Elemental worlds: Specificities, exposures, alchemies

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Abstract
The elements have become the focus of a significant volume of research by geographers and others. Engagements with the elements have been framed in terms of four elemental orientations: matter, molecule, milieu and media. Our aim is to consider what is at stake in efforts to think with, across and beyond these orientations. Avoiding any reduction of the elements to a single ontological or epistemological proposition, we explore possibilities for grasping their implication in the composition and decomposition of worlds. Doing this can be facilitated by thinking about these worlds in relation to three interrelated matters of concern: specificities, exposures and alchemies.

Keywords
alchemy, elements, exposure, media, milieu, orientations, specificity, worlds

I Introduction
Over the last decade or so the elements have become the focus of a significant and growing volume of research by geographers (e.g. Adams-Hutcheson, 2019; Adey, 2015; Anderson and Wylie, 2009; Engelmann, 2015; Jackson and Fannin, 2011; Martin, 2011; McCormack, 2015, 2017a, 2018; McHugh and Kitson, 2018; O’Grady, 2019; Simpson, 2018; Squire, 2016). This work is part of a wider renewal of interest in the elements across disciplines, including anthropology, cultural studies and media studies (see, e.g. Cohen, 2014; Cohen and Duckert, 2015; DeLoughrey, 2019; Hecht, 2012a, 2012b; Jue, 2020; Macauley, 2010; Neale, Phan, et al., 2019; Neale, Smith, et al., 2019; Parikka, 2015; Peters, 2015; Starosielski, 2016). There are many theoretical, empirical and political strands running through this diverse set of works. One thing that cuts across all of them, however, is the negotiation, explicitly or not, of a particular tension. This tension exists between, on the one hand, the use of the elemental to invoke or suggest something basic or fundamental to the composition or understanding of something else and, on the other, the recognition that the elements and elemental are necessarily vague or excessive categories that resist reduction. The former is

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exemplified in efforts to classify and name different elements in areas as diverse as chemistry and fragments of classical Greek philosophy. The latter is exemplified in arguments that the excessiveness of the elements and the elemental are pivotal to their critical analytical value and speculative allure.

This article explores the implications of negotiating this tension in light of how what Adey (2015) calls ‘the force of the elemental’ is surfacing as the focus of a range of political, ethical and environmental concerns in a ‘world of many worlds’ (de La Cadena and Blaser, 2018). Any provisional list of illustrative examples would immediately take us beyond our word limit. This list might include how the Covid-19 pandemic has foregrounded once again concerns about the composition of air, how wildfires have provided indicators of shifting thermal realities and how plastics are now surfacing as part of the composition of the materials of which all kinds of bodies are fashioned and the milieus in which they are immersed. We don’t necessarily want to suggest that each of these issues should be incorporated within some kind of elemental turn (no more than any way of moving needs to be subsumed within a mobilities turn). We do want to claim, however, that none of them can be understood without more work being done on what we mean when we talk about or invoke the elements. It is precisely this work, undertaken in light of the tension identified above, which forms the focus of the present article.

Our point of departure is the fact that something of the elements and the elemental always remains withdrawn from and exceeds forms of technoscientific or conceptual reductivism (Engelmann, 2019a; Engelmann and McCormack, 2018). The elements offer compelling philosophical resources for complicating the dualistic and reductivist categories that have framed western metaphysics and politics for so long (Irigaray, 1992; Sjöholm, 2000). Integral to the lure of the elements (Engelmann, 2020) is how they traverse a particularly wide range of ontological, epistemological, aesthetic and ethico-political entanglements. And they do so just at the time that such entanglements have, in the face of concerns about anthropogenic transformations of the Earth, become the focus of greater critical scrutiny across different domains of expertise, experience and experiment. The elements bring into focus the transformative agency of anthropogenic activity in relation to the composition of the Earth at the same time as they provide insistent reminders of the limits of this agency. They hold together while also holding open possibilities for thinking through materialities, affects and sensations across scales from the atomic to the planetary.

Avoiding the epistemic habits (Murphy, 2017) that tend to frame the elements through a narrow technoscientific reductionism is therefore especially critical. And yet it remains vital to recognize that taking seriously the excessiveness of the elements does not absolve us from critically examining how, and under what circumstances, they can be and are rendered explicit in distinct and divergent ways. In fact, if anything, the openness of these categories requires us to pay especially close attention to how different understandings and apprehensions of the elements take shape. This is important if we are to understand how these categories provide orientations for forms of thought and life. It is important if we are to begin to complicate origin stories about the elements often framed in terms of the versions of the elements found in the fragments of the work of pre-Socratic thinkers like Empedocles (Furuhata, 2019). And it is important if we are to understand how different versions of the elements enter into the tensed and politicized processes through which worlds are composed and decomposed.

In this article, we therefore pursue possibilities for thinking about the elements in ways that refuse reductivism while also understanding how the elements are differentiated in ways that
matter. Our approach to this is developed in two stages, reflected in the organization of the article. To begin, we delineate four different (and unintentionally alliterative) elemental orientations – matter, molecule, milieu and media – in relation to which much of the work about these categories can be situated. Our aim is not so much to offer these as distinct and self-contained categories. Instead, these orientations sensitize us to particular possibilities and questions. They also overlap and intertwine. The largely conceptual work undertaken in these opening sections of the article provide the basis for the second stage of our argument, which revolves around exploring how different versions of the elements are implicated in the composition and decomposition of worlds and in ways that are variously malign and benign. We argue here that elemental worlds can be understood through three matters of concern (Latour, 2004). The first of these is specificity. Developing Melody Yue’s (2020) idea of milieu-specificity, we argue that specificity needs to be considered in relation to other versions of the elements in ways that avoid rehearsing reductivism. The second matter of concern is exposure, which we examine in relation to the question of how different bodies and forms of life are susceptible to the composition of elemental worlds. We use the term ‘forms of life’ here for a dual purpose. It signals how worlds are formed from multiple associations between and attachments across humans and non-humans (de la Cadena and Blaser, 2018). It also allows us to avoid privileging either of the latter two terms while recognizing that attachments to worlds, even those that gravitate towards ‘human’ concerns, remain part of how different versions of the elements surface (see also Anderson, 2020). The third matter of concern – alchemy – is less analytical and more speculative. We suggest that thinking in alchemical terms allows us to hold onto the specificity of particular elements while also following their transversal transformations in ways that acknowledge the excessive ontologies in which the elements are implicated. Taking these matters of concern together, we argue, allows us to grasp how different versions of the elements are implicated in the composition and decomposition of worlds.

