

‘A Sex Life of Metal?’

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LUSTROUS MATTER

‘Just like everything that came forth from the earth, the metals possess the qualities of regeneration, growth and propagation’, observes metallurgical historian R J Forbes of the mystical sympathies of the ancient world. Before adding: ‘The sexuality of the metals is a very early belief that is not yet dead.’¹ In rather less intense and more oblique ways, the metallic elements are still implicated in sexual life. Today, metals are shaped into vehicles that ferry us to our rendezvous, secreted in our communicative devices, slipped into vitamin pills or performance-enhancing medications – and as they have been for millennia - forged into bodily adornments that advertise our availability or unattainability, cast into objects of allure or crude tokens of exchange.

But ‘the sexuality of the metals’ may run deeper than this. As Jane Bennett reminds us, the metallic elements did not wait upon our own species to begin their seductive and conductive adventures. ‘A Life of Metal’, a compact and catalytic chapter at the core of *Vibrant Matter*,² celebrates the vitality of human metalwork. More than this, Bennett’s metallurgy probes the composition and properties of metals themselves, and explores the junctures where biological life mingles with a generative minerality. Hers is a world in which the allure of

¹ Robert Jacobus Forbes, *Metallurgy in Antiquity* (Leiden: E. J. Brill, 1950), 85.

² Jane Bennett, *Vibrant Matter: A Political Ecology of Things* (Durham and London: Duke University Press, 2010).

metals extends far beyond the compass of humankind, where base material bling sparks desires in bodies very different from our own. A world, that is, which invites us to pry further into the ways that the metals work their wonders across a range of sexual and reproductive lives.

It is Gilles Deleuze and Felix Guattari, as Bennett indicates, who lifted the study of metals and metalwork out of sub-disciplinary specialization and into the reaches of philosophical inquiry.³ But then, they had some pretty rich material to excavate and refine. *Metallurgy in Antiquity* by Robert Jacobus Forbes, one of Deleuze and Guattari's key sources, is the culmination of daunting archival research (it has over 300 references - in at least seven languages - just on silver and lead). More than a mere compendium, there is a deep and pervasive democracy in Forbes' detail. In the metallic cosmos he conjures, iron smelters of Nigeria are on equal footing with chalcolithic artisans of Anatolia, bracelets and earrings are of no less interest than sabres or ploughshares.

Eschewing any linear narrative, Forbes evokes an extended field of invention, dispersion, and adaption – a play of nodes and networks seemingly mediated by the metals themselves. Such thinking through 'multitudes' is characteristic of classic metallurgical scholarship, to the extent that storylines often swerve from the human domain altogether. As metallurgical historian Theodore Wertime expounds of the metallic elements: 'They became catalysts of social life for men even as they had been catalysts of energy exchanges for cells in the biological organism.'⁴ Metals re-endowed with 'qualities of regeneration, growth and propagation', we might say, in a more contemporary idiolect.

³ Bennett, *Vibrant Matter*, 59-60.

⁴ Theodore Wertime, 'Pyrotechnology: Man's First Industrial Uses of Fire,' *American Scientist* 61:6 (1973), 670-682: 680.

No one does this inclusive and heterogeneous take on metallurgy better than Cyril Smith, the aptly named metal guru that Bennett and I share. A practicing industrial metallurgist and materials scientist, Smith was insistent that human understanding of the properties of materials derived primarily from non-purposive activity: it emerged out of `a rich and varied sensual experience of the kind that comes directly from play with minerals, fire, and colours.'⁵ In the case of metals, he stressed, the mix of free play and more structured or disciplined activity that characterized artisanal expression also had a lot to do with the physical and chemical structure of metallic elements themselves.

It is Smith's searching empirical observations on the polychrystalline structure of metals that Bennett takes as a portal into the heart of a dynamic, vibratory materiality. While metals are composed of tiny crystals packed together in a regular array, Smith stipulates that it is the `intercrystalline' gaps or irregularities in the composition of different metals which generates the interplay of chance and necessity that is key to their transformative potential.⁶ Thousands of years before scientists were able to come to grips with `imperfections' in the structure of metals, he notes, metallurgists had learned how to set this real-world complexity and inconsistency to work.⁷ Or as Bennett puts it: `The desire of the craftsperson to see what a metal can do, rather than the desire of a scientist to know what a metal is, enabled the former to discern a life in metal and thus, eventually, to collaborate more productively with it.'⁸

⁵ Cyril Stanley Smith, *A Search for Structure: Selected Essays on Science, Art, and History*, (Cambridge, MA.: MIT Press, 1981), 203.

⁶ Smith, *A Search for Structure*, 3-12; Bennett, *Vibrant Matter*, 58-9.

⁷ Smith, *A Search for Structure*, 49-54.

⁸ Bennett, *Vibrant Matter*, 60.

For Smith, it is the interplay of regularity and imperfection - 'which can be combined in an almost infinite variety of ways' – that provides a common thread to the incessant generativity with which both biologists and metallurgists grapple in their respective fields.⁹ Likewise in Bennett's work, it is the recognition that there is a capacity for self organization and the emergence of novelty in both organic life and inorganic matter that throws a bridge across the ontological divide that has characterised modern western thought.¹⁰ This shared 'vitality', for her, is not just a question of potentialities intrinsic to both life and matter, but of the novel structures and arrangements that emerge from the coming together of different kinds of things. There are not simply individual elements or beings endowed with capacities of their own, but always 'a swarm of vitalities at play.'¹¹ And so, for Bennett:

metal is always metallurgical, always an alloy of the endeavours of many bodies, always something worked on by geological, biological, and often human agencies. And human metalworkers are themselves emergent effects of the vital materiality they work.¹²

Even amidst the irruption of 'new materialities' in recent social and philosophical thought, the double movement that Bennett puts into play here is exceptional. Not only are we encouraged to take an interest in mutual encounters between lively humans and agential matter, we are also prompted to consider how the very possibility of a power or an agency that is recognisably 'human' is ultimately an expression of the potentiality of inanimate

⁹ Smith, *A Search for Structure*, 64.

