River Confessions *Permeating* through Time, Bodies and Environment.

Unearthing the Remnants of the Zinc Industry

ABSTRACT This paper dives into a narration of the permeating histories of a river which reveal the interrelations and connectedness between local nature and larger master narratives of international social and environmental injustices. The point of departure is the river Dommel which is used as a case study for unearthing the permeated histories of industrial pollution and river contamination, their deforming effect on diatom communities, as well as the implications with a past of colonialism, violence and extraction affecting Kalkadoon native people and their lands. By interpreting diatom mutations caused by pollutants as semiotic indexes, permeability uncovers the past chains of events.

KEYWORDS River Dommel, diatoms, heavy metal pollution, permeability, semiotic indexes, Kalkadoon people

INTRODUCTION My journey begins with the Dommel, a river that crosses my home city Eindhoven and whose artificial river banks captured my curiosity. The human intervention on the river course was a necessary measure to be taken in response to the high levels of cadmium and zinc contaminations in the soil of the river bed. These pollutants were emitted by the nearby zinc-ore smelters, which have carelessly contaminated the waters of a ditch that runs along the industrial site and coflues with the river Dommel (De Jonge et al., 2008). De Jonge et al. have monitored this contamination of the river through the use of biota indicators; in this essay I focus on the effects of cadmium and zinc pollution on diatoms, single-celled microalgae.

The leitmotif of this essay is the ability of zinc and cadmium to *permeate* through time and environments, leaving behind a thread to follow to its geological origins. I propose *permeance* as a conceptual lens to approach the entanglements of the Anthropocene. *Permeability* as a tool facilitates the recognition of contaminated histories as a continuum in time where past stories cannot be concealed nor forgotten, as pollution can be displaced but not erased, origins of material resources can be traced and with them stories of injustices cannot be silenced. This concept is illustrated through the story of the river Dommel in the form of a case study, which will take the narration across borders and oceans while communicating in beyond-human forms. In this study, I aim to use *permeance* as a tool to expose the unexpected anthropogenic entanglements between diatom mutations, the pollution of the river Dommel and the colonization of Queensland, in Australia. As a result, the history of the Kalkadoon people becomes tangible to the lands the river Dommel crosses.

The essay begins by defining the theoretical framing of the concept of *permeability* (1). In light of Donna Haraway's (2016), Anna Tsing's (2015; 2017) and Eduardo Kohn's (2013a; 2013b) theorizing, I describe the nuances of *permeance*. Subsequently, I describe the cadmium and zinc pollution of the Dommel and introduce biota as indicators for contaminated aquatic environments (2). Following, I present single-celled algae, diatoms, as aquatic indicators (3), then proceed to describe the alterations in forms they manifest from exposure to polluted water and discuss how these abnormalities can be read as *semiotic indexes* (Kohn, 2013a) and as trace of past histories. Finally, I delineate the history of extraction of Century mine, the colonization of the australian continent and how this affected the native population of the Kalkadoon (4).

POSITIONALITY As an architect, I have become interested in expanding my position in the profession by understanding and following (raw) material flows in relation to the extraction processes and their impact on earth and its peoples. The implications of the

commodification of nature, a necessary building block for architecture, are overlooked by architects even though we continue to play a fundamental role in shaping Earth's crust through cities, landscapes, and consequently, societies. I decided therefore to follow zinc and cadmium pollution of the Dommel, a river which flows through my city, Eindhoven, to uncover the industrial processes of zinc-ore extraction in the Neerpelt area, right across the Dutch-Belgian border. The ores lead my research even further to uncover larger histories of mining extraction, colonization of the Australian continent and aborigenal land dispossession.

I recognize that my approach to this essay is grounded in a western perspective of historical timelines and I mostly refer to studies with a scientific approach to nature. Therefore, my position remains that of an outsider, both when discussing the impact of heavy metal pollution on the forms of diatoms and certainly when addressing the narration on the Kalkadoon tribe.