II Elemental orientations

To claim that the relations between elements like earth, air, fire and water are central to different visions of the scope and substance of geography is hardly novel. However, even if the elements in this guise overlap closely with the environmental imperatives of different strands of geographical knowledge, the category itself was relatively under-theorized and insufficiently problematized until relatively recently. The renewed interest in the elements over the last decade is due to various factors. In part, it has much to do with broader materialist trajectories within and beyond subfields like cultural geography (Anderson and Wylie, 2009; Latham and McCormack, 2004; Whatmore, 2006), political theory (Bennett, 2010) and political ecology (Gandy, 1999; Kaika, 2005; Swyngedouw, 2004). These trajectories have precipitated more attention to the processual relationality of materiality in ways that draw in turn on the elemental concerns of a range of philosophers including, for instance, Bachelard (1988), Glissant (1997), Irigaray (1992, 1993, 1999), Levinas (1978), Lingis (1988a; 1988b), Merleau-Ponty (1968) and Sloterdijk (2009). Engagements with these philosophers have perhaps also indicated the double edge of thinking with the elements as devices that can play into ‘master narratives’ about the organization of society and the state, while also being ‘metaphysical descriptors’ (Ferreira da Silva, 2018) that may problematize and work against bifurcations in post-Enlightenment thought. The renewed significance of the elements is also related to greater attention to how diverse materialities suffuse the volatile geo- and biopolitics of the contemporary juncture, whether or not
this is gathered under the name of the Anthropocene (Clark, 2011; Povinelli, 2016; Yusoff, 2018). In these terms, a renewed interest in the elements can be understood as part of an attempt to understand different ways in which the materiality of the ‘geo’ is implicated in the distribution and delineation of forms of living and dying.

In this context, the range of geographical and related work that might be categorized as ‘elemental’ is very wide. It includes work on water in its different phases (e.g. Straughan, 2012; Dodds, 2018; Steinberg and Peters, 2015), on air and atmosphere (e.g. Adey, 2013, 2015; Engelmann, 2015; Foley et al., 2019; Nieuwenhuis, 2018) and on subterranean spaces (e.g. Hawkins, 2019; Squire and Dodds, 2019). But it also includes work on the presence and circulation of chemicals within bodies and environments (Balayannis, 2019; Davies, 2019) and on the mining and persistence of radioactive materials (Carpenter, 2016; Barad, 2017; Brown, 2017). Given the scope of the work that could be included within a survey of geographical research, it is tempting to organize any initial review around the empirical focus suggested by such work (air, water, earth, chemicals, nuclear materials, etc.). Here we want to take a slightly different approach by delineating four elemental orientations – matter, molecule, milieu and media. At the outset, we want to emphasize that these are not fundamental categories. Nor are they mutually exclusive. Matter, molecule, milieu and media are ‘orientation devices’ (Ahmed, 2006) because they are starting points for our thinking and writing. As ‘starting points’, these orientations have a politics, since, following Sara Ahmed, to consider the start is also to consider what came before and what is to come after. This involves an awareness of what has been abstracted and diminished as well as what has become important. These four elemental orientations therefore have as much to do with the work of other scholars as with our own past work. But they are also informed by what we, as co-authors, are tended towards, the paths we wish to trace, the ideas and objects that we want to ‘do things with’ (Ahmed, 2006). To delineate matter, molecule, milieu and media in this way is to respond to existing valences in the work of others while also exposing the political tendencies in our own forms of thought and collaboration.

I Matter

The first orientation is matter. By this we mean any effort to use the elements as the basis for ontological propositions, including those about bodies and worlds. Posing such ontological propositions in relation to the elemental composition of the Earth, the composition of bodies and the nature of the relations between both is not new (Cohen, 2014). The most frequently invoked reference point for such ontological propositions in Anglo-American literature and writing on the elements is classical Greece. Figures including Thales, Anaximenes, Heraclitus and Parmenides are all reputed to have developed versions of the claim that bodies and things are composed of a limited set of elemental substances. Empedocles is the figure often given most credit for the notion that four primary elements – earth, air, fire and water – exist as the eternal roots of all things (Wright, 1981). The existing fragments of his writing indicate that these elements are consistent with observable physical phenomenon and materials in the world. They are also changeless and homogeneous, although he also seems to have suggested that fire could work on and transform the other elements. Importantly, for Empedocles, these four roots are linked in turn by the emotions of love and strife, with the former having a unifying effect and the latter serving to separate and divide (Wright, 1981).

Empedoclean elementalism continues to have a significant, if qualified, influence on contemporary efforts to think with the elements (Alaimo, 2015; Macauley, 2010). While
acknowledging this, it is also worth complicating what is a largely Euro-centric origin story of the elements in relation to other sets of ontological propositions, of which there are many. Here we wish to signal only a few. In Indian philosophy, for instance, three elements – fire, water and earth – are given primacy, each linked in turn to the composition of different parts of, and processes in, the human body. In some strands of Buddhism, air, fire, water and earth are supplemented with a fifth element – space. And in Chinese philosophy, the five elemental ‘phases’ are wood, fire, earth, metal and water. These phases are linked by processes of generation and subjugation and continue to influence folk practices and architecture in the present day (Furuhata, 2019). Moreover, these phases are anything but static categories. As Tim Ingold notes, ‘the Chinese xing, conventionally translated as “elements”, are more like seasons than substances. Their most fundamental property is movement, or better, the potential to turn. Wood turns to fire, for example, as spring to summer; fire turns to earth as the wood is reduced to ash. Elements, in Chinese philosophy, exist not in themselves but only in what each does to the others, in a world that is never fully formed but continually in formation’ (2019: 1).

