporeal perception, yet are rendered detectable through technical mediation and epistemic reconstruction (Angus 2024, 167, 177). Similar techniques circling around the political and actual in/visibility of the mineral uraninite partially also characterize artist Susanne Kriemann's body of work *P(ech)B(lende)* (Kriemann 2016; Angus 2024, 167). In Kriemann's accompanying publication, the artist Susan Schuppli discusses the film material from *Chernobyl: Chronicle of Difficult Weeks* (1986) by Vladimir Shevchenko, in which radioactive particles inscribed themselves on the emulsion layer of the film (Schuppli 2016, 153–57). Herewith, the reel of footage has been transformed into an actual "material witness" (ibid., 145; Schuppli 2020), that is, into entities that "do not merely represent events but are themselves continuous *with* and materialized *as* events" (ibid., 161). In *Sun Under Ground*, however, radiation is staged as a sedimented trace – a transformative and toxic force that inscribes itself into matter, bodies, and technical media: through acoustic experiments, apparatus-based image carriers (such as radiology monitors), and material processes that invite archival contemplations (such as Bernien and Gerbaulet's video still of the blasting operations at Wismut uranium mining sites, fig. 5). Parikka (2016) also describes such inscriptions as material sedimentations. The body functions as a material archive of toxic history and bears the traces of radioactive contamination in the GDR as archival time, which manifests itself primarily as bodily inscription. These latent traces are only fragmentarily legible through media devices such as the Geiger counter.

A central figure for encircling the immaterial, elusive dimensions of radioactive processes is the scanning of stones

5 Wismut blasting in *Sun Under Ground* (Mareike Bernien and Alex Gerbaulet, 2022, video still, TC 00:10:04)

with a Geiger counter, which Bernien and Gerbaulet use to reflect on aesthetic aftercare in *Sun Under Ground*. In doing so, they follow a methodology of trace and hunch – the camera becomes part of the aftercare by carefully circling around what cannot be shown. The pile of gravel, the sand, and the radiation are material sediments that extend beyond mere natural deposits. They store the residues of industrial environmental pollution, economic exploitation, and political control in the GDR's environmental history. In *Sun Under Ground*, these sediments are made epistemologically accessible through an aesthetic layering of media, voices, and apparatuses that manifest what has become illegible. In its aesthetic aftercare, the work negotiates both the persistence of toxic materials and their medial constitution – as legacies of extractive operations.

Conclusion

Rather than reinforcing the iconographic memory of ecological collapse in the GDR (Huff 2014, 523), the artistic practices examined here engage planetary processes of unearthing, undoing, and virtually storing sediments (Falb 2019, 258–59, 267). Video, as a time-based medium, enables a layered and temporally shaped form of engagement. It creates a temporal space in which one can dwell with what disturbs – lingering, returning, recuperating, speculating – while resisting closure. The artists' performative practices of aftercare form a mode of artistic research that persists in confronting environmental and historical damage, even when it exceeds the artists' capacity to act, to fully comprehend, or to repair. The challenge in encountering the slipping grounds after extraction is to remain present with the unease in the face of devastated landscapes. In this sense, the video works approach (after)care as a situated, iterative practice of relating to the material, symbolic, and affective interconnections of extractive pasts and their lingering toxicities. They enact forms of maintenance, attunement, and embodied response across damaged terrains.[12]

12 The artists seem to practice a form of careful wit(h)nessing: staying close without erasure, mourning without paralysis (Ettinger 2001).

This form of aesthetic aftercare can be understood as ecofeminist in its refusal of closure, its insistence on staying with the trouble (Haraway 2016) and the anxiety, and its commitment to continually re-engaging with the "messy grounds" (Knaup 2021, 113) – not by freezing or turning away, but by aligning with a planetary feminist praxis (Tsomou 2022) that acknowledges asymmetrical entanglements and differential responsibilities across space, time, and matter. The spaces of aftercare opened by these video works invite ways of thinking with sediments and ruins (Tsing 2015; Randolph 2022, 12), sensing attritional violence (Nixon 2013; Angus 2024, 168–69), caring for and carrying one another (Puig de la Bellacasa 2017; Ettinger 2024), and imagining forms of response-ability that are neither singular nor sovereign, but collective, embodied, and unresolved – and therefore ongoing. The artists develop methods for engaging with the material and symbolic dimensions of extractive formations, approaching their residues not only as markers of environmental and political histories, but as active sites for (re)thinking earthly matters.

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Re-cycling Cinema

Felix Hasebrink

Recycling is a popular strategy for waste reduction and is often assumed to boost eco-friendly production – in private households as well as in industrial contexts, including audiovisual media. However, the actual effects of recycling have come under increasing critical scrutiny. This chapter offers a re-evaluation of recycling in relation to moving images by arguing for a conceptual shift: instead of viewing recycling solely as (questionable) waste management, it proposes understanding recycling as a broader set of material movements within the production of moving images, one that widens the current focus in film studies on raw material input and, to a lesser extent, on waste output. Tracing these movements through theories of film materials and philosophical concepts of geological stratification and material flows, the chapter explores how recycling enables an understanding of film as a layered material constellation rather than as a solid, closed-off object. A concluding case study illustrates how recycling – as a practice that engages with cinematic remnants – can both open up and re-embed moving images within physical environments.