1. Permeating

In this essay, I would like to propose *permeability* (or *to permeate, permeance, permeation* and *permeating*) as a mode of engaging and vision for earthly life. In many ways, *permeation* is similar to Donna Haraway's (2016) notion of *tentacular thinking,* according to which tentacles stretch out to create new *oddkin* relationships that, *sympoietically*, together shape new *string figures:* from funghi to jellyfish, the intertwinement of appendages, limbs and tendrils collectively forms a web of entangled kin. Although Haraway (2016) does not consider these critters as Individuals, as autonomous entities, since "critters do not precede their relatings; they make each other through semiotic material involution, out of the beings of previous such entanglements" (Haraway, 2016, p. 60), these *symbiotic assemblages* she calls *holobionts* do not extend to all earthly matter. Instead, I envision *permeability* as operating through principles of physics and chemical processes as well as molecular exchanges, biological absorptions. The latter organic process is imagined by Donna Haraway (2016) as a zoophagous chain of critters engulfing one another:

> "Perhaps as sensual molecular curiosity and definitely as insatiable hunger, irresistible attraction toward enfolding each other is the vital motor of living and dying on earth. Critters interpenetrate one another, loop around and through one another, eat each other, get indigestion, and partially digest and partially assimilate one another, and thereby establish sympoietic arrangements that are otherwise known as cells, organisms, and ecological assemblages." (p. 58)

Similarly to what her partner Rusten Hogness suggests, "compost instead of posthuman(ism)" (Haraway, 2016, p. 32), and she herself states, "thinking about

rehabilitation (making livable again) and sustainability amid the porous tissues and open edges of damaged but still ongoing living worlds" (p. 33), *permeability* too can stimulate exchanges between bodies and natural entities. We all, living and non-living, become part of a greater and penetrable world. The impermeable membranes, so desirably sought after by modernity's categorizations, deteriorate into a pile of compost which stimulates exchanges of substances, nutrients, molecules and microorganisms.

Permeance also implies an awareness of participating in symbiotic relationships with Earth. Dismantling our parasitic use of the environment and its forms of life requires us to *permeate* through them in mutualistic, reciprocal encounters. Anna Tsing (2015) writes "we are contaminated by our encounters" (p. 27), we cause and absorb pollutions through our interactions with earthly beings and matter. We all, living creatures, also carry the record of past encounters, it is the key of evolution, it is in our DNA, in the matter that composes our beings, we hold the histories of our contaminations (Tsing, 2015). Not only do we carry pollutants in our biology, in our *permeating* encounters we contaminate through social interactions and relations to the land—colonialism and extractions are among those practices—generating a "contaminated diversity [which] implicates survivors in histories of greed, violence and environmental destruction" (Tsing, 2015, p. 33). *Permeance* uncovers the tracks of such happenings, it allows us to look into the past by following contaminations along a chain of events. Both Eduardo Kohn and Donna Haraway use their theoretical formulations to look into possible futures. Haraway (2016) uses *speculative fabulation*—or *SF*—for her storytelling of "the patterning of possible worlds" (p. 31). Kohn's (2013a) *signs* similarly are "interpreted by a subsequent sign in a semiotic chain that extends into the possible future" (p. 33). *Permeance* rather looks backwards to uncover a chain of connections departing from a specific sign, revealing the implications of our human actions across time and space. Starting from the deformations of diatoms, the *permeating* chain points upstream towards the zinc smelters then navigate across the ocean to mining exploitations and colonial land dispossessions.

Unlike the necessary skill to be able to live in ruins which Tsing (2015) attributes to the ability to recognize and accept living among contaminations, the notion of *permeability* enables us to trace and understand the ruins we inhabit. This emphasis of permeability as past remains can be aligned to the exposition of contamination as 'tracer':

> "Our modes of noticing, however, are themselves monstrous in their connection to Man's conquest. Much of what we know about ecological connection comes from tracking the movements of radiation and other pollutants. Contamination often acts as a 'tracer'—a way to see relations. We notice connections in part through their ruination." (Tsing et al., 2017, p. M8)

This paper indeed follows a history of pollution, which has been the ruination of both ecosystems and indigenous cultures. Unfortunately, these histories still need to be uncovered, as the ability to *notice* (Tsing, 2015) has yet to be refined by the western eye.

To conclude, *permeating* proposes a method for research and narration which reveals the chain of interrelations, connections and exchanges in the encounters of living and non-living beings, through the stage of time and space. Narrating a *permeating* story implicates seeing the entanglements that cross disciplines, where histories cannot be concealed or forgotten, as a trace is always left behind. Noticing the physical movement of pollutants such as zinc and cadmium draws to the foreground all of its encounters, as Tsing et al. (2017) write, contaminations act as a tracer of ecological connections. Furthermore, to *permeate* envisions the inability to distinguish impermeable separations. Too often we—in the west—are blinded by the impermeability of our actions. *Permeating* urges a vision of totality. I would argue that this is only possible if we see beyond the confines of borders, barriers and architectures: rivers flow between confines, histories of pollution can be displaced but not erased, contaminations can be absorbed but do not vanish, material histories can take you back to their geologies and along them stories of extractions and colonial violences emerge. *Permeating* unsilences.