¹⁰ Bennett, *Vibrant Matter*, 50-51.

¹¹ Bennett, *Vibrant Matter*, 32.

¹² Bennett, *Vibrant Matter*, 60.

matter to give rise to animate beings. 'We are', Bennett approvingly cites the geochemist and mineralogist Vladimir Vernadsky, '...walking, talking minerals.'¹³

What then of the conjunction of sex and metals? Mario Perniola speaks of 'the sex appeal of the inorganic' with regard to our propensity, under certain circumstances, to be lured or captivated by inanimate matter.¹⁴ Whereas Perniola (and Walter Benjamin before him) restricts this focus to *human* sensual experience, Bennett invites us to extend the concept far beyond the orbit of our own species being and into modes of attraction and impressionability that inhere in matter itself: 'The "sex appeal" of the inorganic, like a life, is another way to give voice to what I think of as the shimmering, potentially violent vitality intrinsic to matter.'¹⁵

But is this just a matter of what always already sexually divided beings make of lustrous and ductile materials in pursuit of their desires? Or might there be something more we can say about the meeting point between the generative vibrancy of metals and the recombinative potentiality of sexual reproduction? Taking flight from Bennett's exuberant metallurgy, I want to look more closely at the gendering of social practices of mineral transformation, before turning to the role of metallic elements in sex lives further afield than our own. Riffing on recent research that makes claims for the significance of trace metal availability in the very ascendance of sexual reproduction, we return to the metal-urges of the contemporary world. Here, in the face of impending resource scarcities and escalating environmental issues, I suggest that our metallurgical exertions are arriving at a strange

¹³ Bennett, *Vibrant Matter*, 60.

¹⁴ Mario Perniola, *The Sex Appeal of the Inorganic: Philosophies of Desire in the Modern World* (London: Continuum, 2004).

¹⁵ Bennett, *Vibrant Matter*, 61.

conjuncture, one in which the `orgiastic' metallic incitements of organic life may be coming to play an increasingly pivotal role. Returning to Bennett's `geoaffective' take on mineral-biological entanglements,¹⁶ we begin to consider what other possibilities might be lurking in past and current bio-metallic imaginaries.

GENDER AND THE INVENTION OF METALLURGY

`Gold', as the Marx of *Grundrisse* cites an old Peruvian saying, is `the tears wept by the sun.'¹⁷ A vestige perhaps, of Marx's more youthful vital materialist leanings that end up subsumed in a rather more sober account of the historical role of precious metals in capital accumulation. `By the time Marx gets done', Bennett deftly sums up, `the fighting spirit of matter settles down into bodies of men.'¹⁸

The role of metallic ores and other mineral resources in galvanising and entrenching unequal social relations is now a well-established field of critical social analysis. Despite the boost from Deleuze and Guattari, however, cultural or philosophical reflection on metals is more sporadic, though we might see eco-feminist pioneer Carolyn Merchant offering a kind of precursory backstory to Bennett's vital metallurgy. In the *Death of Nature*, Merchant drew attention to the organic cosmology that she argues was ousted by the rise of the modern mechanistic worldview:

¹⁶ Bennett, *Vibrant Matter*, 61.

¹⁷ Karl Marx, *Grundrisse* (London: Penguin, 1973), 833.

¹⁸ Jane Bennett, *The Enchantment of Modern Life: Attachments, Crossings, Aesthetics* (Princeton and Oxford: Princeton University Press, 2001), 120.

Metals and minerals ripened in the uterus of the Earth Mother, mines were compared to her vagina, and metallurgy was the human hastening of the living material in the artificial womb of the furnace ... miners offered propitiation to the deities of the soil, performed ceremonial sacrifices, ... sexual abstinence, fasting, before violating the sacredness of the living earth by sinking a mine.¹⁹

Merchant's account draws on Mircea Eliade's exploration of the entanglement between early metallurgy and religious beliefs²⁰, and further resonates with more recent ethnographic research.²¹ However, some archaeologists have grown impatient with the broader reception of the ecofeminist narrative. As Lynn Meskell voices her misgivings: 'We all know the story: things were peaceful, creative, vegetarian and Goddess-centred ...that is until men ruined it by bringing increased technology, metallurgy, warfare, etc.'²² But archaeology has itself benefited from feminist perspectives, which have encouraged questioning of key assumptions about the gendered locus of agency in studies of prehistory and antiquity. 'Until very recently ... what archaeologists have recognized as the "hallmarks" of human evolution – tools, fire, hunting, food storage, language, agriculture, metallurgy – have all been associated with men', observes Janet Kouran, before going on to

¹⁹ Carolyn Merchant, *The Death of Nature: Women, Ecology and the Scientific Revolution* (London: Wildwood House, 1980), 4.

²⁰ Mircea Eliade, *The Forge and the Crucible: The Origins and Structures of Alchemy* (Chicago and London: University of Chicago Press, 1978).

²¹ See Randi Haaland, 'Say it in Iron: Symbols of Transformation and Reproduction in the European Iron Age.' *Current Swedish Archaeology* (2007/8) 5/6: 91 -110.

²² Lynn Meskell, 'Feminism, Paganism, Pluralism'. In *Archaeology and Folklore* edited by Amy Gazin-Schwartz, A. and Cornelius Holtorf (London: Routledge, 1999), 83- 89: 82.

question the status of the 'big questions' and their occlusion of accomplishments more stereotypically associated with women.'²³

What does seem to have been substantiated – by archaeological and ethnographic research - is the pervasiveness of a gendered division of labour between pottery and metalwork. At least until the more 'industrialized' production that was linked with the development of the potters wheel, pottery has been closely associated with the 'female domain of hearth-centred activities' involving food preparation, presentation and storage, while metalwork appears almost universally restricted to the male domain.²⁴

Although the vision of prelapsarian harmony may have been rattled, the products of metallurgy have by no means been fully acquitted. It has been argued that – amidst a field of troublesome contenders - it was the uptake of the iron-shared plough that had the most significant impact on both gender and socio-economic stratification. By dramatically increasing the area under tillage, the coming of the plough was bound up with new forms of de-communalised land tenure and inheritance - which impacted negatively on women and poorer men. Unequal access to metal weapons seems to have reinforced the widening divide between peasants and elites.²⁵

²³ Janet Kouran, *Philosophy of Science after Feminism* (Oxford: Oxford University Press, 2010), 7.