Much more work needs to be done to ‘expand the referential framework of the “elements” beyond ancient Greece in order to productively complicate the geopolitics of elemental philosophy’ (Furuhata, 2019: np). Part of this involves thinking about how the elements figure as ontological propositions in many indigenous worlds (Clément, 2017). At the same time, as Zoe Todd (2016) suggests, caution is necessary because engagements with indigenous ontologies can easily rehearse versions of colonialism in which those ontologies become magical or enchanting others to an implicitly reaffirmed western metaphysics and politics (see also Macarena Gomez-Smith, 2017; La Cadena, 2015). The broader point to be made here is that we need to develop ways of thinking across and between many elemental ontologies, each of which is implicated in different forms of life and diverse situated epistemologies (Cruikshank, 2012). This requires the elaboration of particular practices of ‘equivocation’ (La Cadena, 2015) across different elemental orientations that avoid suggesting that such orientations are indicators of a kind of universal elemental commons or that they are necessarily or straightforwardly reconcilable.

These elemental equivocations always daily, however, with forms of reductionism and essentialism. We can see this, for instance, in the elemental philosophy of Irigaray (1992, 1993). For Irigaray, the point is to take seriously the proposition that the elements are significant influences on bodies and lives in ways that complicate enlightenment thought. As she writes: ‘We still pass our daily lives in a universe that is composed and is known to be composed of four elements: air, water, fire, and earth. We are made up of these elements and we live in them. They determine, more or less freely, our attractions, our affects, our passions, our limits, our aspirations’ (Irigaray, 1993: 57; see also Schwab, 2020). The claims about determination here might well be too strong for many. For Irigaray, however, the risk attached to such claims is worth taking if it allows for a revalorizing of the links between material imaginaries, sexual differences and knowledge production, and more specifically, for a highlighting of legacies of western thought that have implicitly associated (feminine) bodies with elemental substances while diminishing their agency. Similarly, Elizabeth Grosz invites us to remember ‘the elements through which all living things are born and live, a cosmological element’ and ‘the specific body, indeed a chain of bodies, from which we come, a genealogical or maternal element’ (2004: 2). In such claims, both Irigaray and Grosz remind us that while ontological propositions about the elements may veer at times towards a limited essentialism, they do not need to become reductive gestures. They
can instead become orientations that open up and continue to unsettle matter’s implications in the ontological politics of diverse forms of life and non-life.

2 Molecule

A second and related elemental orientation is the molecular. In its simplest terms, this version signals how the elements are rendered explicit and manipulatable as atomic arrangements (see Myers, 2015) while also denoting ways of thinking that resist such atomism. In relation to the former, the elements as molecular become explicit through a range of technoscientific devices and experiments that work to organize and systematize matter. A key device in the formal schematics of this rendering is the periodic table of elements, in relation to which the elements are defined as molecules or materials composed of atoms with the same number of protons in their nuclei. The periodic table is a remarkable techno-scientific and aesthetic diagram, used and applied across a range of domains of expertise from education to industry where it remains critical to how the elements are understood, imagined and visualized. The table is also obviously a particularly durable and powerful form of abstraction. The aesthetic elegance and relative simplicity of the periodic table can give the impression that the elements it depicts exist in isolation as discrete entities and substances. Even if in some instances this is more accurate than others, it is also the case that many elements exist only under incredibly rare conditions and even then as brief achievements realized at enormous cost and technical effort. In simplifying and arranging the elements, it does not, and indeed cannot, capture how the elements are implicated in different forms of life. In that respect, it is like all chemical models, which tend to exclude ‘complex reactivity with living- and non-living being’ (Murphy, 2017: 495). This is not a critique of abstraction per se but of the fact that abstraction in relation to the elements often functions to conceal the complexity of the lives in which they are fully implicated while also remaining barely perceptible (Murphy, 2006; Myers, 2015). Equally, as a map, the periodic table is also incomplete – the elements diagrammed do not represent all forms of matter. Indeed, in cosmological terms, they represent only a minority, not least because at least 80 per cent of matter in the universe consists of ‘dark matter’. This diagram is also open and potentially modifiable and hackable – a point to which we will return below.

Highlighting the periodic table here does not mean naively affirming it as a straightforward map of the molecular elements: it means instead acknowledging that the elements it isolates through abstraction play a critical role in shaping worlds. It is also obviously the case that while a molecular orientation seems to reduce the elemental to the terms of scientific epistemologies, it also opens onto other ways of thinking, resisting any neat equation with the atomic. This is because the molecular does not so much stabilize the category of the elemental in the form of an entity but also signals something irreducible to this form: the molecular becomings of the elements refer to combinations and compositions operating transversally to the formal schematics of technoscience and extending into the processuality and politics of many domains of life (McCormack, 2007; Rose, 2007) and non-life.

There are some precursors of this sense of the molecular. It emerges, for instance, through the thinking of Deleuze and Guattari (1988), where it invokes forms of benign and malign becomings in which the chemical may be implicated but to which it is not reducible. Molecular transformations in this sense capture the instability of matter and the fact that this instability is an ontological element of bodies, subjects and worlds. Such molecular becomings may be modest, but over time they have the potential to rework the conditions within which thinking, feeling and acting take place (Grosz, 2008).
Elsewhere, but in a similar vein, scholars like Mel Chen remind us of the importance of the molecular as a mode of relational and affective becoming-otherwise. As she writes: ‘there is a potency and intensity to two animate or inanimate bodies passing one another, bodies that have an exchange – a potentially queer exchange – that effectively risks the implantation of injury. The quality of the exchange may be at the molecular level, airborne molecules entering the breathing apparatus, molecules that may or may not have violent bodily effects’ (2012: 206). As Chen reminds us, while acknowledging the reductivism of some formulations of the molecular as chemical or biochemical, it remains necessary to hold open this elemental orientation to formulations that resist such reductions. This is not about rehearsing a naive form of enchantment with a kind of molecular sublime. It is instead about the value of speculating carefully with the molecular as a relational orientation in ways that unsettle the sorts of molar diagrams and categories into which the elements are often placed.