Pollution is a form of *permeation*: in the context of the Dommel river, heavy metals have *permeated* through bodies, from the river into the nearby vegetation, both in the flora which thrives on (industrial) soils high in metal content, as well as in aquatic and river margin plants. Cadmium has also *permeated* in the bodies of microalgae and macro invertebrates such as earthworms. In the following sections I will present the influence of cadmium and zinc contamination in the river Dommel and describe the role of biota as scientific pollution indicators.

2. River pollutants and biota

The Dommel catchment comprehends an area stretching between the Kempen (Belgium) and North Brabant (the Netherlands), it is a natural fluvial system extending for the length of 146km which conflues in the river Meuse after passing the cities of Eindhoven and 's-Hertogenbosch (Wijngaard et al., 2017). Following my initial curiosity towards a sight of scraped down river banks of the Dommel I began noticing multiple anthropogenic interventions on the river along its course. Eager to understand why this earth had been removed and replaced and what implications it must have had on the river ecosystem, I decided to follow the Dommel up- and downstream to see what other stories the river wants to tell. Tracing the river backwards, I crossed the Dutch-Belgian border, arriving in the Neerpelt area and seeing for the first time the Nystar industrial smelters in the distance.

Right after passing under the Bocholt-Herentals canal through a concrete tunnel, the Dommel is joined in a series of water swirls and bubbles by its affluent, the Eindergatloop. This narrow ditch that runs between the canal and the border of the Nystar industrial terrain, gradually manifests, to my untrained eye, more evident traces of contaminations. Just before the smelters, there is an artificial sedimentation pond, I noticed more clusters of white bubbles, a nasty smell and an oily film on the surface. Continuing along the Nystar terrain, I arrive at the end of the ditch where water emerges from a concrete pipe underground. The water has a brown-orange undertone and along the margins I spot orange sludge tangled in reed bushes.

Discussing these findings and my preoccupations for the state of the river to a close friend and PhD Candidate (Faculty of Science, UvA) specializing in biodiversity and ecosystem dynamics, she introduced me to the array of bioindicators which help scientists asses the water system's health and confirmed that the Dommel and it's ecosystem had been severely polluted in the past. The Dommel catchment area, which stretches between Peel (Belgium) and the 's Hertogenbosch (the Netherlands), has been repeatedly polluted by the emission of the ore-smelting activities of fuel combustion gasses and heavy metal contaminated waters (Wijngaard et al., 2017). For over 125 years, in the period between 1880-1974, Nystar's industrial extraction and fusion of metal ores was particularly polluting, due to the release of toxic gasses–including the burning of coal in the smelters–and the discard of contaminated water with dissolved zinc and cadmium particles (De Jonge et al., 2008; Wijngaard et al., 2017). The industrial by-product was dumped into a ditch, the Eindergatloop, which runs along the border of the smeltes. This water stream carried the pollution further along merging in the river Dommel where it eventually bounded to the soil bed to form a contaminated sludge (Wijngaard et al., 2017). The accumulation of heavy metals in the river sediment required human intervention to physically remove the contaminated earth by scraping the river bed and margins, and has also required the installation of sedimentation tanks that hold the polluted sands. According to the study conducted by Wijngaard et al. (2017) and De Jonge et al. (2008), despite the interruption of direct pollution, the concentration of zinc and cadmium in the river sediment is still dangerously high for both aquatic and terrestrial creatures.

River biota participate in this contamination by ingesting and expelling heavy metals (Wijngaard et al. 2017), a process which causes these pollutants to enter the food chain and also contaminate larger beings (Falasco et al., 2009). Crucially, the biota of the Dommel have been used by scientists De Jonge et al. (2008) as monitoring indicators for the metal pollution. This method ranges from observing fish population and macrophytes to tracking macroinvertebrates and collecting diatoms (De Jonge et al., 2008). In the following

section I will develop further how diatoms speak to scientists about the contaminations of their environments.