Keywords: Recycling, Film, Materiality, Extractivism, Waste

Cinema Geologica

A distant mountain range, a barren desert, and a solitary person with a pair of contact microphones: this is the set-up of Ulrika Sparre's short film *Ear to the Ground (Wandering Rocks)* (2020).[1] The Swedish filmmaker sets out to collect sounds of rocks in Death Valley National Park (USA), one of the hottest and driest areas on Earth. Besides Sparre, the camera does not capture any living beings in the vast arid landscape. Yet there are further audible movements. Sparre's microphones register a muffled creaking and clacking in the rocks, presumably not only triggered by gusts of wind on the rock surfaces but hinting at forms of motion within the rock itself.

Sparre's film testifies to a growing fascination among documentary filmmakers for geological processes and the underground. Filmmaker and scholar Sasha Litvintseva understands this trend as part of an overriding interest in non- or more-than-human phenomena. The geological, she writes, represents a "limit case of the human attempt to grapple with the nonhuman" (Litvintseva 2022, 38), which becomes an imperative concern in the face of the ongoing climate and biodiversity crisis. Many films, like Sparre's, envision the geological as processual – a domain that is permeated by multiple movements, even if these exceed human perception and human-centered time frames.

In parallel with films and other artistic works, film and media studies have also become increasingly interested in geology. Since the 2010s, the geological informs new research on media materiality, notably regarding the physical hardware of digital media (Parikka 2015). Film scholars like Nadia Bozak or Adrian Ivakhiv started to probe new approaches to examine what Ivakhiv (2013, 38–40) calls the "material ecology" of moving images to account for the multifaceted entanglements of films in real, physical environments. While Ivakhiv (ibid., 25), as he himself admits, only hints at these relations and does not fully investigate them, Bozak (2012, 18, 54) tries to unearth specific connections between cinematic aesthetics, natural resources, and ecological impacts through concepts such as "fossil image" or "resource image." A preliminary culmination of this research are works like Siobhan Angus' (2024, 4) recent book *Camera Geologica*, which revises the history of technical image media such as photography and film from "the perspective of the mine." In a way, then, film begins underground as well: with minerals that need to be mined, refined, and processed in order to build the infrastructure and technical components

1 The film was part of a program titled *Four Lessons in Cinematic Stratigraphy* that Petra Löffler and I curated together with the workshop from which this chapter emerged. Other films in the program were *Dark Matter* (2020, Victor Brim), *Mined Soil* (2015, Filipa César), and *Freiheit 3* (2020, Anna Zett). See Ulrike Gerhardt's contribution in this volume for a detailed reading of *Freiheit 3*.

1 Small rocks as an accumulation of granular matter in *Ear to the Ground (Wandering Rocks)* (Ulrika Sparre 2020, film still, TC 00:07:22)

necessary to create moving images. The penultimate shot in Sparre's film provides a fitting image for such a focus on small, granular, elemental matter: the filmmaker holds a small pile of pebbles in her hand, which she lets trickle to the ground, stone by stone (fig. 1). It is crude and gritty matter such as this that the fabric of film, in a physical sense, is actually made of.

In what follows, I take up the call to pay more attention to the physical building blocks of film. However, my aim is to broaden this line of research beyond the pervasive focus on extracted minerals and "the mine." I propose to take a closer look at areas where physical materials needed to make films turn into waste but can spark new material cycles. In other words, I will approach the "material ecologies" (Ivakhiv 2013, 38) of moving images through the lens of recycling. For me, this perspective is not necessarily in contrast to the geological, which – at first glance – seems to be more associated with solidification and permanence, less with circulatory movements. It is precisely geologic processes that point to physical traces and remains of moving images – and the many places where these remains are deposited, left behind, and slowly accumulate. Material practices of recycling then suggest that these places are not

dead ends. The "stuff" that moving images are made of moves in many directions, some of which lead not only to junk yards, landfills, and incinerators.

The perspective on recycling that I propose strives to go beyond the usual, often rather vague and metaphorical uses of the term. Recycling in moving images is not just some continuation or reworking of images, scenes, or creative ideas that were developed elsewhere. I take recycling to be a specific movement of film-related *materials* that, at some point in the lifespan of moving images, have become waste. Bearing in mind that waste is a notoriously elusive and slippery concept, marked by uncertainty and indeterminacy (Liboiron and Lepawsky 2022, 55–58), I take these waste materials to be momentarily useless remnants discarded during or left over after production and distribution activities. Some of these remnants can be picked up again and fed back into filmmaking processes. Paying closer attention to these movements can lead to a more nuanced understanding of films (and other types of moving images) as open material constellations, not as fixed objects.

I develop this argument in four steps. First, I will examine general discourses of recycling – including its current criticism in waste and discard studies – and focus on cases where recycling indicates specific material processes. Second, following these links between recycling and (waste) materials, I will investigate recent discussions of cinematic materials, specifically in the context of research on media, elemental materials such as minerals and chemical substances, and extractivism. I understand "extractivism," following Imre Szeman and Jennifer Wenzel (2021, 506), as a two-dimensional concept: it is "a mode of economic production in which 'natural resources' are taken out of one geographic location ... and utilised as 'raw materials,' that is, as inputs to industrial processes elsewhere," but also a "cultural and ideological rationale" (ibid., 508) that underpins this economic logic and can also be a consequence of it. Third, I will try to expand the perspective on media and resource extraction by connecting film materials to philosophical concepts of layering and material flows by philosophers Gilles Deleuze and Félix Guattari, and anthropologist Tim Ingold. Recycling comes back into play here as a material movement between "layers" of moving images. Lastly, I will discuss a short film where the recycling of film-related waste materials becomes artistic practice. The film translates the idea of cinematic layers into a specific aesthetic form, thereby indicating that recycling

can “open up” and reconnect moving images to physical environments.