²⁴ Haaland, 'Say it in Iron', 101.

²⁵ Joan Huber, 'Macro-Micro Links in Gender Stratification: 1989 Presidential Address.' *American Sociological Review* 55: 1 (1990) 1-10: 5; Jack Goody, *Metals, Culture and Capitalism: An Essay on the Origins of the Modern World* (Cambridge: Cambridge University Press, 2012), 48-9.

Though it does little to revise this story of deepening sexual and social stratification, metallurgical history can do much to complicate any hard-line division between the domesticity or decorativeness of women's artisanship and the techno-scientific advancement most often accredited to men's craft. As I intimated earlier, historians of metals and metalworking often seem to perform a sort of prescient unsettling of axioms of linear progression. As Forbes insists: 'the early metal worker was not pushed along the path of progress because he had no idea it was a path at all.'²⁶ As we have already glimpsed, scholars of metallurgy stress that play and open-ended experimentation was as central to learning how to transform metallic ores as was disciplined and rigorous knowledge. Indeed, as Cyril Smith would have it: 'Nearly all the industrially useful properties of matter and ways of shaping materials had their origins in the decorative arts.'²⁷

But the 'deconstructive' work done by historians of metallurgy goes further than this. Researchers have also shown that early metalwork cannot be understood apart from the other arts and skills with which it was enmeshed. Some decades ago, Theodore Wertime drew attention to 'the often forgotten but massive effects of man's re-shaping of earthy materials by fire.'²⁸ Advancing the idea of a 10,000 year spree of experimentation in heat-driven transformation of the materials of the earth, he proposed that ceramics, metallurgy,

²⁶ Forbes, *Metallurgy in Antiquity*, 12.

²⁷ Smith, *A Search for Structure*, 242.

²⁸ Theodore Wertime, 'The Furnace versus the goat: The Pyrotechnologic Industries and Mediterranean Deforestation in Antiquity.' *Journal of Field Archaeology*, 10: 4 (1983), 445-452: 446.

glassmaking and related arts formed 'a single, complex pyrotechnic tradition.'²⁹ Within this interweaving of crafts, Wertime and fellow pyrotechnical scholars draw special attention to the intensive synergies between the ceramic and the metallurgical arts. While potters gifted smiths with the techniques and fireproof materials to make molds and crucibles, metallurgy came to be a source of the metals and oxides used to color and glaze pottery.³⁰

Such exchanges, however, are not simply symmetrical. In order for an expanding range of 'earthy materials' to be subjected to artful transformation, certain temperatures needed to be attained – just as a certain attitudes towards heat itself were required. Both the will and the technical aptitude necessary for working with metals, metallurgical scholars insist, had earlier origins. Pottery, they propose, was the primordial pyrotechnology: the Neolithic pottery kiln being the first heat chamber capable of generating temperatures high enough to smelt metallic ores. Earthenware came first, it is argued, because it relates most closely to the daily experience of the cooking hearth or oven – where the grains produced by early agriculturalists were rendered edible.³¹ And the hearth, Wertime suggests, was the crux of the emergent explorative attitude toward the properties of minerals and ores: 'Its walls were a self-registering pyrometer showing in their colors and hardness the degrees of temperature attained as well as the oxidizing or reducing atmospheres.'³²

²⁹ Wertime, 'Pyrotechnology', 676; see also Nigel Clark 'Fiery Arts: Pyrotechnology and the Political Aesthetics of the Anthropocene', *GeoHumanities* 1: 2 (2015) DOI: 10.1080/2373566X.2015.1100968.

³⁰ Theodore Wertime, 'Man's First Encounters with Metallurgy,' *Science* 146: 3649 (1964), 1257-1267: 1265; Smith, *A Search for Structure*, 127–8.

³¹ Lesley Aitchison, *A History of Metals, Volume 1* (London: MacDonald & Evans, 1960): 9.

³² Wertime, 'Pyrotechnology', 672.

Far from an autonomous technological breakthrough, then, the metallurgical branch of the pyrotechnical lineage appears initially in a rather more derivative light. Metals historian Leslie Aitchison notes that azurite and malachite, two of the ores of copper, were first used as ingredients of decorative pottery glaze. This leads him to surmise that the smelting of copper – probably the first metal to be produced from ore - may have occurred accidentally, as the metallic products of these ores dripped onto the floor of a pottery kiln.³³

The details are, of course, debatable, and Aitchison was writing a good half century ago. The more general point is that the invariably male field of classic metallurgical scholarship has - rather inadvertently – provided foundations for elevating *women's* 're-shaping of earthy materials by fire' to an axial role in the developments at the core of both ancient and modern technics. Metallurgy may have ended up a male domain, but there are sound reasons to believe that the more generalised principles of applying heat to 'earthy materials' were essentially female inventions.

As Wertime wraps up: 'It was through working with bright, glittery metals that men came to have some scientific understanding of the physical forms of materials.'³⁴ But a feminist approach to pyrotechnology might do more with the idea that male metallurgists had their initial fun in heat chambers designed and constructed by women - that men fashioned their first spangly baubles in ovens built for rendering agricultural produce edible and hardening clay into durably decorative kitchenware. In this context, and in the light of subsequent feminist scholarship, the genre of mid-20th century male-scribed metallurgical musings - to which Jane Bennett and I have both taken a shine - might gesture towards a more fully pyrotechnic eco-feminism. A focus on gendered practices of heat-induced transmutation of

³³ Aitchison, *A History of Metals*: 40.