3. The diatom forms

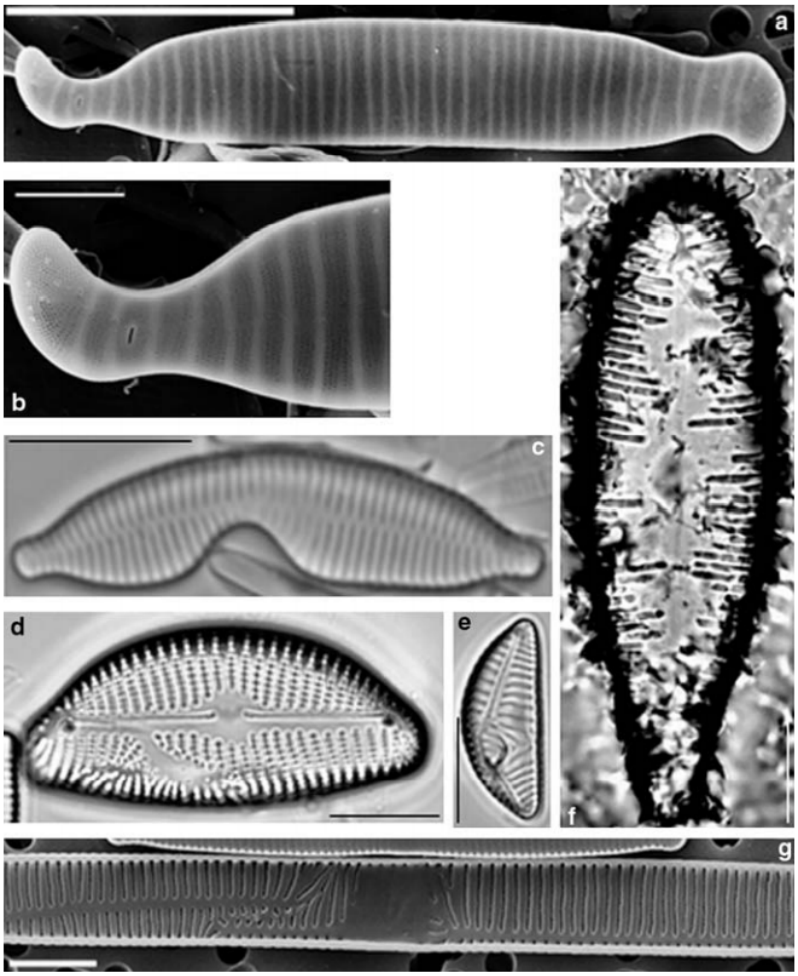

Figure 1: Diatoms affected by stresses such as heavy metal contamination presenting teratological forms including: abnormal valves outline and abnormal striation patterns (Falasco et al., 2009).

The Anthropocene and diatoms share more than just histories of pollution. Indeed, freshwater diatom expert Eugene Stoermer of the University of Michigan, introduced the term 'Anthropocene' in the 80s, to describe the increasing transformations occurring on Earth due to anthropogenic activities (Haraway, 2016). Since diatoms are fast-growing organisms which rapidly adapt to their environments in the span of a few generations, they manage to keep up with our anthropogenic contaminants. Due to their efficient signaling of human disturbances, diatoms have warned humans about our excessive footprint on Earth, to the point that we have named a new geological epoch after ourselves.

Diatoms inform scientific biological monitoring of aquatic systems through changes that are manifested in their forms. Indeed, the principal characteristic of diatoms can be found in their cell wall structures arranged in intricate ornamentations made of silica (Falasco et al., 2009). These structures are transmitted through generations, conserving the

exact form of each species (Falasco et al., 2009). Stresses, either physical or chemical, absorbed through their aquatic environment, will affect their characteristic ornamentations in various ways, ranging from abnormalities in outlines and striation patterns, alongside influencing the variety of the diatom populations (Falasco et al., 2009). According to the studies of biologist De Jonge et al. (2008) researching metal gradients on diatom samples of the catchment area of the Dommel, *Gomphonema parvulum* and *Nitzschia palea* were associated with high metal concentrations, while E*olimna minima* and *Sellaphora seminulum* with high quantities of zinc. Increased 'non essential' concentrations of heavy metal such as cadmium can have drastic effects even in small doses (Falasco et al., 2009). These pollutants can *permeate* in diatoms either through passive or active cellular transport mechanisms and can disrupt the cell's development, respiration, reproduction, photosynthesis, nutrient assimilation and biochemistry (Falasco et al., 2009). Also, heavy metals can gather in the cytoplasm of the cell if the diatom does not die due to low tolerance (Falasco et al., 2009).

