Vertical Fire: For a Pyropolitics of the Subsurface

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Geoforum (forthcoming)

Iron is taken out of the earth, and copper is smelted out of the ore. Man sets an end to darkness, and searches out, to the furthest bound, the stones of obscurity and of thick darkness…. As for the earth, out of it comes bread; Underneath it is turned up as it were by fire. (Book of Job 28-2-5)

1. Introduction

Perhaps the foremost question of our time is how to govern a world whose livability and legibility is being compromised by the act of turning it inside out. Or more precisely, through bringing to the surface that which was once obscure, sequestered, stratified – and setting it alight. By burning fossil hydrocarbons, we – some of us, at least – have pushed our planet to the limits of its current operating state, as geoscientists like to put it. This destabilization, this making unfamiliar, is provoking us to rethink the meaning of the *geo* in geopolitics. "(C)ombustion", asserts political geographer Simon Dalby, "is the key driver of climate change and contemporary patterns of Anthropocene geopolitics"' (2018; 720).

In their recent invitation to advance a 'subterranean geopolitics', Rachel Squire and Klaus Dodds rightly insist that the subsurface is "a space where the earth's elemental properties really matter" (2020: 11). At the same time, like others who venture beneath the sub-aerial Earth, Squire and Dodds attest to the challenge of rendering the dark, tight, dense tracts of the subsurface visible (2020; Elden, 2013; Hawkins, 2020). Bringing together the thematics of elemental properties and visualization, I want to make a case for the long-term geopolitical significance of fire: for the preeminent role of combustion both in

extending the reach of political agency beneath the planetary surface and in the setting to work of subterranean materials in above-ground exercises of power.

Without fire to show the way, the subterraneous Earth is out of bounds to a surface dwelling creature like us, our wayfaring reliant on vision, our vision attuned to daylight. Bereft of flame to split rock, fire to roast ores, high heat to forge rock-hewing implements, we would have remained reverent visitors to the underworld, rather than emerging as its most aggressive transformers. As the Old Testament Book of Job attests, the fiery unearthing of the subsurface has inscribed itself in ancient texts and deep cultural memory. Yet for all this familiarity, the long, tortuous, enfolding of fire with the sub-terrain has delivered us into practical and imaginative predicaments that seem utterly baffling – as if we found ourselves thrust underground, lightless, flailing, fearful.

It is the conjunction of fire with our planet's unmaking that renders the current global crisis such a perturbing object of political thinking – of *any* thinking. Western thought has traditionally taken the Earth as the foundation from which sense making sets out, the given from which to gauge the necessary and the possible, the stable ground upon which to strategize. So too have we in the West – and not in the West alone - taken fire as the original source of illumination, the bringer of light to darkness, the medium through which opacity is made clear. That it is fire – applied to the Earth's own hidden recesses - that is ungrounding the ground is, in this way, a double jeopardy, a compounding of abominations. This makes of the fiery undoing of our planet a true disaster, as philosopher Maurice Blanchot (1995) would define it, an event that not only visits ruin upon the world, but lays waste to our very means of comprehending this world.

"The shock of modernity" writes geographer Gavin Bridge of the Earth's surface-subsurface divide "…. is in part about the radical mixing together of these two different planes" – before going on to stress the role of the extraction and combustion of buried carbon in this planet-scaled upheaval (2013: 56). For philosopher Michael Marder, the contemporary world has reached a point where multiple fires converge: the burning of coal, the smog of urban pollution, and the incineration of tropical forests fusing into one vast 'planetary burnout' (2015: 94-5). So significant is the escalation of human firepower through the industrialized combusting of fossil biomass, asserts environmental historian Stephen Pyne (2015), that the nascent geologic epoch might best be termed the Pyrocene. While heeding calls for geographers to engage more consistently with the subterranean dimensions of the Anthropocene (Melo Zurita et al., 2018), we should not forget that the progenitor of the concept, atmospheric chemist Paul Crutzen is himself a pioneering

theorist of the role of fire in the composition of the Earth's atmosphere (Crutzen and Meinrat, 1990). Moreover, he was also an early exponent of the nuclear winter thesis – the idea that firestorms by ignited thermonuclear war could trigger global climatic change (Crutzen and Birks, 1982).