Recycling and Material Trajectories

Recycling, as a term related to waste, dates back to the 1920s. Historian Finn Arne Jørgensen (2019, 8) reconstructs that the term first emerged as a technical concept, denoting cyclic recovery processes for chemical liquids. The activity itself – the recuperation of waste materials to funnel them back into agricultural or industrial production – is arguably much older, and so are attempts to conceptualize circular movements of matter. In his influential study on *Animal Chemistry* (1842), Justus von Liebig described chemical conversion processes in living organisms as a “metamorphosis” and “change of matter” (“Stoffwechsel”), thus providing foundational observations on what became known as “metabolism.” In his *Critique of Political Economy* (1859), Karl Marx used the same term to describe the conversion of “natural products” or “elements” into goods through human labor and the ensuing circulation of these goods as commodities in capitalist societies. However, it was not until the first half of the twentieth century that organized practices of “recycling” acquired a proper name, and that recycling was explicitly linked to the waste streams generated by industrial manufacture.

For several decades, recycling remained a purely technical term. Toward the end of the 1960s, however, it resurfaced as a prominent buzzword within the environmental movement, specifically in the context of the first “Earth Day” in April 1970 (Jørgensen 2019, 1–3). At the same time, the first anti-litter campaigns began to publicly frame recycling as, in Gay Hawkins (2006, 34) words, “virtue-added disposal,” encouraging morally “upright” ways of managing one’s private household waste. Today, as Jørgensen (2019, ix–x) summarizes, recycling is at once a series of material processes, a complex infrastructure, a set of sociocultural values, and an array of different ideologies. Recycling blends habits of consumption with disposal routines, ethical considerations with policymaking, non-profit initiatives with business agendas.

This mélange helps explain why recycling has become a somewhat contested concept within the emerging fields of waste and discard studies. Researchers have shown that recycling has repeatedly been susceptible to corporate cooptation (MacBride 2012). Companies and lobbyists can

effectively use recycling initiatives to divert public attention away from the excessive generation of waste "upstream" – during resource extraction and manufacturing – and redirect it toward consumer behavior, which has a comparatively smaller ecological impact. As a waste processing infrastructure, recycling can even create further waste and pollution due to transportation and shipping. Moreover, it has not yet resulted in a meaningful reduction in the mining of raw materials (Hird 2024, 36–46; Liboiron and Lepawsky 2022, 67–69). Against this background, the broader vision of recycling – the creation of a closed loop with no need for further external resources – may indeed remain an alluring, yet ultimately unattainable "promise of salvation," as historian of technology Heike Weber (2020) puts it.

Contemporary audiovisual media are marked by similar hopes, promises, paradoxes, and pitfalls surrounding recycling, as seen in other industries. The term figures predominantly in debates about how moving images can reduce their own ecological footprint. Recycling pervades numerous "green production" manuals (PGA Green 2014) and is usually required to obtain subsidies from film commissions and funding bodies (Arbeitskreis 'Green Shooting' 2024). As such, recommendations to recycle film equipment, set constructions, plastic packaging, or used oil are both necessary and reasonable. Yet, as in other sectors, media conglomerates can easily use recycling to "greenwash" their product portfolio and avoid regulatory scrutiny (Maxwell and Miller 2012, 82–83), thereby continuing environmentally destructive practices behind the scenes (for instance, the sheer mass of new content produced for streaming platforms, or tax rebate schemes and subsidies that lead to more travel and more production abroad[2]).

2 Thanks to journalist and FFA Green Cinema consultant Birgit Heidsiek for pointing this out to me.

Although recycling is now strongly associated with sustainable or "green" production practices in response to ecological crises, it is not a recent development in audiovisual media. Angus (2024, 89–95) discusses a notorious example, relevant for both still photography and film. In the first decades of the twentieth century, the company Eastman Kodak rose to prominence as one of the largest suppliers of raw film stock. At the time, film was made from cellulose and was coated with a thin emulsion of silver. The company's silver consumption was enormous – as was the quantity of toxic waste it generated. Kodak's residue contaminated soil and groundwater around its plant in Rochester, New York, as well as the adjacent Genesee River (Maxwell and Miller 2012, 72–74). To stabilize supply chains, Kodak implemented silver recycling operations early on.

Angus (2024, 93) shows how the company created its own in-house "silver mine" to extract silver from discarded shreds of film. In this way, Kodak was able to constantly feed remnants from its own products back into manufacturing.