3 Milieu

The third elemental orientation we wish to foreground here is milieu. In its simplest terms, this refers to how the elements are understood as surroundings in relation to which different forms of life – and non-life – are defined. The elements can of course be considered in relation to a range of spatial concepts, including, for instance, territory and volume, both of which continue to be stretched and reworked by geographers (Elden, 2010) with the latter in particular becoming the focus for critical analyses of the spatialities of the elements (Steinberg and Peters, 2015; Squire, 2018). We focus on milieu here because of the way in which it crystallizes the condition of being in the midst or in the middle of an elemental environment. Milieu, in these terms, is a kind of elemental environmental surround. This is the sense of milieu that we can see, for instance, in recent writing by Melody Jue (2020) on different ways of being in, experiencing and imagining seawater.

Milieu is also worth thinking-with in relation to the elemental because it allows us to acknowledge how the elements are implicated, often problematically, in different genealogies of the relations of influence that exist between environment and forms of life. These genealogies figure elemental milieus as what Lamarck (in Canguilhem, 2001: 9) called ‘influential circumstances’ (see also Pearce, 2010). Paralleling the development of mechanistic and biological understandings of milieu are anthropo-geographical understandings found in the work of Carl Ritter and Alexander Von Humboldt (Canguilhem, 2001: 15). Implicit within these diverse ideas are assumptions that air, water and earth are environmental conditions within which bodies – human and non-human – are constitutively immersed with different degrees of influence. Similar claims about elemental influence can, of course, be traced through the writing of figures like Semple and Huntington (Huntington, 1922; Semple, 1911). For Semple, the geo-historical link between the elements and ‘man’ is clear: the former has ‘entered into’ ‘the bone and tissue’ and ‘mind and soul’ of the latter (1911: 1). Our point here is not to revisit well-rehearsed discussions of environmental determinisms and their legacy (e.g. Keighren, 2006). Instead, it is a reminder that thinking with the elements implicates us in geopolitical and biopolitical questions about the relations between life and environment (Kline, 2019; Yusoff, 2018). And it is a reminder that milieus can easily be framed as biopolitical mediums for forms of action at a distance in relation to which apparatuses of security operate (Foucault, 2007: 19; see also Foucault, 2006; O’Grady, 2019).

Milieu as an elemental orientation is not only a matter of the relations between bodies and their external surrounds. Elemental milieus mix and mingle across different forms of life.
sense of milieu is found in the thinking of Deleuze and Guattari (1988) for whom the term also combines the meaning of circumstance, medium and middle (Massumi, 1988). Things are composed, at least in part, of multiple milieus. As they put it, ‘the living thing has an exterior milieu of materials, an interior milieu of composing elements and composed substances, an intermediary milieu of membranes and limits, and an annexed milieu of energy sources and actions-perceptions’ (1988: 313). Elemental milieus in this context not only involve relations between already formed bodies: milieus, and the relations between them, have different temporalities, and their rhythms give an intensive consistency to forms of life and of non-life. Understood in these terms, elemental milieus are not a kind of plasma in which bodies are immersed but are relational, rhythmic arrangements across and within bodies that have a certain consistency, a consistency which is never guaranteed. This invites us to think across elemental milieus through, for instance, examining how chemical molecules support or destroy the conditions for different forms of life in relation to other milieus (geological and atmospheric). Thinking across elemental milieus in this way is not to rehearse a biopolitical determinism but to become oriented to the relational composition (and decomposition) of those milieus (Grosz, 2004; Gunaratnam and Clark, 2012; Mackenzie, 2014).

This kind of transversal elemental thinking allows us to understand milieus in terms that are not tethered to any single elemental matter (ice, water, etc). Milieus consist of many different kinds of materials and molecules. As Astrida Neimanis (2020: np) puts it, ‘the milieus with which our bodies contend are material, comprising particles, gases, forces, pressures, contaminants and other matters’. This complicates any strict division between the meteorological and the oceanic, for instance, as elemental or political domains. More generally, it also serves as a reminder that the materiality of elemental milieus is layered with culture, society and politics in ways that make those milieus ‘intra-active, natural-cultural’ phenomena (Neimanis, 2020).

4 Media

The fourth elemental orientation – media – is perhaps the least obvious or intuitive but is critical to how the molecular matters of milieus are mixed and recombined. And it is becoming more visible as scholars across a range of disciplines begin to think about how the elements are implicated in various forms of sensing and signalling (Blum, 2019; Jue, 2020; Peters, 2015; Staroskielski, 2016). It is also closely related to milieu insofar as it emphasizes approaching the relations between bodies and elements in terms of mediation: put another way, bodies (human and non-human) mediate and are mediated by their milieus. This sense of elemental media takes us beyond a consideration of how the elements are represented in various media platforms and genres (even as these considerations remain current). It is closely aligned with various traditions of thinking of the elements as the indeterminate but influential conditions in which perception and sensing takes place for different bodies (e.g. Levinas, 1978; Lingis, 1988a; Sallis, 1998), traditions which in turn have informed phenomenological and post-phenomenological work by geographers and others on the elemental (Anderson and Wylie, 2009; Ingold, 2010; Jue, 2020; Martin, 2011).