³⁴ Wertime, 'Pyrotechnology', 674.

earthy materials, perhaps, that potentially mediates between the pit-fired earthenware goddess and the metallic circuitry of the cyborg.³⁵

METAL AND THE INVENTION OF SEX

Its one thing to suggest some ways in which the invention of metallurgy might be caught up in gendered subdivisions of human work and play. But we can look at this from another angle. If human metalworkers are indeed 'emergent effects of the vital materiality they work with', as Bennett notes, then we might wonder, what role have vibrant or agential metals played in the biological processes through which metalworkers are reproduced? Or in any other human or nonhuman organismic body, for that matter. In short, how did our species, along with most other animal life, come to be sexually reproducing itself in the first place?

As Wertime's observation on the catalytic role of metals in biological life intimates, we humans are far from the first living things to feel the allure of the metallic. Most living systems require metals in minute quantities to perform respiration, digestion, photosynthesis, nitrogen fixation or any of hundreds of other metabolic processes. These trace metals are especially important for the catalytic activity of enzymes: for both increasing the speed and improving the specificity of metabolic reactions.³⁶ And this means

³⁵ See Donna Haraway, 'Cyborg Manifesto: Science, Technology, and Socialist-Feminism in the Late Twentieth Century'. In *Simians, Cyborgs and Women: The Reinvention of Nature* (New York: Routledge, 1991).

³⁶ C. Andreini, I. Bertini, G. Cavallaro, G. Holliday, and J. Thornton, 'Metal ions in biological catalysis: from enzyme databases to general principles,' *Journal of Biological Inorganic Chemistry* (2008) 13: 1205–1218.

that availability of metals has been a key to the evolutionary pathways that life on Earth has taken. In particular, research has shown that access to certain 'bioessential' metals – including copper, zinc and molybdenum – was pivotal in the rise of the more complex 'eukaryotic' domain of life.³⁷

Biological life seems to have emerged relatively early in the Earth's history: towards the end of the planet's first billion years or much earlier by some reckonings. For well over two billion years, single-celled organisms of the Archaea and Bacteria domains (collectively known as prokaryotes) shaped and ran the biosphere. With miraculous success, evolutionary biologist Lynn Margulis would remind us.³⁸ Microscopic life radiated out into a huge range of environmental niches and evolved nearly all the known metabolic processes that define 'life'.³⁹ But around 1.6 to 2 billion years ago, saw the emergence of organisms with more complex cellular structures – most notably a membrane-enclosed nucleus. And they eventually formed a new domain of life: the Eukarya. Some of these eukaryotes developed into multicellular forms, gradually evolving into algae, fungi, plants and animals. Initially, however, many eukaryotic newcomers, inexperienced at foraging and equipped with less-pervious cell walls, had a tough time competing for bioessential metals with their more permeable and better-practiced prokaryotic counterparts.⁴⁰

³⁷ J. Parnell, M. Hole, A. Boyce, S. Spinks and S. Bowden, 'Heavy Metal, Sex and Granites: Crustal Differentiation and Bioavailability in the Mid-Proterozoic,' *Geology* (2012) 40: 751-754

³⁸ Lynn Margulis and Dorian Sagan, *What is Life?* (New York: Simon & Schuster, 1995): 68-89.

³⁹ Myra Hird, *The Origins of Sociable Life: Evolution after Science Studies* (New York: Palgrave Macmillan, 2009): 22.

⁴⁰ A.D Anbar and A. H Knoll, 'Proterozoic Ocean Chemistry and Evolution: A Bioinorganic

There are big questions, then, around how and why the evolutionary take-off of eukaryotes finally occurred. As a recent theory would have it, it took a massive influx of bioessential metals into their environment to provide an opening for more complex life forms in a biosphere dominated by bacteria and archaea. The decisive events were planetary in scale. Around 1.9 billion years ago, according to geologist John Parnell and his colleagues, there was an uncharacteristically large volume of molten crust-forming material pumped out of the Earth's mantle, contributing to the formation of a new supercontinent.⁴¹ Magma then continued to burst up through the continental plate itself. Hardening into granite, the extruded rock was rich in metals. As this bumper effusion of granite gradually eroded over the next few hundred million years, exceptional quantities of copper, zinc and molybdenum were released, collecting in terrestrial soils and shallow bodies of water. While also good for archaea and bacteria, these trace metals were especially conducive to the proliferation and diversification of eukaryotes.

Parnell teases out the broader evolutionary implications of this surge in availability of bioessential metals:

It was the introduction of the metals into these single-celled organisms that changed their chemistry and allowed them to evolve into the complex multi-celled organisms which were the first step towards more diverse life on Earth. When a cell is more complex it means it can perform more functions – and one

Bridge?' *Science*, New Series, 297: 5584 (2002): 1137-1142: 1140.

⁴¹ Parnell et al, 'Heavy Metal, Sex and Granites.'

of the new functions of the complex multi-celled organisms which developed at this time, was sexual reproduction.⁴²

Albeit a relatively late arrival, sexual reproduction - most life scientists agree - had momentous implications for life on Earth. Exactly how and why reproducing sexually makes a big difference, however, is surprisingly contentious.⁴³ Like reproduction, sex was nothing new. Bacteria and archaea reproduce in a variety of asexual ways, mostly involving some form of budding or fission. But most are also sexually active, if sex is defined as the mixing of genetic material between individuated bodies. Prokaryotes acquire new DNA in numerous ways: by fleshy couplings (sometimes with multiple partners simultaneously), by ingesting dead fellow microbes, via viral transmission, or through bodily absorption of free-floating genetic material in a liquid medium.⁴⁴ All of this makes for a level of unbounded and promiscuous 'lateral' gene transfer without peer in the world of more complex organisms. And so there is both sex and reproduction in the prokaryotic world. It's just that they are two quite distinct aspects of life.