The Kodak case illustrates that recycling does not inherently equate to eco-friendly production. Rather, it provides a more nuanced picture of what recycling in film and media can actually entail. Similar salvage operations were – and still are – a feature of other areas of film and media production. Well-documented historical examples include the recycling of used sheets of cellulose acetate ("cels") in animation studios (Frank 2019, 37, 141), or the repeated recycling of inexpensive film sets in British film and television during the 1960s and '70s (Ede 2012, 53–54). These recovery processes shift attention away from the reuse of entire artifacts toward more basic materials such as silver, cellulose, or wood. They underscore that recycling often involves disassembly, breaking down, or shredding residuals (processes that may, admittedly, generate new waste). At its core, recycling entails the separation of valuable components (e.g., Kodak's silver emulsion) from worthless ones (e.g., the cellulose base). From this perspective, waste is not a static endpoint, but a zone of latency and potential transformation.

The idea of latency also runs through Michael Thompson's *Rubbish Theory*. For Thompson (2017, 24–27), waste constitutes a zero-value phase through which everyday objects ("transients") must pass before potentially regaining value as "durables" (collectibles, antiques, vintage cars etc.). Recycling represents an alternative trajectory out of the waste zone – but one in which objects do not remain physically intact, as Thompson implicitly assumes. This is precisely what distinguishes recycling from other forms of (re-)use. *Reuse* refers to an object that is no longer needed but still intact and suitable for its original purpose; *repurposing* implies a new context or function. *Recycling* alone, however, involves a proper "becoming waste" followed by disassembly or physical decomposition. Through this, discarded objects are returned to a state of undifferentiated materiality.

Recycling, then, traces the trajectories of materials – rather than fixed objects – as they circulate through cycles of production, use, and disposal. It raises questions about how, where, and in what directions materials move once they have been discarded as residue or by-product. In the field of moving image media, the recycling concept therefore leads to the question of what exactly can be understood

by "materials" – and what the term, in relation to film, can potentially include.

Elemental Film Materials

Examples such as the enormous demand for cotton, silver, and water at Kodak have recently come into focus in new research exploring the links between moving images and extractive economies. Increasingly, scholars emphasize that extractivism – the transformation of environments into property for violent exploitation – was fundamental for the emergence of mass media such as photography, sound recording, and cinema. As media scholars Priya Jaikumar and Lee Grieveson argue, this becomes especially apparent in the political histories of the "materiality" of moving image media. For them, materiality primarily means a long list of minerals, chemicals, and other "raw" materials: "copper, camphor, silicon, lithium, oil, silver, coltan, tin, and so on" (Jaikumar and Grieveson 2024).

In *The Cinema of Extractions* (2025), media historian Brian Jacobson connects this new attention to the elemental matter of media to cinematic forms and their historical development. In doing so, he attempts to develop a more systematic account of how cinema relates to extraction (and vice versa). Following Tom Gunning and André Gaudreault's concept of a cinema of attractions – films around 1900 based primarily on exciting spectacle and visual stimuli – Jacobson (2025, 41–48) observes that the infrastructure of extractive industries (oil fields, derricks, mines, trains, etc.) was a frequent visual "attraction" in early cinema. At the same time, the products of extractive industries created the necessary infrastructure for cinema as a new, rapidly expanding image technology. Jacobson (ibid., 36) argues that at the turn of the twentieth century, extractive industries and cinema joined forces to bring forth a particularly modern vision of the world, shaped after the fantasy of a continuous exploitation of bottomless natural resources. Films, made possible by large-scale mining, portrayed the world as endlessly "manageable, usable, and manipulable."

The early cinema of extractions is the most explicit and, arguably, foundational link between film aesthetics and extractivism. Jacobson traces this relationship through subsequent iterations: the recurring presence of mining and drilling in narrative films and documentaries from the 1910s onward; industrial films about resource extraction from the 1960s; and what he terms the "cinema of resource integration." In this latter category, extraction rarely appears onscreen as a

subject, but persists as "structuring absence," perceptible only in "latent form" (ibid., 16).

Jacobson frames his study not only as a historical investigation of the entanglement between image technologies and physical resources. He also understands his work as a methodological intervention, that is, as a new way of reading films. He proposes a model for analyzing "film materials and their forms" (as the subtitle of his book puts its), drawing on a linguistic framework by Louis Hjelmslev. Expanding Saussure's dual model of signifier and signified, Hjelmslev had introduced the categories of "expression" and "content," each with sub-categories of "form" and "substance." Jacobson adapts these to create a heuristic grid of four domains for analyzing film: Category 1, "substance of content," comprises "the raw material, including ideas and material things, available for cinematic and media representation." Category 2, "form of content," covers "the forms that this raw material takes in the world independently of the cinema and prior to filming." Category 3, "substance of expression," concerns "film and media materials, techniques, technologies and industries," while category 4, "form of expression," addresses "audiovisual representations" and "elements of media language" (ibid., 23).

In Jacobson's adaptation of Hjelmslev's model, the first two categories pertain to phenomena external to cinema, while the latter two address the material and aesthetic dimensions of film itself. The term "raw material" functions across multiple categories, which may cause some conceptual ambiguity. In category 1, "substance of content," the term refers to pre-existing physical reality that can be represented in film – a notion that resonates with Siegfried Kracauer's (1960) theory of film as a medium particularly attuned to capturing physical reality. Friedrich Balke (2015) even interprets Kracauer's work as a theory of cinematic "raw materials." Meanwhile, Jacobson's category 3 references "raw material" in a more literal sense: as the chemicals and minerals required to make and operate image technologies. Oil and coal serve as concrete examples.[3] The raw material of film, according to Jacobson, can thus be "content" as well as "expression." Both dimensions are foundational, but they address different aspects of cinema's material basis.