Crutzen's concern with conflict-generated conflagration is a reminder that even before fossil fuel combustion was incontrovertibly linked to climate change, the geopolitical significance of fire was under consideration. Two remarkable works dealing with the escalation of firepower in modern combat anticipate the current thematisation of a world set ablaze by global warming. In *Bunker Archeology* (1994), first published in 1975, cultural theorist Paul Virilio proposed that the proliferation of explosive weaponry in the 20th century presented a situation in which the aim of warfare became the total transformation of the physical environment. Under conditions in which ambient space, the atmosphere, the very solidity of the Earth was now at stake, the only option for command centres, combatants and civilians was to take shelter underground.

> It was …not until the advent of rifled artillery and the First World War that there was the creation of steel-vaulted heavens, of a sky of fire by the very density of projectiles, shells, torpedoes, bombs, etc…. The possibilities of weapons had become so great that the mineral element became a part of the fluidity of fluid …. retreat was now into the very thickness of the planet and no longer along its surface (Virilio, 1994: 38-39).

Writing a quarter of a century later, philosopher Peter Sloterdijk makes a related case that modern combat has turned from targeting individual bodies to attempting to render the entire milieu of the enemy unlivable (2009: 13-16). In *Terror from the Air*, he argues that the deliberate ignition of firestorms in the allied bombing campaigns of World War II inaugurates a new kind of 'extensive thermoterrorism' (2009: 56):

> The bombing of Dresden on the night of February 13, 1945 by two fleets of Lancaster bombers of the Royal Air Force relied on a pyrotechnic concept: the point was to surround the city center …with a thick ring of high explosive- and firebombs and engulf the entire area inside it in an overall blast furnace effect (Sloterdijk, 2009: 54).

These two texts drive home how important it is to supplement the thematisation of planar, surficial, and topographic struggles in geopolitical inquiry with attention to the

vertical and volumetric – a point also stressed in geographer Stephen Graham's germinal writing on aerial warfare (2004; 2016). In turn, Stuart Elden's comprehensive engagement with the verticality of politics weaves together themes from Virilio, Graham, Sloterdijk, and architect Eyal Weizman in order to advance the study of "the politics, metrics and power of volume" (2013: 49). Whereas both Graham and Elden effectively probe the connection between aerially delivered ordnance and the retreat into subterranean bunker spaces, it is the elemental force of fire that features so prominently in Virilio and Sloterdijk's respective accounts that I will be dwelling on in this article. For both theorists, hostile fire fills the sky, transforms the atmosphere, and sucks away the very requisites of life – and it is in this all-consuming sense that the infernos ignited by modern warfare seem premonitionary. "Could war be prospective?" ponders Virilio (1994: 14). With the hindsight of several more decades, Sloterdijk directs our gaze from the conflagrations of total war to the combustion of "great quantities of fossil fuels" and rise of "the anthropogenic greenhouse effect" (2009: 89-90).

In this regard, Virilio and Sloterdijk set the scene for the story of rock-fire interactions that follows, lighting the way for my own account of how geopolitical landscapes have been forged through the fusion of terrestrial flame and subterranean strata. But there is also a vital sense in which they both gesture towards the deep history of vertical fire that I put at the centre of my analysis – without themselves pursuing it. In describing the configuration of the modern military bunker, Virilio alludes to a much older architectonic framing of fire: "This narrow door", he observes, "opens into a watertight coffer in which the air vent looks more adaptable to an oven than to a dwelling; everything here bespeaks incredible pressures" (1994: 15). As the earlier reference to a 'blast furnace' intimates Sloterdijk too makes connections between the intentional immolation of an urban milieu and the controlled intensification of flame within a purpose-built container:

> Prior to August 6, 1945 the history of applied horror had yielded no other example of "lifeworld" devastation covering an area almost as big as an entire city district by producing a sort of high performance combustion chamber; inside the chamber the fire's temperature climbed to over a thousand degrees (2009: 55)

The appearance of the oven, the blast furnace, the combustion chamber at these pivotal moments may have more than metaphoric significance. For if the post-history of explosive combat is to be found in the overheated atmospherics of global climate change,

I want to argue, then its prehistory lies precisely in the chambered flame of kiln and furnace.