In the metal-charged world of emergent eukaryotic life, sex and reproduction were irrevocably fused - though other ways of reproducing at the cellular level persisted. While Parnell fairly modestly ventures that sexual reproduction 'gave early life the added

⁴² Cited in University of Aberdeen (2012) 'Heavy Metal, Sex and Granites - critical role of granite in evolution of life on Earth revealed': <http://www.abdn.ac.uk/news/4414/>

⁴³ Lynn Margulis and Dorian, *Dazzle Gradually: Reflections on the Nature of Nature* (White River Junction, VT.: Chelsea Green Publishing, 2007): 112- 120.

⁴⁴ Margulis and Sagan, *Dazzle Gradually*: 113-115; Hird, *The Origins of Sociable Life*: 96 – 103.

dimension of natural selection and variability,⁴⁵ even that assertion comes with question marks. Evolutionary biologists with an empathy for bacteria note that asexual reproduction is faster, more prolific and less energy intensive than sexual reproduction, and some would vouch that there is scant evidence that reproductive sex increases variation or allows faster adaptation to changing environments.⁴⁶ Although sexual reproduction eventually gave rise to complex multicellular organisms –such as slime moulds, mushrooms and mammals - this offers no initial incentive for organisms to commit themselves to this kind of sex. It has been suggested that evolutionary processes selected for complex cells and differentiated tissues, and as more complex organisms survived, sexual reproduction was simply `taken along for the ride.'⁴⁷

What is less contentious is that the rise of sexual reproduction was bound up with a new kind of termination. There is no necessary dying off in bacterial or archaen lineages – though, of course, individuals succumb to hunger, desiccation, predation, toxicity or other threats. But as Margulis points out, the price of relying on reproduction involving the passing on of half one's genetic material to offspring – which spells an end to the revitalizing process of fission - is inevitable, pre-programmed death.⁴⁸

⁴⁵ cited in Will Ferguson, `Sex born from hard rock and heavy metal.' *New Scientist* 2870 (2012) http://www.newscientist.com/article/dn21947-sex-born-from-hard-rock-and-heavy-metal.html#.U_SmElavuFI

⁴⁶ Margulis and Sagan, *Dazzle Gradually*: 112; Hird, *The Origins of Sociable Life*: 95.

⁴⁷ Margulis and Sagan, *Dazzle Gradually*: 120.

⁴⁸ Lynn Margulis, *The Symbiotic Planet: A New Look at Evolution* (London: Phoenix, 1998): 115.

Between one and two billion years ago, then, a geologically exceptional influx of metals into terrestrial environments may well have triggered the rise of complex life: a 'key point in evolution which eventually led to human life on Earth.'⁴⁹ And with this – bound up with metallic stimulation of the catalytic action of enzymes - came the ascendance of sexual reproduction. Though perhaps just as strong a case can be made for the association between metal and death.

If the rise of forms of difference that came to be characterized as 'sexual' rest on a certain geophysical and elemental contingency, so too is the emergence of a species capable of accidentally or intentionally working with metal without predetermination. Still less could it be anticipated that these capacities would be associated with the gendering of roles within this species, or that they would, over time, migrate across these divides. If the question of how the production and use of metal might be implicated in further transformations in gender relations is as yet unresolved, no less open are questions about what might yet become of metallic catalysis of biological potential and difference.

PLANETARY FUTURES, METALLIC ORGIES

Bennett's vibrant materialism, its worth keeping in mind, never promises an easy ride or a happy ending. Traversing species barriers, she noted in the *Enchantment of Modern Life*, is 'both liberating and dangerous,'⁵⁰ while her take on the 'sex appeal of the inorganic', we should recall, invokes a '*potentially violent* vitality intrinsic to matter.'⁵¹ Any renegotiating of the relationship between life and minerality, between the organic and the inorganic, it

⁴⁹ Parnell cited in University of Aberdeen, 'Heavy Metal, Sex and Granites'.

⁵⁰ Bennett, *The Enchantment of Modern Life*, 31.

⁵¹ Bennett, *Vibrant Matter*, 61, my italics.

would appear, comes without guarantee or guardrails. Along these lines, it might be added, the eventual genesis of a creature with the capacities of our own species could not be anticipated from the moment of metal-charged invention of organismic complexity.

Likewise, the current predicament of anthropogenic heating of the entire planet can hardly be read-off from early human experiments in baking the materials of the Earth – which is certainly *not* what Deleuze and Guattari intended when they tentatively proposed that a single ‘phylogenetic line’ might extend all the way from ‘the pot to the motor.’⁵²

Nonetheless, the coming of chambered fire – the construction of ovens and kilns which intensified processes of combustion – can be seen as a vital precursor of later ‘heat engines’ capable of harnessing the condensed energy of fossil fuels,⁵³ just as we might see early artisanal control over the properties of metals as a step on the way to the metallic machinery that put these energies to work. It was not long after the Earth emerged from the last glacial epoch that some humans set out on the fiery path of transforming ‘earthy materials’, and as we are now only too well aware, one of the consequences of a chain of interlinked social and technological developments is another period of unstable climatic and environmental conditions. In the context of emergent responses to this predicament, I want to suggest, can be glimpsed new strategies for conjugating metals and biological life.

Around the time that human-induced climate change was ascending the global political

⁵² Gilles Deleuze and Felix Guattari, *A Thousand Plateaus: Capitalism and Schizophrenia*, (Minneapolis: University of Minnesota Press, 1987), 407.