Jacobson's focus on coal, carbon, or tungsten is typical for the growing interest in film studies on the elemental underpinnings of media. Yet, these elements are not the only constituents of what could count as film "materiality." The "techniques, technologies and industries" in Jacobson's third category could

3 Jacobson's following case studies of carbon and tungsten indicate that, in addition to geology, chemistry is also an important point of reference. On the renewed interest in chemical elements in the humanities, see Papadopoulos, Puig de la Bellacasa, and Myers (2021).

potentially include more variants of "film materials" beyond minerals or chemical elements. Before moving on to the question of how recycling might figure in such a model, I would like to outline three more possible meanings of film materials – because some of them complicate the categorical distinctions that Jacobson introduces.

A third meaning of "film material," in addition to physical reality or chemicals and minerals to build and operate film technology, can be the respective cinematic carrier medium: celluloid, magnetic tape, 16mm or 35mm stock, and their digital counterparts (codecs, storage formats, hard drives, etc.). These are traditionally seen as part of the medium's "materiality" in media studies, and they clearly fall within Jacobson's "substance of expression."

A fourth meaning of "film material" would be *footage* – larger volumes of uncut shots or sound recordings. Footage is tied to logistical concerns (storage, cost, shooting ratios), but also exists as a distinct aesthetic entity. In the state of footage, moving images differ from edited shots (Hasebrink 2024, 259–65). Footage is therefore yet another "raw material" of film, although only in contrast to later edits. In Jacobson's terms, footage is rooted in physical processes of filmmaking (category 3), yet it also belongs – at least partially – to category 4 ("form of expression").

Finally, film materials can include the broader physical *infrastructure* necessary for production: studio spaces, cameras, hardware, props, server farms, etc. Some of these items are harder to classify within Jacobson's scheme. Props can serve as a case in point. Props come in all shapes and sizes. They can become noticeable onscreen as important "cinematographic objects" (Pantenburg 2022) but may also be accumulations of nondescript "stuff" that film viewers usually overlook. Props are not raw materials in the sense of crude resources that have to be mined, refined, and brought into shape for further manufacture. Props are existing physical things, some of which are also used in real-life contexts. In some cases, props are actual trash – wasted objects, collected by set dressers, that are given new aesthetic value by putting them in front of a camera (Bloch 2013). In Jacobson's matrix, they would be substance and form of expression at the same time – or rather, in the case of props, a sharp distinction between substance and form makes little sense.

Film materials, in a broader sense, can thus go beyond elemental minerals or chemicals. While understanding the

materiality of film as natural resources arguably has theoretical and methodological advantages, it does come with some side effects, as the work of Grieveson, Paikumar, and Jacobson implicitly suggests. For one, the focus on natural resources tends to overemphasize the "input" side of media materiality while downplaying the other logical end – the "output" side of waste, residue, and lingering remains. Moreover, it risks portraying material movement as a one-way street. Crude materials, pulled from the earth, are assumed to flow from the (literal or metaphorical) mines straight into moving images. This conception leaves little room for other movements of materials – including recycling. Yet processes and practices of recycling, as I outlined them above, indicate that materials of media do not just move in one direction. Disposed materials can loop back, re-enter assembly and manufacture, take detours, and flow in circular movements "through" moving image media. Recognizing these trajectories requires a more expansive notion of what "film material" is, how it constitutes levels of cinematic materiality, and how it may be recycled.

Layers, Folds, and Leaks

Long before current discussions of audiovisual media and their ecological footings, Hjelmslev's four-part model made a prominent appearance in Gilles Deleuze and Félix Guattari's *A Thousand Plateaus: Capitalism and Schizophrenia* (1987, 43). For Deleuze and Guattari, Hjelmslev is first and foremost a geologist. They interpret his matrix not as a mere extension of the signifier/signified binary, but as a model of double layers or "strata." Hjelmslev provides the conceptual framework for what Deleuze and Guattari call a characteristic "double bind" in layered structures. Strata, they argue, always come in pairs. Moreover, each stratum is further divided into two additional, internal layers (ibid., 40–41).

Strata emerge when matter – "the unformed, unorganized, nonstratified, or destratified body and all its flows" (ibid., 43) – takes on specific forms or structures. To illustrate this process, Deleuze and Guattari refer to geological sediments and rock formations. They argue that in any given pairing, including geological layers, one stratum typically serves as substratum for the other. The main role of the substratum is to provide "substantial elements" (ibid., 49). Deleuze and Guattari call these elements "materials" (ibid.). These materials are initial "forms" of matter and constitute a sort of "prebiotic soup" (ibid.) from which a stratum draws its constitutive elements. Strata can

thus be understood both as "content," in the sense of formed matter, and "expression," in the sense of functional structures.

This duality does not amount to a static system. Deleuze and Guattari emphasize that each stratum has dimensions of content and expression (and corresponding forms and substances), relative to other strata. Consequently, they interpret Hjelmslev's matrix not as a fixed grid, but as a relational model of shifting forms and functions. In this aspect, their reading of Hjelmslev differs from Jacobson's. While Jacobson understands Hjelmslev's model as a potential classification to differentiate between raw materials, infrastructures, and media representations, Deleuze and Guattari would probably argue that these categories are just examples of cinema's many internal stratifications. Crude materials, technologies, infrastructures, different physical supplies and, ultimately, the resulting films would simply be different cinematic "strata" that can both serve as content or expression, and that are internally divided into shifting substances and forms.