So integral to the form and functioning of 'civilized' life is the enclosure and intensification of flame that it tends to withdraw from visibility. Anthropogenic climate change may indeed make problematic the fossil-fuelled machines that have put their stamp on the last two centuries. But behind the clamour of modern heat engines lies a world of earlier fire chambers – an array of encased thermochemical reactions that have been vigorously, energetically, shaping built environments for some 10,000 years. Ovens, kilns, and forges I propose in this paper, are the under-acknowledged key players in the hinging together of the flammable, sunlit surface of our planet with its rocky interior. It is through their capacity to metamorphose inorganic matter – the subsurface 'stones of obscurity' – I want to argue, that fiery furnaces have come to articulate between the life-sustaining envelope of the sub-aerial Earth, and the layered, solidified and sometimes still molten forces of the subterranean Earth.

Chambered fire, I claim, is the largely unheralded hearth, the literal crucible of the geopolitics of much of the last five thousand years. When we think about the governance of life – what has come to be called biopolitics - questions very soon arise of what is to be burned, whose task it is to kindle and sustain flame, at what is to be made of the myriad things that emerge from concentrated heat. "So important is fire, or has fire been across most of the earth's surfaces", I have written elsewhere, it is hard to "imagine a 'biopolitics' that was not first and foremast a 'pyropolitics' – centred on the regulation, manipulation and enhancement of fire' (Xxxxx, 2011: 164-5). That no longer seems adequate, however, for the flames that have come to matter over recent millennia are not only those that play across the surface, but those that serve as portals to the subsurface. When Pyne draws our attention to "the pyrotechnologies that underwrite much of humanity's power" (2012: 14) – it is the *under* in underwrite that we need to attend to. For it is not only through direct control over fire that power is channeled and accrued. My argument here will be that social and political power also, perhaps primarily, arises through the use of fire to gain purchase over the still greater, deeper, older forces of the Earth.

But even the ancient chambering of fire did not spring into the world fully formed. Like the infernal wartime prehistories of global warming signaled by Virilio and Sloterdijk, the firewalling of high heat had vital predecessors. The closer and harder we look, the further the enmeshing of human fire and the subsurface recedes into the past, the more it seems like a condition of possibility of our being human – an originary complication rather than

a late acquisition. And the deeper we go, the more that the embodied entanglement of fire and rock looks to be a matter not only of negotiating the depth, verticality and volume of terrain, but of engaging with the very geologic processes that form and deform these masses.

My key concern, then, is not the present social embroilment with fossil hydrocarbons – about which much has been said, but the deep-seated, richly plural precursors of the current planetary combustive predicament. I begin by setting out a conceptual framework that pivots around the ways that human fire and the subterranean Earth have been literally 'enfolded' at key historical junctures. The story then turns to some of the earliest hominin uses of fire and considers their implication in a rifted, stratified and geologically active landscape. The following section addresses the chambering of fire by ancient artisans – and the material and political significance of its products in emergent city-states. Returning to themes broached by Virilio, Graham and Sloterdijk, I then look at the more recent discovery of rapid chain reaction fire – and the role of explosive weapons in gunpowder empires. Finally, we circle back on the question of how revisiting the *longue durée* of human fire-subsurface entanglements might help us conceive of alternative pyropolitical realities. Throughout the paper, my focus on the dynamics of fire is intended to bring depth and substance to the 'geo' in geopolitics, while heeding geographer Ian Klinke's council that such re-materializations ought to illuminate rather than obscure "the intellectual tradition of geopolitics and the question of war and peace more broadly" (2018: 15).