The category of elemental media is a particularly expansive orientation, going well beyond understandings of media as print or broadcast media and also beyond human sensing and perceptual capacities. As John Durham Peters observes, ‘the idea that media are message-bearing institutions such as newspapers, radio, television, and the Internet is relatively recent in intellectual history’ (Peters, 2015: 2). For Peters, anything legible is therefore a form of media. This means that sky, sea and fire are
message bearing systems of a kind, offering signs, signals or portents of things to come (see also Serres, 2012). It also means that capacities for making sense of these signs are distributed across many practices, ontologies (de la Cadena, 2015) and ‘sensory ecologies’ (Daly and Shepard, 2019) that extend well beyond the human. Think of how, for instance, trees seem to be able to communicate or how non-human animals have all kinds of sensory capacities (Lorimer et al., 2019). Or think about how non-human devices such as seismographic sensors can detect, in the form of quakes and tremors, signs of the Earth’s motility (Kahn, 2013). Beyond this, materials like water and ice are becoming instrumentalized as part of assemblages of devices for sensing the presence of otherworldly, sub-molecular particles like neutrinos (Thomson and Engelmann, 2017).

Thinking of elemental media also orients us to how the elements become infrastructural. As Nicole Starosielski suggests, one of the most significant dimensions of a turn to the elements is that it involves the ‘investigation of media’s material and conditioning substrates’ (Starosielski, 2016: 1). Elements – from silicon to sodium (Young, 2020) to copper (Grappi and Neilson, 2019) to helium – are critical to the composition of devices and technologies as part of the geology of media (Parikka, 2015). The processes of extraction and refinement that facilitate this as complex, contested and far from clean are revealed, for instance, in what Starosielski (2016) calls the ‘thermocultures of media’. As she writes, ‘thermal manipulation is critical to the transformation of the earth’s raw materials into media and to maintaining those materials as media’ (2016: 293). The operation of ‘smelters or crucibles’ allows ‘copper and silicon’ to become ‘usable elements for media transmission’ (2016: 298). The thermal relations between elements and media can be complicated further if we think about how the infrastructures that sustain contemporary forms of media are themselves now shaping the very conditions – or milieus – on which these media depend for their own performance. Thermal manipulation and the maintenance of coolness has long been a factor in the performance of computing systems (Velkova, 2016). But now the infrastructures that sustain those systems, most notably data centres, are often located at sites that take advantage of the relative coolness of the prevailing climatic conditions (Lally, 2019) as part of new economies of ‘climate-extraction’ (Brodie, 2020). This does not diminish the fact that the manipulation and storage of data is becoming an increasingly significant source of energy consumption to the extent that media infrastructures are contributing to the recomposition of the elemental milieus in which they are immersed. In the process, those infrastructures are becoming elemental agencies altering the molecular composition of milieus in which different signs and signals are sensed.

This expansion of the category of media in relation to the elements does beg the question of what this category actually excludes or if it is now so generalized and analytically diluted to be unhelpful: put another way, what does it mean to say that media are everywhere? One answer to this question might be that the matter of the ‘geo’ and the matter of media are becoming ever more interlaced. As elemental processes, earth-writing and earth-reading implicate ontologies, forms and experiences of mediation to different ends.

### III Elemental worlds

These four elemental orientations sensitize us to different ways in which the elements become explicit through various forms of speculation, expertise and experience. Equally, even if separated here, there are often no clear distinctions between each of these orientations. Thus, elemental milieus are composed of molecular formations that facilitate, amplify or dampen different forms of elemental media. This emphasis on the mixing and entangling of the
elements allows us to avoid the reductivism of certain forms of elemental thinking. It is also a reminder that the elements have never been ontologically pure but have always been unstable and categorically mixed. The key point here is that the elements are becoming more and more entangled in ways that are shaping the conditions of different worlds. This raises some important questions. How to acknowledge the ways in which different versions of the elemental mix while also recognizing that sometimes certain versions matter more than others? How to understand the differential composition and decomposition of elemental worlds and their consequences for diverse forms of life? What kinds of practices and devices, of varying kinds and capacities, allow us to develop more diverse ways of making sense with and within elemental worlds? In the remainder of the article, we wish to address these questions in relation to three matters of concern.

1 Specificities

The first is specificity. Here we draw on Melody Jue’s (2020) arguments about the milieu-specificity of forms of elemental media. By focusing on seawater, Jue’s analysis emphasizes how elemental milieus condition or influence different forms of experience, sensing and thinking. This process is revealed in the relation between bodies and water, especially if we think of differences, for instance, between ways of moving, qualities of buoyancy, capacities to breathe and so on (see also Neimanis, 2017). Developing Jue’s claims further, we would also suggest that the concept of specificity is not only germane to milieus: it can help us think about each of the elemental orientations outlined above. It is possible to think in terms of matter-specificity, molecule-specificity and media-specificity. Equally, the relation between the elements and specificity is not limited only to each of the orientations described above. The elements can also be grasped in terms of relation-specific (Manning, 2009) affinities and bonds within and across different orientations.

The question of specificity holds particular purchase for the question of the molecular and its implication in the composition/decomposition of worlds. Here specificity is a way of acknowledging the problems of reductionism while also realizing the necessary value of a limited constraint for understanding the relations between different versions of the elements. Molecule-specificity foregrounds the properties and relations in which certain molecular arrangements are implicated without necessarily essentializing those arrangements as if they exist in isolation from forms of social, ethical, technical and political life. Focusing on molecule-specificity can involve tracing how the elements rendered visible and actionable via the periodic table become implicated in the spacetimes of different arrangements of living and non-living matter. We can point here to a growing volume of work examining the geographical and geopolitical entanglements of specific elements including aluminium (Sheller, 2014), carbon (Pasek, 2019; Yusoff, 2015), copper (Grappi and Neilson, 2019), plutonium (Davis and Hayes-Conroy, 2018) and uranium (Hecht, 2012a, 2012b).