This applies not only to the granular raw materials that Jacobson and other authors are interested in. Other cinematic materials could equally be understood as layers or strata. For instance, technical equipment could be regarded as the "expression" layer of a substratum composed of aluminum, magnesium, brass, or plastics. Technical equipment, in turn, would be a substratum for the layer of moving images. Seen in this light, cinema or moving images become a system of many different double layers or strata.

In this line of thought, film-related waste would constitute yet another layer of moving image media. All variations of film materials that I sketched out above can potentially become waste – and this waste does not just disappear. In some places, film waste appears as actual accumulations and stratifications – for example in archive depots where outmoded technical equipment is slowly piling up. In the words of filmmaker and curator Dorothee Wenner, these remains of film machinery form "geologically precise waste layers" (quoted in Schneider and Strauven 2013, 410), patiently waiting to be examined by future film scholars (fig. 2). Another example for the "geological" condition of cinematic residua are sites where the remains of weathering sets or backdrops have been left behind, are slowly dissolving into small particles and seeping into the ground. Processes of recycling, then, would be transfers and transitions from this layer of waste to other strata, potentially still within the medium of moving images. Recycling

2 “Layers” of obsolete technical equipment in a typical film archive depot (Source: Felix Hasebrink 2024)

means that materials move within a layered or “stratified” system to adopt new positions and functions.

Deleuze and Guattari’s idea of matter as a “flow” from which specific material entities emerge is a cornerstone of recent concepts of materiality that favor process and change over stable, definite artifacts. From the perspective of ecological anthropology, Tim Ingold develops a concept of materiality that takes greater account of the active capacities and “flows” of physical materials in processes of making. This, for Ingold, leads to a new perspective on crafted things – and also, I would add, to a new perspective on filmmaking and the recycling of film materials.

Ingold’s (2012, 432) reflections start with two usual views on materiality: raw or “brute materiality” as the tangible, physical quality of the world, and the idea of human beings appropriating raw matter to turn it into artifacts. These two views are complementary. And, according to Ingold, they are equally problematic. Both perpetuate the idea that all things

are essentially a synthesis of matter (*hyle*) and form (*morphe*), a bedrock of Western thinking that goes back to Aristotle. Hylomorphism, says Ingold (ibid., 432–33), assumes that to create things is to impose a preconceived design on a passive lump of matter. Interestingly, contemporary media studies research on copper, silver, camphor, or gelatin also tends to view these extracted materials as basic "matter" to be put into specific (audiovisual) forms – as Jacobson's distinction between the "substances" and "forms" of cinematic expression implicitly suggests. The critique of hylomorphism in ecological theories of materials, as advocated by Ingold, has not yet been considered in the context of research into the fundamental material components of moving images.

Ingold's own project is to establish a different idea of making that moves beyond the hylomorphic dualism. He argues that making, seen from the perspective of the practitioner, means attending to the immanent movements and variations of materials. In *A Thousand Plateaus*, Deleuze and Guattari (1987, 405–16) had already given an extensive description of how metallurgists follow the movements of metal – a prime example for their idea of undifferentiated matter. Briefly returning to Hjelmsev's model, they even described the iterant metallurgist as a possible "form of content," but without directly linking this idea to their theory of doubly structured layers.[4] Ingold follows up on their findings. For him, making is basically a "process of growth" (Ingold 2013, 21). Materials themselves are active; practitioners carefully "intervene in worldly processes that are already going on" (ibid.). Instead of imposing forms, they "correspond" to materials by "drawing out or bringing forth" the "potentials immanent in a world of becoming" (ibid., 31).

4 To my knowledge, Deleuze and Guattari's theorization of mines, underground labor, imperial administration, and nomadic artisans has not yet been taken up in current discussions of extractivism.

Ingold's theory of materiality is instructive for film, because it not only rejects a certain idea of (manual) making, but also a conventional idea of the resulting artefact. Making, for Ingold, brings physical things into being, but things are never fully complete. They are processual, porous entities, not impenetrable, closed-off containers. Ingold compares this capacity of things to living bodies that constantly absorb and expel other materials. Ingold argues that this constant give and take is necessary for things – and bodies – to sustain themselves over a longer period of time. Bodies and things, in short, are "leaky" (Ingold 2012, 438).[5]

5 This argument connects to a central observation from discard studies: The disposal of residue is system-preserving and thus an instrument of political power, but not a bad thing as such (Liboiron and Lepawksy 2022, 61–65).

Following Deleuze and Guattari, moving images can thus be understood as layered structures that, as Ingold would say, are permeated by porous openings. In such a system, recycling, on the one hand, is an exchange relationship between layers, a

movement of materials from a layer of "waste" to another. On the other hand, the recycling of waste materials would not just be a technical, abstracted industrialized process. Following Ingold, recycling can be a form of attentive making, of engaging with materials.

Grounding Film

Films, too, are leaky things. Over the course of their lifespan, they constantly emit residue, during their own production as well as throughout their distribution, consumption, or later storage. Some of this residue – broken equipment, obsolete hardware, office waste – may be directly channeled into the usual waste management infrastructures. Other types of remnants can be recycled – not just in industrial contexts, but also in artistic practices.