2. Framing the fire-subsurface nexus

How and why should we delve deeply into the background – the understory – of our current "world historical blaze?" (Marder, 2015: 164). First the how question. Let' s return briefly to Virilio and Sloterdijk's references to fire chambers. If we take the military bunker as a firewalled stronghold which seeks to protect its occupants from a milieu that has erupted into flame, then we might see it as kiln or furnace turned inside out – with the thermochemical reactions now taking place outside while humans take cover on the inside. But in turn if we were to ask what is the 'logic' of a kiln, it could be described as a container that has severed a small portion of the outside world's free-ranging fire from its ecological milieu and enfolded into an enclosed space (Pyne 2001: 129-130). In this way, the *unfolding* of fire from its containment in the wartime inferno depends on a much earlier enclosure or *enfolding* of flame.

Philosophers Giles Deleuze and Félix Guattari (1987) help us to understand the structural logic behind such folding in and folding out, in more general terms, by way of their concept of *involution*. Taking issue with narratives that explain change in terms of a continuous line of development (as in much *evolutionary* thinking), Deleuze and Guattari contend that the most generative and unforeseeable transformations in the world tend to arise out of an enfolding or involution of an outside – distinguished by its scale, composition or origin – so that it forms a new kind of interior (1987: 238, 46-7). Philosopher Elizabeth Grosz (2008) teases out this logic, with special attention to the way that a living body or a creative human agent can – if care is taken – isolate, enclose and engage with the great forces of the Earth and cosmos. It is through the establishment of a barrier, division or perimeter of some kind, she suggests, that it becomes possible to approach otherwise overwhelming forces, to "temporarily and provisionally slow down chaos enough to extract from it something not so much useful as intensifying, a performance, a refrain, an organization of color or movement…" (Grosz, 2008: 3).

This structural logic of involution – of enfolding and unfurling – I am suggesting, offers a common plan or 'diagram' to help make sense of the multiple ways in which fire can be articulated with the geologic body of the Earth. Fire is one of the most powerful and generative forces of the surficial Earth. And it is the capture, enfolding and enhancing of fire that is the key to the way members of our species have in turn been able to gain purchase on some of the most powerful and generative forces of the *inner* Earth (Xxxxx, 2018a: 184-5). To put it another way, firepower is the hinge through which we gain a hold on 'geopower' – Grosz's general term for the vast and formidable forces of Earth and cosmos that ultimately underpin the collective agency of humans and other living beings (Yusoff et al., 2012: 973-8).

So too should we be alert to inverse movements. If the annexing of extraneous forces enables a body, entity, or apparatus to radically enhance its capacities – if it provides opportunities to intensify and elaborate upon the captured qualities – then there is every likelihood that the acquired powers will sooner or later impact back upon the outer world. We should not be surprised when enclosed fire or enfolded geological power seeps out, breaks free, reverberates through the wider milieu.

But why think in this way, why dig so deep into a past history of elemental entanglements, when the geopolitical problems we face today are so glaring and urgent? Why dwell on ancient or abyssal causalities, geographer Andreas Malm and anthropologist Alf Hornberg

justifiably ask, when the flagrant environmental and social injuries of the global capitalist fossil-fuelled economy cry out for head-on critical confrontation? (2014: 64).

There are three reasons why I have chosen to explore the diagramming of the fire-subsurface nexus in as much depth as possible. The first has to do with my opening claim that human agency is turning the Earth inside out. To understand how power or capacity to transform the climate and other Earth systems has reached current magnitudes, I would urge, we need to examine the long series of developments through which our species has step-by-step, fold-by-fold, accrued its geologic power. This is more than a matter of identifying causal pathways and attributing blame. As geographer Kathryn Yusoff rightly insists, an approach that attends to origins and deep trajectories is vital if we are to make any sense of forces that we have captured, internalized, and in the process, *made into ourselves*. That is, we must "begin to understand ourselves as geologic subjects, not only capable of geomorphic acts, but as beings who have something in common with the geologic forces that are mobilised and incorporated" (Yusoff 2013: 787). In short, we need the very *longue durée* so that we might start to make sense of ourselves as emerging *through* our interactions with fire and rock, rather than as always-already social beings who at some late stage turn earthward, as if we had not been earthly or geological all along.