Such research recognizes that molecule-specificity is not a given but is instead an achievement. This is a necessary demystification of the fetishization of the elements as discrete entities facilitated, in part, by the periodic table, and informed by their value as commodities (see also Starosielski, 2016) within the political economies and ecologies of extraction and transformation through which materials are purified. At the same time, this work also reveals how complex molecules circulate within and across worlds (Barry, 2017; Guthman, 2019; Romero et al., 2017; Shapiro and Kirksey, 2017). While framed to some extent by the periodic table, the point here is to understand the operation of specific forms of chemical intimacy (Chen, 2012), kinship (Balayannis and
Garnett, 2020) and contamination across and between different entities and bodies at a range of scales in ways that sustain or erode worlds (Nading, 2017). In short, far from a form of reductivism or fetishization, thinking about the composition of elemental worlds means mapping the different kinds of specificity in which the elements are entangled.

2 Exposures

Tracing the composition of elemental worlds involves more than specifying the presence and circulation of different elements in the milieus of which these worlds consist. It also involves understanding exposure to the effects of this presence within and across the denizens, from humans to microbes, of elemental worlds (Greenhough et al., 2018; Wakefield-Rann et al., 2019). The question of exposure in relation to elemental worlds can and has often been framed in terms of toxicity (see Liboiron et al., 2018; Tironi, 2018). Toxicity is an indicator of how the relative presence of particular elemental matters in milieus renders them more or less hospitable to forms of life. Recognizing the differential distribution of the toxicity of elemental exposures across worlds is not necessarily new (Edelstein, 2004; Fortun, 2001), but it is increasingly clear that this distribution is shaped by a range of different social, cultural and political factors. The distribution of this exposure can be grasped as a form of ‘slow violence’ (Nixon, 2011) that shapes the conditions in which worlds are made and remade as it becomes distributed across and within these worlds (Davies, 2019; Laurie and Shaw, 2018) and at different rates and temporalities (Garnett, 2017). In these terms, a toxic world refers to ‘the ubiquitous condition of chemically altered living-being, a condition that is shared, but unevenly so, and which divides us as much as binds us’ (Murphy, 2017: 497). While toxicity can be framed explicitly in terms of the chemical, it is not however reducible to it.

Exposures to the relative toxicities of worlds can be sensed via the capacities of different bodies and devices. Here the ontological question of the molecular composition of milieus and worlds and the epistemological question of how this composition can be sensed mix with particular volatility and urgency (Shapiro and Kirksey, 2017). The molecular toxicity of elemental milieus is not always explicit. It can be latent in the background of worlds. Nick Shapiro’s (2015) ethnography of living with formaldehyde in US domestic environments is exemplary here. Present in many building and furnishing materials (plywood, furniture, carpet backing, etc), formaldehyde can seep into the breathable atmospheres of homes, generating a range of toxic effects which accumulate within the body, and which tend to be more prevalent in low-income prefabricated housing. Critical here are the capacities of bodies to sense ‘barely perceptible’ variations in elemental worlds evolving ‘well before cognition catches wind of protracted chemical encounters’ (2015: 375).

In this way, bodies can be understood as modest but situated elemental media devices with capacities to sense signs and symptoms of exposure to everyday toxicity in domestic milieus (Cragger, 2018). The intuitive understandings generated by these capacities can be given a degree of further legitimacy through the use of a range of low cost and community-based devices and technologies for measuring the presence of toxic substances (Zhang et al., 2019). Other forms of collaborative media experiment are exploring possibilities for making explicit the composition of milieus through a range of devices and practices (see Calvillo, 2018; Calvillo and Garnett, 2019).

Weathering is a way of thinking about how bodies become differentially exposed to the specific toxicities of elemental worlds. Where Tim Ingold (2010) has written of ‘weather-worlds’ as a noun, we prefer the sense of weathering as a verb: weathering worlds refers to the condition of being exposed to the elemental molecules
and milieus that can render those worlds toxic to different degrees. Here we follow scholars like Astrida Neimanis and Jennifer Mae Hamilton (2017) and Christina Sharpe (2016) who use the term ‘weather’ to refer to both the process of being exposed to the elements and the fact that this process is experienced and endured differently across worlds. By invoking Sharpe’s work here, we don’t wish to suggest that it is reducible to the concerns of our article – her work is centred on and conditioned by a specific historical–geographical project of wake-work. Our point is not to reduce Sharpe’s use of the concept to an instance of weathering more generally. However, her use of weather reminds us that this process is not specific to the forms of violence associated with late liberalism or with the exposure to the effects of climate change. For Sharpe (2016), weathering is one way – among others – of thinking the ongoing condition of being exposed to the racist climate that persists in the ongoing wake of slavery. In this context, blackness is ‘constituted through and by continued vulnerability’ to the toxic and traumatic conditions of elemental worlds (2016: 134); at the same time, ‘black microclimates’ are ‘acts of practice that disrupt the weather’ through tactics of organizing and protest (Sharpe, 2017: 18).

These scholars and others are careful to avoid the tendency to think of toxic exposure either as an individual experience or as one that simply renders ‘lives and landscapes as pathological’ (Murphy, 2017: 496). Enduring the weathering of worlds is, as Neimanis and Hamilton suggest, about ‘cultivating attunement to how our own bodies, and bodies of others, experience weather. This includes how we and they manage it architecturally, technologically, professionally and socially’ (2017: np). Weathering embodies a different ethos than terms like resilience and sustainability because it foregrounds what is lost or worn away as much as what endures and survives within worlds. Weathering provides a way of thinking across the relation between the elemental force of different scales and temporalities of exposure and the various ways in which this exposure is endured, tempered and ameliorated. In this vein, Manuel Tironi and Israel Rodrigues-Girault (2017) explore the ‘damaged worlds’ inhabited by communities abandoned in the face of the toxic milieus around Punchuncavi, about 150 miles from Santiago in Central Chile. In that context, as in so many others, toxicity is not a ‘spectacular disruption lived in the excitement of the eventful, but a chronic, silent, and creeping condition that is inseparable from life’s ordinariness’ (2017: 94).