⁵³ Stephen Pyne, *Fire: A Brief History*. (Seattle: University of Washington Press, 2001), 135–6; Nigel Clark and Kathryn Yusoff, ‘Combustion and Society: A Fire-Centred History of Energy Use,’ *Theory, Culture & Society* 31: 5 (2014): 203–226.

agenda, oceanographer John Martin famously quipped: 'Give me half a tanker of iron and I'll give you the next ice age.'⁵⁴ Martin's 1988 provocation was intended to spark interest in using oceanic iron fertilization to stimulate algal blooming - for the purpose of removing carbon dioxide from the Earth's oceans and atmosphere and thus counteracting global warming. A number of trials followed. The logic behind these projects is the principle we looked at in the last section - the role of trace metals in catalyzing basic metabolic processes, coupled with scientific evidence which purportedly shows that iron deficiency puts limits on phytoplankton growth in much of the Earth's oceans. Relatively small amounts of soluble iron applied to 'desolate' marine zones, it is believed, would stimulate algal photosynthesis, promoting prolific reproduction. If sufficient volumes of phytoplankton bloomed, expired and then sank to the depths of oceans floor, their cold-stored organic remains would sequester significant amounts of carbon - for decades or even centuries.⁵⁵

There is considerable controversy about the effectiveness of oceanic iron fertilisation and about possible side effects, and most critical commentators currently interpret the London Dumping Convention and the Convention on Biodiversity as prohibiting open ocean trials. But in the broader picture - the several billion year annals of vibrant matter we have been considering here - the turn to metal-charged organismic sex and death as a means of modifying the Earth's geochemical composition looks worthy of attention. 'To become effective', philosopher Michel Serres observes, 'the solution to a long-term, far-reaching problem must at least match the problem in scope.'⁵⁶ Intuiting a similar logic, it might

⁵⁴ Cited in Charles Graeber, 'Dumping Iron,' *Wired* 8:11 (2000):

<http://archive.wired.com/wired/archive/8.11/ecohacking.html>

⁵⁵ Graeber, 'Dumping Iron.'

⁵⁶ Michel Serres, *The Natural Contract* (Ann Arbor: University of Michigan, 1995), 31.

appear, those who would manage the current planetary predicament are turning to metallic orgy as a means of attempting to restore Earth systems to order.

A second emergent site of active conjugation of metals and organismic life looks to be wider ranging and more broadly 'environmentally' acceptable as a response to global challenges. The miners of ancient Rome, and perhaps Phoenicia also, took advantage of microbial activity to leach copper out of mineral ores – though they were unaware of the role played by microorganisms.⁵⁷ Today, as demand for metals escalates, as higher grade reserves of ore are depleted, and as environmental constraints on mining tighten, a more intentional turn to the 'biomining' capacities of microbes is taking place.⁵⁸ The natural ability of bacteria, archaea, fungi and other microorganisms to mobilise metals is increasingly being used to extract gold, copper, iron, and uranium from the mineral matrices in which they are found. Replacing more environmentally heavy impact chemical and pyrotechnical processes, specialised micro-organisms that thrive in the acidic environments generated by decomposing ores need little more than oxygen and carbon dioxide to do their work, using the mineral itself as an energy source. Although, as we will see, getting the right mix or 'consortia' of microbes is also important.

⁵⁷ M. H. Siddiqui, A. Kumar, K. K. Kesari and J. M. Arif 'Biomining - A Useful Approach Toward Metal Extraction' *American-Eurasian Journal of Agronomy* 2:2 (2009): 84-88, 84.

⁵⁸ Mazen Labban, 'Deterritorializing Extraction: Bioaccumulation and the Planetary Mine.' *Annals of the Association of American Geographers* 104: 3 (2014): 560-576;

D. B. Johnson, B. Grail, B. and K. Hallberg, K, 'A New Direction for Biomining: Extraction of Metals by Reductive Dissolution of Oxidized Ores.' *Minerals* 3 (2013): 49-58.

The potential of select microorganisms to extract and 'bioaccumulate' metals found in low concentrations is opening up possibilities for recovering residual metals from old mine tailings. It is also being advanced as a safe, efficient means of recycling the metallic components of scrap consumer goods – especially electronic waste – given that waste piles or landfills often have a higher metal concentration than ores that are being conventionally mined.⁵⁹ E-waste, as geographer Mazen Labban explains:

happens to have high concentrations of valuable metals occurring in “complex assemblages” ... For example, one ton of e-waste contains up to 0.2 tons of copper; that is, a 20 percent grade compared with an average, and declining, head grade of 0.2 to 1.65 percent. One ton of printed circuit boards contains 500 g of gold, besides other metals, compared with a declining average of 0.85 to 1.65 g/ton of mineral ore from open pits.⁶⁰

Housed in steaming vats, or 'inoculated' directly into tailings and low-grade ore reserves, specialised microbes utilize bioessential metals to reproduce prolifically, then simply die off when their bioaccumulation deeds are done and their metabolic fuel runs out. As one study reports:

Following the exploitation of the tailings or ore bodies, the microbial population is reduced drastically returning to natural levels. The population was controlled by nutrients and water concentration in the laboratory conditions after 3 weeks of being deprived of nutrients, 99.9% of the

⁵⁹ Johnson et al, 'A New Direction for Biomining,' 55.

⁶⁰ Labban, 'Deterritorializing Extraction,' 565.

microbial system was eliminated.⁶¹

Gold, then, not so much as 'the tears wept by the sun', but as a secretion of the sweated labour of compliant and expendable bodies. A 'capitalist wet dream', as Labban aptly observes, 'bringing the technical metabolic cycle within urbanized space and closing the materials loop by the very act of growth in production.'⁶² But even this fortuitous confluence of metal, sex, reproduction and death may be inadequate to the job at hand. Given the demands of contemporary extractive industries, even the twenty minute or so reproduction time - and resultant exponential population growth rates - of many microbes has been deemed too slow and too irregular.⁶³ 'There are requirements ... to increase the efficiencies of biomining operations, both in terms of rates and in metal recovery' as one researcher puts it.⁶⁴ These demands are initiating research aimed at selecting and engineering the optimal consortia of microorganisms for each task. As microbiologists Rawlings and Johnson elaborate: 'there is considerable scope for the selection of mutants with altered gene regulation and expression that permits rapid mineral breakdown under the conditions provided by the bioreactor.'⁶⁵

⁶¹ V. Appanna, J. Lemire, and R. Hnatiuk. *Biomining: A Green Technology to Mine Valuable Metals* (undated): <http://vappanna.laurentian.ca/Biomining%20-Carmen%20Tailings-Com.pdf>: 18.

⁶² Labban, 'Deterritorializing Extraction,' 565.

⁶³ Labban, 'Deterritorializing Extraction,' 563, 569.