As reported by scientists Falasco et al. (2009), deformities of the outer cell structure (frustules) and abnormalities in the striation patterns can indicate both teratological forms, accidental effects of environmental stresses, and polymorphism, a genetic adaptation which allows diatoms to survive and evolve in adverse environmental conditions. Polymorphic species of diatoms have a diverse genetic pool which manifests under selection due to external environmental factors and is therefore regarded as an adaptive response (Falasco et al., 2009). Instead, teratological malformations are not genetic variations, they are responses to alterations of environmental stresses and the frequency in which they manifest is associated with the magnitude of the perceived stress (Falasco et al., 2009). The study by Falasco et al. reveals cadmium contaminations in the *Eolimna minima* caused in particular deformations to the outline of the valve, abnormal striations; while the *Sellaphora seminulum* presented malformations in the frustules, striation patterns and in the movement fissures, called raphe (see Figure 1 for reference). According to Falasco et al. these cell alterations could cause limitations in the motor skills and physiology. The deformities affect diatoms from 'birth' and are nontoxic for adults, which would otherwise cause a loss of specimen diversity (Falasco et al., 2009). Indeed, these structural malformations, differently from the polymorphic genetic alterations, do not manifest after sexual reproduction in the offspring (Falasco et al., 2009). However, the overall prevalent response to heavy metal contamination is a change in the variation of diatom specimen in a community, as the more sensitive cells die causing the loss of diversity of the ecosystem (De Jonge et al., 2008; Falasco et al., 2009).

As presented in the previous paragraph, scientists have individuated various alterations to diatom structures as indicators of pollution: adaptation and evolution (polymorphy), deformations (teratologic forms), absence through death (loss variety in colonies). We could interpret these diatom indicators as semiotic *signs* according to which these algae inform biologists in beyond-than-human communications. Relying on Charles Peirce's 19th century work on semiotics, Eduardo Kohn's (2013a) book 'How Forests Think', extensively demonstrates how to interpret the environment's signs to know how nature does think. By understanding the relationship that exists between human and nonhuman forms of representation, like signs, humans can listen and communicate with other beings (Kohn, 2013b); in fact, Kohn states, "symbolic representations exist beyond the human" (2013b, 7:10). According to Eduardo Kohn (2013b), organisms think through biological and evolutionary processes which manifest themselves through semiosis. Indeed, an organism's adaptation to environmental stimuli is a response to the world they inhabit (Kohn, 2013b); Kohn in fact states "this fittedness is a representation, it is a thought, [signs are] forms and patterns that propagate through the forest" (9:50, 2013b). Indices, in particular, which have different properties than icons and symbols, point to those things which they represent (Kohn, 2013b), they force us to notice and focus our attention on something which has occurred although the initial relation might remain unclear (Kohn, 2013a). As diatomic malformations are a consequence of environmental alterations, these structural changes can be taken as *indexes* of pollution. The *permeation* of cadmium and zinc in the cells of algae causes diatoms to manifest a sign, an index as reaction to the contamination in the form of deformations of their bodies. The abnormalities of the valves and striations of the *Eolimna minima* and the malformations of the frustules, patterns and raphe of the *Sellaphora seminulum* (Falasco et al., 2009) inform scientists about the state of pollution of the Dommel. The diminishing variety of diatom species due to the death of the least resistant varieties, also is a sign of river contamination, their *absence* from the community also constitutes an index according to Kohn (2013a). An event indicated by an index occurs whether humans pay attention to it or not (Kohn, 2013a), in fact, scientists might not notice changes in diatoms but their alterations due to pollution occur nevertheless.

Beyond the interpretation of biologists, the *indexes* signaled by the diatoms also inform aquatic ecologists of the pollution emitted by the zinc ore smelting industries in the Neerpelt. Moreover, the declining population of certain river diatoms is a trace of an *index* we humans did not notice in the past. Their unnoticed *absence* is picked up by scientists decades later; attending to this ignored past signal, I have decided to return to past chains of events and navigate history upstream. This *permeating* chain also uncovers the molecular composition of the type of zinc and cadmium in the algae cells causing the

anomalies, linking it to geological compositions and formations in the Australian continent. Indeed, the origin of the contaminants follows the same path as the imported zinc ores from Century Mine. The following section will continue this *permeating* journey, retracing colonial histories.