While these worlds are weathered, forms of attachment and practices of living on continue. Drawing upon the work of Maria Puig de La Bellacasa (2012), Tironi and Rodrigues-Girault argue that care works as a circumstantial set of practices and ethico-political orientations that amplify capacities to be affected by other entities, including those elements that are not so benign. Care is about cultivating partial connections in and across elemental milieus through openness to ‘new forms of sensual and ecological knowledge about beings, things, and relations’ (2017: 89; see also Kirksey, 2017). This emphasis on care should not be taken to mean that worlding is always possible or that the affirmative sense of weathering as enduring is any guarantee of the continuity of different forms of life. Instead, as Mel Chen (2012) has shown, toxic exposures can be grasped as a process of ‘unworlding’ in which the sensory, physiological and affective orientations of worlds and the bodies they implicate are unsettled and diminished.

3 Alchemies
Specificities and exposures can be understood as modes of assaying the compositions and decompositions of elemental worlds. The third matter of concern we wish to foreground here combines assaying with a more speculative
sense of the elemental. This is the alchemical, understood by Pete Adey as the ‘magic of attraction’ (2015: 60) or a ‘moment of transformation’ when two or more elements fuse together (2015: 69). The alchemical highlights mixtures, transmutations and compositions that do not fit neatly within any particular version of the elements. As Yuriko Furuhata (2019) notes, alchemy (rather than modern chemistry or Greek elemental philosophy) has attracted attention in media studies, especially in studies of computation. This has much to do with alchemy’s connotations of experimentation and mystery which speak to computational ‘wizards’ as well as the refining, processing and smelting of earth elements intrinsic to computational power. Alchemies also come to the fore in new organizations and diagrams such as the Anthropogenic Table of the Elements (see Neale, Phan and Addison, 2019), and in ways that both complicate the purity and stability of the periodic table and show how the elements are often better grasped in terms of the alchemical properties and affective entanglements of molecular as well as cultural forms. Reworked thus, these diagrams complicate hierarchies of scientific and non-scientific knowledge, privileging different kinds of visual, expressive and sonic artefacts that bear witness to processes of fusing, transforming and mingling in elemental worlds.

Artists are unsettling traditional senses of matter and the molecular through elemental alchemies. For instance, in her performance work, A Trans-Atlantic Periodic Table, Ayesha Hameed addresses gold, bone, pearl and lead, citing their molecular compositions alongside their complicity in the economies of the Middle Passage. Chronicling her visit to a gold museum closed decades ago, or feeling overwhelmed holding a few glass beads discovered in a sunken slave ship, Hameed reminds us that these elements are haunted with colonial and racial struggles. Time, space and geography fold into new transmutations as Hameed says, “these past objects, séanced into the present, have undergone a sea change” (emphasis ours; Hameed, 2019: np). While Furuhata suggests that geopolitical tactics of weather modification are enchanted with the logic of elemental phases, Hameed proposes that the weather of empire produces alchemical state changes on the seafloor and on the surface. A series of elemental materials and molecules become lures for an alchemical inquiry into human suffering, colonial violence and the depths of the Atlantic.

Alchemy may also be invoked to describe the vast transformations in elemental milieus and media precipitated by sociopolitical and economic forces. For example, Denise Ferreira da Silva (2018) turns to the elements as ‘metaphysical descriptors’ for thinking outside of linear constructs of time and progress and towards a notion of history as a series of phase-transitions. More specifically, it is the stifling heat of the air that conveys positive feedbacks of colonialism, capitalism and extraction. Ferreira da Silva explains: ‘The accumulation of atmospheric gases expresses (is equivalent to) the extent of expropriation and the intensity of the concentration of expropriated internal (kinetic) energy of lands and labour facilitated by coloniality and raciality’ (2018: np). Thermodynamic transformations in the atmosphere are not treated as purely chemical, mechanistic or irreversible processes but are material and medial phase shifts driven by colonial and capitalist forces.

These are concepts and approaches that Ferreira da Silva explores further with filmmaker Arjuna Neumann in their growing body of artistic work. Neumann and Ferreira da Silva’s first collaborative film Serpent Rain, inspired by the story of a sunken slave ship, operates ‘from inside the cut between slavery and resource extraction, between black lives matter and the matter of life, between the state changes of elements, timelessness and tarot’ (Ferreira da Silva and Neumann, 2016: np). Their second film 4 Waters: Deep Implicancy follows routes through the Pacific, Atlantic and Indian Oceans.
as well as the Mediterranean Sea, conveying solid-fluid state changes and depicting moments of eruption, volatility and sublimation. Complementing Ferreira da Silva’s philosophical thought, *Serpent Rain* and *4 Waters: Deep Implicancy* are audiovisual exercises exploring alchemies of the elements in relation to socio-political forces, economies and histories. By probing these dimensions of elemental worlds, artistic practices address the ways these worlds are constructed, highlighting their contingency. These practices make important propositions for elemental geographies since they operate across the four elemental orientations while foregrounding the ubiquitous and specificity of transformation through performance, storytelling and audiovisual essay.

Such explorations of and experiments with elemental alchemies also help us signal the importance to elemental worlds of the generation, reproduction and destruction of different forms of affective attachment. These forms of attachment are not, of course, necessarily intentional nor a matter of choice: they can precede intention or awareness, being formed through exposures that take place outside of awareness (Povinelli, 2017). They are also affectively multivalent, involving elemental alchemies that variously increase and decrease the capacities of bodies and forms of life. A sensitivity to such alchemies can be found in the Empedoclean version of the elements, combining as it does ideas of love and strife. Stacy Alaimo has suggested that such ideas may provide imaginative, aesthetic and ethical resources for thinking with the elements as both inescapable and always excessive of our epistemologies. As she writes, ‘love of the world may propel us toward that which we seek to know, but we are bound to bump up against that which is unknowable. An oscillating epistemology of love and strife may be invaluable within the Anthropocene’ (Alaimo, 2015: 306). To foreground love in this sense is not to return to some kind of rose-tinted view of the elements as benign sources of affective reassurance in a toxic world. Instead, it amplifies the specificity of exposure to the elemental conditions of different worlds, in the process fracturing, as Alaimo continues, ‘the blithe obliviousness of humans toward the stuff of the world’ (2015: 307). Equally, while we can take much from Alaimo’s qualified use of Empedocles, the alchemical currents of this thinking need to be supplemented by different traditions in ways that allow us to understand, to paraphrase de la Cadena and Blaser, a ‘world of many elemental worlds’ (2018). These alchemies can help us become sensitive to the expressive, affective, partly unknown or otherwise excessive dimensions of elemental experience. And in doing so, they can provide a critical corrective to the incessant modes of ‘capture’ that are a feature of efforts to reduce the ontology of elemental lifeworlds through forms of epistemic reductivism.