A widely discussed form of recycling in experimental filmmaking is working with pre-existing, "found" footage. Filmmakers take footage, originally shot for other projects, and use it to assemble a new film. Occasionally, this footage is visibly damaged or decaying. In these cases, filmmaking becomes a direct form of "cultural recycling" (Knowles 2020, 29) of rejects and discards, most prominently in "ruin films" such as *Decasia* (2000) by Bill Morrison. Some filmmakers deliberately damage footage themselves, for instance by exposing it to wind and rain, submerging it in different liquids or by burying it underground. Possible forerunners of this practice were the West German film collective Schmelzdahin. The group assembled their short film *Stadt in Flammen* (*City in Flames*, 1984) from scenes taken from the French-Canadian feature *Cité en feu* (Alvon Rakoff, 1979) which they had previously buried, exhumed, and copied onto a new reel, thus preserving the visual effects of the decomposing emulsion.

Schmelzdahin pioneered an artistic practice that media scholar Olga Moskatova calls "bacteriogrammatical" (2019, 307): filmmakers allow soil bacteria to leave visible marks on buried celluloid. The buried strips of film may contain pre-existing footage (as in Schmelzdahin's case), but can also be transparent blanks, or unexposed, yet already developed black frames.[6] In all these cases, the process of burying film is generative. It causes material impairment of the celluloid, but this leads to new images, even though the results may be hard to calculate beforehand. I would like to take a closer look at a film that also owes its creation to the practice of burying, but – in contrast

6 A well-known example is Emmanuel Lefrant's *Underground* (2001). The film collective *silt* from the San Francisco Bay area also buried unexposed celluloid film (Vergé 2016), as did Greta Snider for *Quarry Movie* (1999), and, most recently, Jacquelyn Mills for her documentary feature *Geographies of Solitude* (2022) (see Wedel 2025).

to many other examples – understands this, very directly, as a material recycling of film-related residues.

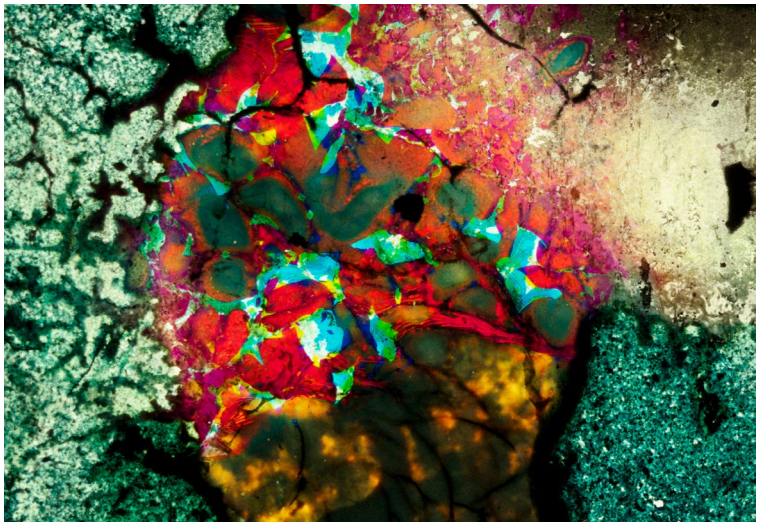
Jennifer Reeves's *Landfill 16* (2011) consists of outtakes that Reeves originally shot for her double-projection installation piece *When It Was Blue* (2008). The outtakes are leftovers from the editing process. They represent surplus material that was no longer needed at some point during the completion of the film, and which Reeves would normally just have disposed of. Instead, she decided to temporarily bury the 16mm outtakes in her garden in Elkhart, Indiana. Later, Reeves exhumed the film, colored parts of the frames by hand, and edited the material into a nine-minute short film.

The resulting film looks like a cinematic soil sample. *Landfill 16* does not depict the garden patch in a figurative sense but allows soil to inscribe itself into the material. In a way, Reeves seems to have "developed" the footage a second time, with the help of subterranean microorganisms instead of the usual chemical solutions. This second-order development is intended to retain as many indexical traces in the frames as possible. *Landfill 16* shows biochemical decomposition at work – slightly altered, of course, by Reeves's own artistic interventions. Muffled sounds accompany the images, as if they were recorded underground as well (fittingly, the soundtrack includes actual recordings of a bulldozer, as well as noises from old 16mm film equipment).

The physical decomposition and Reeves's manual reworking of the frames have strong aesthetic effects. Instead of discernable shots, *Landfill 16* consists of granular visual matter, structured by different qualities of movement. Patches of imagery pop up and vanish, crinkle and bubble, swell and disperse, swing back and forth. Moreover, the moving images gain painterly and sculptural qualities, as Knowles (2020, 78) and Moskatova (2019, 291) observe in other buried films. In *Landfill 16*, the painterly surfaces of the pulsating moving images sometimes appear like a veil of fragile stains of color, fissures, and fine cracks (fig. 3). The original footage occasionally shimmers through, or flashes up, in particular throughout the second half of the film. Briefly, shots of a groundhog, two deer, a spider, or a bird become perceptible (fig. 4). Yet, only split seconds later, these shots collapse and disintegrate.