4. The Kalkadoon people

The zinc industry in Neerpelt operated under various company names, over time fusing with other corporations like Umicore, the Australian Zinifex and, nowadays, Nyrstar. In 2000, Zinifex[1] began importing raw material from the Australian Century Mine (ABdK, n.d.), also owned by the then Zinifex corporation. Between 1999 and 2016, Century Mine was one of the world's largest open pit zinc mines, located in North Queensland, an Australian region known for the vast mineral deposits of zinc, copper and silver, located 250 km north-west of the city of Mount Isa (Salvoni & Dight, 2016).

The surrounding territories to Mount Isa have been the land of the Kalkadoon people for over 60000 years[2], an indigenous tribe that resided in Emu Foot Province (Who are we? Kalkadoon People, 2020). Their land was dispossessed in 1884 in a final battle the Kalkadoon fought against the colonization by white settlers. This war is today remembered as 'Battle Mountain', during which 150 Kalkadoon natives were massacred for resisting settlers (Laurie, 1959; Blake, 2005). Over the course of the following 6 years, between 1878 and 1884, it is estimated that up to 900 Kalkadoon people lost their lives while defending their people and land from incursions (Who are we? Kalkadoon People, 2020). The Native Police secured and protected the settler's advancement in northern territories, under the command of inspector F. C. Urquhart (Blake, 2005). This paramilitary unit, also known as Black Police, also conducted frontier patrols, repressions, punitive missions against indigenous tribes with the intention of 'dispersing' the native communities (Blake, 2005). The Native Police was utilized for the expansion and protection of the Australian frontier and was mainly composed by indigenous men recruited from distant indigenous settlements in southern colonies (Blake, 2005). These native people were selected to combat the local tribes because they did not have kinship loyalties to northern people and were enrolled due to their ability to track and ambush, and knowledge of the Australian landscape (Blake, 2005). Since the first explorations of the inland, the Native Police began supporting the exploration of settlers searching new lands to claim for their cattle expropriating them from

[1] Information regarding the company's history is not available on the official website of Zinifex (see: For an overview on the industrial processes, complexes and histories I therefore refer to the website: www.zinkindekempen.nl, and the academic article by Salvoni & Dight (2016) which analyzes a case study on Century Mine.

[2] The website https://www.kalkadoonpbc.com.au/about-us/who-we-are reports another date: 40000 years

indigenous tribes, among which the Kalkadoon people (Blake, 2005). According to the oral tradition of the Kalkadoon, their first encounter with white settlers was in 1861 when explorers Burke and Wills departed in an expedition to cross the Australian inland (Blake, 2005). Robert Burke and William Wills were part of the very first organized western exploration missions in the australian inland (Blake, 2005). 255 years prior, in 1606, Dutch colonial navigator Willem Jansz arrived as the first european in Australia by approaching the shores of northern Queensland (Laurie, 1959). His explorations and first european mappings of the continent, opened the doors to Australia's european colonization and exploitation (Laurie, 1959).

In conclusion, through the lens of *permeability*, the chain of events beginning with the *indexes* of abnormal diatom have led the way to Australian colonial history, and as a result, the story of the Kalkadoon people has become linked to the pollution of the river Dommel.

CONCLUSIONS After 85 year of uncontrolled industrial discharge, in the 80s, it became evident that the river bed of the Dommel had particularly high levels of zinc and cadmium attached to its sediment. Nowadays, the level of pollution in the river continues to be dangerously high even if the direct emissions of the Neerpelt zinc smelters have ceased (Wijngaard et al., 2017; De Jonge et al., 2008). Through the conceptual framing of *permeability*, I followed the chain of events into the past starting by the *indexes* of abnormal diatom bodies caused by cadmium and zinc industrial pollution. This process of upstream tracing of cadmium and zinc signs through space and time, led to uncovering the implications of mineral extraction from the australian Century mine and the land disposession and murder of Kalkadoon people.

Permeance, through the use of semiotic indexes, offers a beyond-human understanding of causality and agency. *Permeance* reveals that zinc and cadmium pollutants carry molecular stories of land dispossession and colonial violence, creating a direct link between the western present and the Kalkadoon past, exposing unconventional truths. The teratological and polymorphic forms of diatoms are indices that communicate the colonial horrors which took place in aborigenal Australia. As I conclude this essay, cadmium and zinc will continue their *permeating* journeys, leaving traces behind that reveal how *entangled, contaminated* and *polluted* our beyond-human *encounters* really are.

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