⁶⁴ Johnson et al, 'A New Direction for Biomining,' 1371-2.

⁶⁵ D.E Rawlings and D. B Johnson, 'The microbiology of biomining: development and optimization of mineral-oxidizing microbial consortia,' *Microbiology* 153 (2007): 315-324: 317.

Three to four billion years of experience at metal-catalyzed reproduction and diversification, it would seem, has left microbial life insufficiently prepared for its full subsumption into the global economy. But there are other contexts in which metal-infused microorganismic *overachievement* might be the bigger problem. As Labban points out, the very order that dreams of eliminating waste from the production process systematically generates refuse at the other end of the commodity chain: the same economic imperatives that convert entire mountain ranges into industrial feedstock inevitably produce mountainous piles of discarded matter.⁶⁶

Less than 10% of e-waste is currently recycled.⁶⁷ And scrapped electronic gadgetry, with its spangling of rare earth and precious metals, is the glamour end of the garbage pile.

Elsewhere recovery rates drop even lower. According to a somewhat shaky global accounting, sociologist Myra Hird notes, over 95% of all refuse is landfill-bound.⁶⁸ There are, of course, aspirations towards complete recycling, just as there are visions of a massive rollout of bioremediation - the use of microorganisms to safely break down the harmful components of modern waste.⁶⁹ But the current and foreseeable situation is that most what goes into landfills will eventually find its own way - unseen, unregulated, unremediated - into the domain of the microorganisms that dwell beneath the Earth's surface.

Along with masses of organic matter, what goes back down into the ground is the hyperbolic inheritance of all the heat and chemical-induced means of transforming inorganic 'earthy

⁶⁶ Labban, 'Deterritorializing Extraction,' 564.

⁶⁷ Labban, 'Deterritorializing Extraction,' 565.

⁶⁸ Myra Hird, 'Waste, Landfills, and an Environmental Ethics of Vulnerability', *Ethics and the Environment* 18:1 (2013): 105-124, 111.

⁶⁹ Hird, 'Waste, Landfills,' 116.

materials' we have developed over the last ten thousand years or so. A compendium, in particular, of the accelerated transmutation and recombination of the Earth's elements over recent decades. A landfill anywhere on the planet, researchers observe, is likely to contain a sample of the seven million known chemicals (including the 1000 or so new chemicals which enter into use each year), along with a full spectrum of organic matter, which might include any number of the 14,000 food additives and the manifold contaminants found in our food scraps.⁷⁰

Once in the ground, bacteria get to work on the more easily metabolized ingredients of refuse, converting them into a heady soup or 'leachate'. Typically, Hird observes 'leachate is a heterogeneous mix of heavy metals, endocrine disrupting chemicals, phthalates, herbicides, pesticides and various gases including methane, carbon dioxide, carbon monoxide, hydrogen, oxygen, nitrogen, and hydrogen sulphide.'⁷¹ And leachate, by definition flows. No matter how well a landfill is lined, sooner or later there is seepage into surrounding soils.

Here, percolating fluids meet up with a host of microorganisms: archaea, fungi, algae, protozoa. And, of course, bacteria. With some 40 million of them inhabiting every gram of earth, bacteria are so populous and metabolically active they practically *are* the soil.⁷²

Within, beneath and far beyond any landfill site, Hird concludes:

⁷⁰ Myra Hird, 'Knowing Waste: Toward an Inhuman Epistemology', *Social Epistemology* 26: 3-4 (2012): 453-469.

⁷¹ Hird, 'Knowing Waste,' 457.

⁷² Nigel Clark and Myra Hird, 'Deep Shit,' *O-Zone: A Journal of Object-Oriented Studies* 1 (2014): 44-52, 45-6.

multitudes of bacteria collaborate with human debris and geological forces in creating entities, some of which we know need managing, and other entities—contaminants of emerging concern—that have yet to be identified, and whose management is therefore virtual.⁷³

A little short of two billion years ago, long bursts of geological activity infused the world of living organisms with exceptional qualities of bioessential metals. Amongst the outcomes was the rise of reproductive sex, death and complex life forms: the ascendance of a whole new domain of biological life. But these events, which scientists are only just beginning to piece together, were strung out over more than a billion years. Today's metallic orgies are less patient, telescoping geological and evolutionary time into decades, years, days. Bacteria and archae – with more ways of swapping genetic material and multiplying themselves than we staidly sexual reproducers can even imagine - have been evolving for up to 4 billion years. They will continue to evolve. Into what they might eventually transform themselves – given a feedstock of richness and variety without planetary precedent - microbiologists simply have no idea.⁷⁴ And in all likelihood, won't be around to observe.

METALLURGIES TO COME

The headlong way in which novel assemblages of metallic elements and living things are now being concocted leaves little room for optimism. Being overly precious about metals has brought about some of the most socially exploitative and environmentally destructive activities ever witnessed. Harsh on the living conditions and reproductive possibilities of other species, the advance of mineral extraction – with its characteristic homo-social

⁷³ Hird, 'Waste, Landfills,' 107.

⁷⁴ Clark and Hird, 'Deep Shit'.

barracking and enclaves of sex-work – can be far from generous to the gender or sexual relations of our own species. In an intimate manifestation of the resource curse, the presence of high grade ore too often precipitates low grade socio-economic and sexual relations.