Overall, then, *Landfill 16* functions like a look inside an active landfill. Viewers can witness footage dissolving into grainy particles and color fragments, resembling the undifferentiated, yet colorful mass of decaying refuse in a garbage pile or

3 and 4 Painterly surfaces of decaying celluloid and brief glimpses of footage still intact (in this case, a shot of a flying bird), in *Landfill 16* (Jennifer Reeves 2011, film stills, TC 00:06:39, TC 00:08:07)



a compost heap. Reeves's film presents a kind of sped-up version of natural decomposition, made visible via a dual structure: the original footage, still visually present at times, and the ongoing dissolution of this very footage, presumably triggered by fungi and bacteria – even if the exact involvement of these non-human co-agents remains speculative, as Moskatova (2019, 307) emphasizes in her description of film-burying practices. Throughout the film, these two layers relate to each other in a compositional logic of foreground and background. There is a prominent visual "front" of the dissolving effects, and the corresponding, intermittent "behind" or "underneath" of the original shots. On the visual surface of the image, patterns of decaying emulsion and soil inscriptions flicker and bubble; behind or underneath them lie the remnants of the original footage.

Coming back to Deleuze and Guattari's terminology, *Landfill 16* can thus be read as a typical interplay of two layers. Reeves's film translates the idea of cinema and films as layered structures into aesthetic form. The original outtakes serve as the substratum from which the core elements of the other stratum, those of visible decomposition, constantly emerge. The original, buried footage provides the source material, which, through processes of earth-based recycling, give rise to a second layer of flickering, abstract imagery. In this arrangement, it is possible to distinguish layers of content and expression and their corresponding forms and substances. But, as Deleuze and Guattari write, these terms designate relative positions. "Content" can be the original footage, which is given a new "expression" by being buried. Similarly, the "top" layer of the bubbling, flickering effects of dissolution can equally be defined as "content," which "expresses" another level, namely the remains of the original footage.

Landfill 16, in its entirety, is anything but a closed system. The two visual layers, resulting from Reeves's recycling practice, do not shield the film from real-world surroundings. On the contrary, *Landfill 16* exhibits the many leaks and openings of film in nearly every frame. Reeves's film points to the fact that moving images do not just emit waste, but, as Ingold argues for all bodies and things, can incorporate new materials as well. Letting footage decompose underground means that all kinds of microorganic elements can enter the film. Recycling, in Reeves's garden patch, means new material intake. It opens up an emerging film for new, previously non-cinematic "raw materials."

5 "Cinema shack," constructed from 35mm analog prints on the lawn of the silent green Cultural Quarter in Berlin as part of the exhibition *The Third Life of Agnès Varda* (2022), curated by Dominique Bluher and Julia Fabry (© silent green, Bernd Brundert)

Loose Ends

Projects like *Landfill 16* return film to the earth. While research on media and extractivism focuses on resources being "dug up," Reeves shows how cinematic leftovers migrate back into the ground. *Landfill 16* depicts the terminal states of moving

images *within* moving images. The disintegrating film strips appear as "an unstable assemblage of various chemical substances" and "transitory compounds of matter" (Löffler 2020, 82), constantly interacting with fungi and bacteria underground. The film thus allows existing cinematic residue to sediment and slowly merge with the soil – but only up to a certain point, because if Reeves had not exhumed the decomposing outtakes, there would obviously be no new film to watch.

Recycling, for Reeves, is primarily connected to film materials in the sense of footage and its celluloid base. Other filmmakers and artists explore different film materials – in the many senses of the term outlined above – that have turned to waste, were abandoned or became obsolete, but can be recycled to create new artistic works. Agnès Varda, for instance, began to build so-called "cinema shacks" in the early 2000s from leftover film canisters and copies of her less successful earlier films. She arranged the canisters and prints into airy structures resembling greenhouses, archways, or tents (fig. 5). Through Varda's peculiar recycling processes, film becomes an open constellation of physical things – a structure exposed to the environment and to decay, which visitors to Varda's exhibitions can enter and move around in.

These and other practices of recycling film-related waste underline that film materials are not bound to fixed, linear trajectories. As I have tried to show, moving images are not solely based on one-dimensional material flows leading directly from "extractive zones" (Gómez-Barris 2017) to film industry production facilities, and from there to waste heaps and trash dumps. Film, as a medium, is permeated by multidimensional material flows. The fundamental idea underlying recycling concepts – new cycles emerging out of wasted objects – can lead to fresh insights into the materiality of media, despite the justified criticism of today's recycling campaigns. Examples like *Landfill 16* demonstrate that it is precisely recycling that can reconnect moving images to the physical world.

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From Debris to Sediment: Unearthing Imperial Geology

Edited by Felix Hasebrink and Petra Löffler

In geology, the term sediment refers to organic or mineral particles that were set in motion and transported to a new location by air, water, or ice. Today, new sediments are emerging that challenge traditional concepts of geological processes: the global spread of microplastics, the contamination of soil and water with toxins, infrastructural remainders of industrial manufacturing, or the material legacies of imperial and/or colonial resource extraction.

From Debris to Sediment addresses the rising relevance of these residues. From the perspective of media studies, geography, sociology, environmental sciences, and artistic research, the contributions to this volume deal with key sites and issues related to the mounting layers of anthropogenic refuse and explore sediments as a geo-philosophical figure of thought. What media, politics, and ecologies are implicated in accumulating "future fossils"? And how do they envision the new material cycles emerging from these growing deposits?

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