Second, an extended gaze can and should unsettle the focus of much geopolitical inquiry on a modernity defined and contoured by four-to-five centuries of European or Euro-Atlantic global ascent. Even the work that has so helpfully prised open the vertical, volumetric and elemental dimensions of the field of geopolitics still tends to prioritize western modernity's advancing capacities to visualize, strategize and utilize the planetary body. A geopolitical scoping of the fire-subsurface nexus with a thousand, a ten-thousand, a million-year horizon, I hope to show, radically recontextualises the recent interval of European vertical and horizontal expansion. However speculative it must be, an account of firepower and geopower that reaches across continents, across social history and into geologic timescales can help us to provincialize Europe - not only as a socio-political formation, but as an ecological and geological formation.

Third, what is at stake in contemporary *geo*political analysis, I contend, is not just the question of how to derail the dominant global order from its blatantly unsustainable trajectory. It is also a matter of imagining and beginning to construct alternative modes of 'geologic life', as Yusoff (2013) puts it, or what human-physical geographers Adam Bobbette and Amy Donovan refer to as "a political geology of the future" (2019: 21-4). More than an issue of how to desist from burning fossil biomass, it's about what else we

might yet do with fire, the subsurface, and all the geologic forces that have made us what we are. This brings us into the domain of what geographer Harriet Harman (2020) refers to as the "geopolitical aesthetics of the subterranean" – which for her comprises not only questions of how the governance of underground spaces calls for their visualization, but also the matter of how different actors creatively explore and mobilise the dynamic properties of the 'geo'.

What begins to emerge when we take a deep historical approach to fire-lit transactions with the subsurface, I want to suggest, is not just a sense that geopolitical aesthetics of the subterranean go back a long way, but an intimation that 'volumetric practices of power' (Harman, 2020: 235) may be inseparably bound up with 'fiery' creative and charismatic expression from the very outset. Spiralling out from these questions in the final section, I consider the possible role of alternative geosocial applications of combustion, extending what I have referred to elsewhere as a "pyropolitical aesthetics for the Anthropocene" (Xxxx 2016: 278-282)

3. Human origins, igneous encounters

"Our situation today", declares Marder, "is that of *neither land nor sea*; updated for the twenty-first century, the central political elements are the dyad of air and fire" (2015: 4). Before *Anthropos* had the power to envelope the Earth in a fire-tainted atmosphere, however, we had first to take fire downwards – to cross-fertilize flame with rock and stone. Or rather, 'we' – our obscure and remote ancestors – learned to play variations on the interplay of fire and the subterranean Earth that was already on offer.

With rare exceptions, the fires that have been flaring across our planet for the last 400 million-plus years have been surface phenomena. Fire's natural habitat is terrestrial ecosystems that combine its three essential elements: fuel (usually biomass), oxygen, and an igniting spark, most often in the form electrostatic discharges from overhead storm clouds (Pyne, 1997: 3). Much of the Earth's terrestrial life uses fire in some way - to open seeds, promote new growth, flush out prey. But only our own genus has learned to handle, disseminate and kindle fire.

Our bond with fire marks a juncture in Earth and life history. For the first time, Pyne proclaims, this solar system's sole fire planet spawned a fire creature (1997: 3). It may not be coincidental, however, that we picked up this defining trick at another kind of juncture.

The genus *Homo* is believed to branched into existence in the midst of the largest, most long-lived, fracture zone on the Earth's surface. Formed, geoscientists hypothesize, by the arching and faulting of the Earth's crust atop a giant upwelling magma plume, East Africa's Great Rift Valley is a zone characterized by "complex tectonics and intense volcanism" (King and Bailey, 2006: 277). The resultant profusion of escarpments, lava outcrops, pooling water bodies, and fertile sedimentary basins, geophysicist Geoffrey King and archaeologist Geoff Bailey propose, is a propitious environment for agile but otherwise defenseless primates (2006: 266-8).

The same terrain may also have been opportune for a quick-witted biped with grasping hands to encounter the element of fire. Less exposed to sweeping wildfire than savanna, more hospitable to fire than closed-canopy forest, the topography of the Rift Valley was conducive to frequent patchy burning – while its constant volcanic activity supplemented lightning's spark. From the 18th century naturalist Comte de Buffon to contemporary fire scholars, there has been speculation that hominins first captured flame not from raging wildfire but from the more constant ebb of lava in their immediate environments (Buffon, 2007: 382; Medler, 2011).