The world of working with metalliferous minerals, then, cries out for critical thought and practice. But as Jane Bennett has often reminded us, criticism reft of a warm, desirous supplement can be a grim business, cold and arid as the realities it would contest. Metalwork, she would affirm, is not beyond redemption. The mostly masculine domain of metallurgy, Bennett has gleaned, offers an unexpectedly rich lode of enchantments. With its combination of exacting discipline and aesthetic sensibility, metalwork and metal-thought has been a haven of the sensual appeal of the inorganic. Even practicing metallurgists, men accustomed to the grime and grit of pyrotechnical industry, make a habit of sudden affective swerves. ‘All big things grow from little things’, muses Cyril Smith, ‘but new little things will be destroyed by their environment unless they are cherished for reasons more like love than purpose.’⁷⁵

More than merely celebrating the allure of the metallic to receptive human agents, Bennett encourages us to explore excitations, attractions and expressions proper to metals themselves. Still rare in political and philosophical thought, her probing of sensitivities intrinsic to the fully inhuman world perhaps enjoys its most luminous resonances in the arts. In particular, Bennett shares with fellow North American poet and writer Anne Michaels the vision of a mineral sensorium pulsing far beneath human susceptibility. Most explicitly, in the novel *Fugitive Pieces*, Michaels evokes a ‘lyric geology’ that reaches: ‘even down to the generosity of an ionic bond. “Perhaps the electron is neither particle nor wave but

⁷⁵ Smith, *A Search for Structure*, 331.

something else instead, much less simple – a dissonance – like grief, whose pain is love”.⁷⁶

Or again: ‘It is no metaphor to witness the astonishing fidelity of minerals magnetized, after hundreds of millions of years, pointing to the magnetic pole, minerals that have never forgotten magma whose cooling off has left them forever desirous.’⁷⁷

At the metallic interface between the sciences of geology and biology – the mineralogical occasioning of desire is even more literal: the metabolic stimulus provided by enhanced trace metal availability playing a part in the ascendance of sexual reproduction – and all the attractions and enticements this involves. But to focus the role of bioavailable metals in the evolution of new modes of organismic reproduction also points up essential differences between organic and inorganic existence. Metals bond, conduct, exchange ions, catalyse biochemical reactions and even trigger evolutionary diversification. They are most certainly a vital part of the metabolic processes and the sexual activity of living beings. But it would seem to be overstretching a literal reading to suggest they have a metabolism or a sex life of their own.

There are questions, then, about how far we might want to run with Deleuze and Guattari’s notion of a ‘nonorganic life’,⁷⁸ generative though it has been. Once the ground has been cleared for a reassessment of mineralogical agency, and overzealous ontological divides between matter and life have softened, it may be time to turn afresh to the interface between the organic and the inorganic. If, as Bennett suggests, there is both danger and potentiality in any significant renegotiation of the mineral-biological juncture, then this uncertainty may well be an expression of the very profundity of the divide being traversed.

⁷⁶ Anne Michaels, *Fugitive Pieces* (London: Bloomsbury, 1997): 209, 211.

⁷⁷ Michaels, *Fugitive Pieces*, 53.

⁷⁸ Deleuze and Guattari, *A Thousand Plateaus*, 404-415.

'Avoiding biocentrism', in this sense, might be as much about attending to the stubbornly 'anorganic' properties of the mineral or geologic stratum as it is about affirming a vitality proper to matter.⁷⁹ Or about acknowledging the presence of a base materiality within the living. For if, as Vernadsky ruminates, we humans are indeed minerals that eventually came to life, what he may also have been reminding us was the extent to which biological life, however animated, remains shot through with a basal and recalcitrant minerality. And this may mean that working - or playing - our way out of current, less-than-desirable, conjugations of metals, sex and death could be a matter of both recognizing the catalytic potentiality of the metallic *and* confronting the anorganic core of all corporeal being.

Today, our metallurgical exertions are arriving a strange conjuncture in which, it might be said, excessively straight imperatives seek to capitalise on the unfathomably queer. Some seven or eight thousand years after metalworking disentangled itself from the feminine domain of 'domestic' pyrotechnology, the extraction and processing of metals is in many ways more hyperbolically masculine than it has ever been: an unreconstructed, male-dominated assertion of power over nature.⁸⁰ At the same time, I have suggested, there is an emergent faith that the *potentia* of sexually cosmopolitan and reproductively profligate microorganisms might be harnessed as a means of undoing the damage wrought by a minerially insatiable economic order.

As the entropic dispersal of previously high grade metallic ores advances, a vision is materialising of irruptions of microorganismic activity that will restore richness and purity. It

⁷⁹ Bennett, *Vibrant Matter*, 2010: 61; cf Nigel Clark, *Inhuman Nature: Sociable Life on a Dynamic Planet* (Sage: London, 2011), 24.

⁸⁰ see Merchant, *The Death of Nature*, 295.

seems to rest on the faith that life forms a few micrometers in size will be able to reproduce – or mutate – themselves fast enough to undo the work of machines that excavate a quarter of a million tons of mineral ore each in a single day. There is a lot that bacteria, archaea and other microscopic life can do. But to expect microorganisms to perform a real time remediation of what is effectively an on-going geological upheaval may be something of an overestimation of the potentiality of the evolutionary assemblage of metals and life.

Just saying no to metal-fuelled orgies of microscopic life, however, may not be the most effective way toward more auspicious organic-inorganic couplings. What else could be done with a passion for the metallurgical? How else might we answer to the allure of the metallic that human subjects share with bacteria, archaea, protozoa and every cell of our own bodies? And how else might we reengage with the base minerality that imbues our very flesh and fibre? Just as the earliest sex and death-enthralled eukaryotes had options other than evolving into bipedal *homindae*, other possibilities inhered in the first human ventures into heat-induced transformation of the mineral Earth. There were, and are, other paths for pyrotechnology, other possible metallurgies, besides those that culminated in the heavy metal excesses of carboniferous capitalism.

Shimmering at the heart of *Vibrant Matter*, 'A Life of Metal' is a timely catalyst for reconsidering the metallic memories and yearnings of the living body - in all its manifestations. Opening up a conversation with 'Cyril and other Smiths',⁸¹ Jane Bennett's metalliferous political ontology also invites conversation with the poetic geology of Anne Michaels, the exuberant microbiologies of Lynn Margulis or Myra Hird, and the pyrotechnical aesthetics of unnameable female artisans of the early to mid-Holocene. Though current enfoldings of minerality and biological life cannot simply be 'remediated', Bennett and her

⁸¹ Bennett, *Vibrant Matter*, 60.

co-conspirators – actual and virtual – might just be taking the first steps in the direction of radically different assemblages of metal, sex, gender and death.

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