**IV Conclusion**

In this article, we began by arguing that work on the elements can be understood in relation to four different orientations (matter, molecule, milieu and media). We presented these not as alternatives to a kind of Empedoclean fourfold classification system but as different possibilities for sensitizing thinking to the elements and the elemental. Admittedly, these orientations are not by any means exhaustive and there are others that could be considered, including, for instance, the question of how the elements figure as distinctive forms of capital. And there are other issues absent from this discussion. For instance, a range of methodological questions arise from the arguments of this article, particularly in relation to the problem of exposure. There is much to be said about the kinds of ethics that might emerge from different elemental orientations, not least in relation to environmental pedagogies (Rooney, 2018). And there is also much more that could be said about how different elemental agencies (of which fire is
one of the more obvious) are becoming the problematic objects of different forms of governance (Neale, Zahara, et al., 2019; Veland, 2017). Nor are these orientations settled: as we noted above, part of the value of thinking with the elements is an ongoing agitation by a range of anthropogenic and other processes.

We then argued, in the second part of the article, that these orientations can help us understand the composition and decomposition of different elemental worlds through attention to three matters of concern (specificities, exposures, alchemies). We have used the idea of elemental worlds with caution. With its roots in phenomenological traditions of thinking, this term has often been used by geographers to express a distinctively human sphere of experience, attachment and affective value (e.g. Buttner, 1976). It has also often been subject to critique on the basis of its inadequacy for dealing with contemporary ecological problems whose scale vastly exceeds human worlds (Morton, 2013). We are using world here in a post-phenomenological sense: by this, we mean that it is not circumscribed by human experience but does not preclude particular modes of anthropocentric affective attachment (de la Cadena, 2015; McCormack, 2017b; Stewart, 2007). Understood thus, elemental worlds, or worldings, and the matters and milieus of which they are composed, can involve forms of life whose intimacies are variously benign or toxic (Chen, 2012). There are multidimensional worlds for spiders, for instance, as much as there are for humans, and lots of ways in which both worlds are entangled (Engelmann, 2019b). By elemental worlds, we therefore mean worlds whose composition and conditions are shaped—but not determined by—the circumstantial relations between the four elemental orientations outlined above: in the spider’s world, for instance, the web becomes a milieu and media infrastructure composed of the molecular properties of silk. Thinking in terms of the relations between these orientations does not mean that they collapse into a kind of undifferentiated plenum. Instead, as we have suggested, they direct our attention to how the composition of worlds can be grasped in relation to specificities, exposures and alchemies.

We are not suggesting that the elements are the only factor we need to take into account when thinking about worlds—far from it. Worlds are also tensed, diminished, enhanced, exhausted and destroyed by a whole range of forces and factors (see, for instance, Laurie and Shaw, 2018). Our aim instead has been to foreground the participation of different elements in the composition and decomposition of worlds, questioning at whose expense, and with what effect on the capacities of which entities. The elements are an increasingly significant and as yet only partially explicit influence on how worlds are made, valued and experienced and, furthermore, in how they are made habitable or uninhabitable. They are likely to become more influential and for reasons that are not difficult to divine. When we began writing this article, in the forefront of our minds were the many ways in which issues such as climate change, air pollution and environmental injustices were rendering the elements explicit as matters of concern across different worlds. As we revised this article, the global Covid-19 crisis emerged. It is obvious that this crisis will also reshape elemental worlds in profound ways that are yet to be understood. But even now it is clear that the unfolding geographies of this crisis reveal many different ways in which exposures to different milieus and molecules are mediated by a range of social, technical and political devices. Exposures to toxic molecules and particles suspended in the air are amplifying Covid-19 vulnerabilities. For instance, a nationwide, cross-sectional study in the US showed that ‘an increase of only 1 µg/m³ in PM2.5 is associated with an 8% increase in the COVID-19 death rate’ (Wu et al., 2020: 2). These exposures render bodies vulnerable to elemental milieus in ways that are already shaped by the structural violence of race (Tessum et al.,
Black and Latinx communities who have historically faced disproportionate levels of exposure to air pollutants like PM 2.5, and yet who are least responsible for the emissions of such pollutants, are disproportionately vulnerable to Covid-19 because of these historical and ongoing exposures.

As the Covid-19 pandemic transitions from an urgent to a slower but no less violent or racialized emergency (Anderson et al., 2019), elemental milieux will become the focus for new and intensified forms of biopolitical and necro-political techniques and technologies that monitor and modify their molecular composition through many forms of mediation. Their composition will generate a range of responses, including diverse forms of ‘resigned activism’ (Lora-Wainwright, 2017) for living and weathering exposures to different worlds. If we are being hopeful, we might speculate that this crisis will encourage the reworking of affective attachments to the promises and possibilities of worlds in the recognition that the elements, in all their versions, are constitutively commingled in these attachments in ways that demand equity, reparation and justice. We might also speculate that this crisis will help us to grasp how we participate in collectives and communities that are differentially impacted by molecular, medial and material forces, whether we have consciously chosen to participate or not. And it might allow us to grasp the extent and duration of old and emerging harms as they percolate through the intimacies of humans, non-humans, the elements and their various lifeworlds.

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