So it might be said that well before our forebears first ventured underground, the subsurface had already come up to meet them. Ancestral hominins, in other words, were traversing strata and cohabiting with active geomorphic forces from the very beginning. As King and Bailey observe, the major pathways of human migration across and beyond Africa appear to have followed tectonically and volcanically active zones (2006: 276-9). When they journeyed, hominins carried flame and wherever they stayed fire left its mark in the Earth. In this way, as soon as humans began scrambling over exposed strata bearing fire, they also began to create a stratum of their own. "Charcoal" observes Pyne "is the spoor of early hominids" (2001:30).

There were other ways, too, that the inner Earth rose up to meet ambulating, fidgety-fingered primates. Volcanic eruptions strew a variety of rocks and glassy minerals around the Rift Valley, and there is evidence of hominins working these materials as long ago as three million years. Formed from rapidly cooling lava – and strictly speaking, glass rather than rock – obsidian was the favoured material of early toolmakers (de la Torre, 2011). There are intriguing signs that when humans migrated away from their ancestral volcanic homelands, they found a way to use fire to reproduce something of the power of the igneous geology they had left behind (Xxxxx, 2018b). Researchers have long been fascinated by the evidence that early humans used the heat of their hearth fires to improve

the flaking and sharpening properties of available rocky materials. By burying selected stones in the ash and sand beneath their fires, prehistoric artisans appear to have used controlled heat to transform sedimentary rock so that it acquired some of the vital properties of its glassy, sharp-fracturing volcanic counterpart. In the words of archeologists Marian Domanski and John Webb "heat treatment of fine grained siliceous rocks yields a material judged second only to obsidian in the manufacture of blades and pressure flaked points" (1992: 602).

Recent cave excavations on the southern coast of Africa suggest that as early as 70,000 years ago hominins were using fire to transform rock in this way (Brown et al., 2009). Perhaps the earliest evidence of the human use of high heat to change the structure of inorganic matter, we can also view this processes as a kind of involution: one in which a little of the simulated power of volcanism is subsumed into the modest space beneath the domestic fire. Recent ethnographic evidence suggests that many nomadic peoples are aesthetically and symbolically attracted to the reddish colouring that often results from heat treatment (Domanski and Webb, 2011). But we can add that improvement the blade-like quality of flaked stone tools and weapons is also likely to be implicated in the shifting power relations between human groups – and perhaps more importantly between us and other species. In this way the domestication of high heat to alter the properties of lithic material may well have marked a step-change in the geopower available to ancestral humans

It is telling that the oldest evidence of heat treatment of rock comes from cave sites. As diurnal (day-active) beings, the darkness of caves would have been forbidding to our distant forbears, as I suggested earlier, were it not for the sensory affordances of fire. Architectural theorist Luis Fernández-Galiano's speculations on the significance of fire for the origins of architecture prompt us to consider whether early inhabitation of caves might have been as much a matter of protecting fire from the elements as sheltering the people who handled this fire (2000: 7-11). So too, for those who ventured underground, fire would have afforded some protection against the carnivorous megafauna who shared with ancestral humans a predilection for cave dwelling (Hunt, 2019: 42).

More than sites of shelter, subterranean chambers may also offer us a kind of primordial narration of evolving firepower. Though their precise meanings will likely prove indecipherable, the enchanting depictions of animal life that adorn hundreds of Paleolithic caves offer an window onto shifting symbolic and power relations between human and nonhuman species (Hunt, 2019: 273; Yusoff, 2016). If earthy materials such as ochre,

manganese oxides, hematite, calcite – some sourced from cave floors – provided the palette of prehistoric artists, it has been suggested that the flickering light of grease lamps may have helped bring the animal figures to life (Zorich, 2014). Back on the surface, the same flames applied to grassland and shrubland helped shift the balance of power between human hunters and their often much larger prey: fire being used both to stimulate the plant growth that lured foraging herbivores and to stampede game into the clutch of hunters.

Again, the fire that warmed and lit the Paleolithic cave can be seen as a form of involution – an enfolding of the flame that periodically swept through the landscapes of the sunlit outer world. But in the process of introducing fire to an underground space – severing it from a living ecology and enchambering it in a nonflammable inorganic environment – human uses of fire were enhanced, intensified, transfigured. Heat transmutes the minerals used to flesh out visions, tongues of flame animate the daubed and painted beasts, fire transforms a lifeless lithic cavity into a reliquary of symbolic and material power. Or to put it in Harman's terms, the embellishment of caves, like the desirable colouration of heat-treated stone, may have had geopolitical aesthetic dimensions from the very outset.

We should not forget that Lascaux, arguably the apotheosis of unearthed cave art, was rediscovered during World War II. "The secrets of these dark underground places became known in 1940", observes Yusoff, "just as everything visible on the surface was in darkness, illuminated only by the exploding field of destruction" (2016: 44). In the following two sections, I offer some stepping-stones from the flickering illuminations of the Paleolithic cave to these explosive conflagrations of total war.

4. Chambered flame and city-state geopower

Like fire's prehistoric enclosure in the stony subterrain, so too might we view the furnishing of fire with its own purpose-built mineral chamber as a significant juncture in the fire-subsurface nexus. The earliest known kilns – an estimated 26-30,000 years old, were excavated in the 1920s at Dolní Věstonice in today's Czech Republic. Using glacial loess soils as raw material, and firing their rudimentary kilns up to 500-800°C, the semi-nomadic artisans of Dolní Věstonice produced a multitude of amorphous shapes, numerous animal figurines and a handful of the famously voluptuous `Venus' female forms (Vandiver et al., 1989: 1008, Xxxxx and Yusoff, 2018).

As with the images embellishing Paleolithic caves, the exact meaning of these baked objects to their creators remains opaque to us. None of the 10,000 odd kiln-fired pieces exhumed from Dolní Věstonice appears to serve any discernible purpose. There are no recognisable vessels, building materials, implements (Vandiver et al., 1989). Neither is there anything resembling human males: nothing akin to the exuberantly gendered female figures. The encapsulation of fire in the kiln, it could be said, has helped forge a new kind of geopower: a capacity to conjure and congeal enduring objects out of bare earth. Gendered though it seems to be in some pronounced but indecipherable way, the nature of this power, its strategies, targets, and affordances continue to elude contemporary audiences.

When the final Pleistocene glaciation ceded to warmer, steadier climates, chambered fire developed along pathways that offer more familiar analytic footholds. As nomadic peoples settled into more sedentary life styles, fire concentrated and boosted by robust containment burgeoned into a vital constituent of Neolithic life. While ovens rendered grains grown by farming communities digestible, they also fired earthenware vessels in which foodstuffs could be stored and served, roasted plasters and cements with which to seal domestic walls and cisterns, and baked bricks and tiles to fabricate urban-agrarian infrastructure (Wertime, 1973; Xxxxx and Yusoff, 2014). Later, out of the fiery furnace came a succession of novel materials: durable, ductile and lustrous. Most likely beginning as glittery by-products of pottery glazing, metals would eventually accrue a multitude of meanings and applications in the ever-more complex socio-material life of emergent city-states (Xxxxx, 2015).

Demand for metallic ores draws us once more into the depths of the Earth, and mining makes new demands of fire. As Pyne reminds us, 'fire-setting' – exposure to high heat followed by quenching – was the early miners' chief means of cracking stubborn rock. But fire had other tasks: "Prospectors burned over hillsides to expose rock. Miners relied on fire to tunnel, to smelt, to forge .... They had to crush and process as much (ore) as possible on site, and nearly every stage demanded fire" (Pyne, 2001: 131). As mining fed ores into the furnace, so too did tools forged by metalworkers facilitate extractive processes. Chambered fire and the penetration of the subsurface propelled one another: as demand for ores escalated, the drive and the wherewithal to extract these minerals correspondingly advanced. Further and deeper into the Earth went the shafts.

But there is more to the subsurface than depth or verticality. Archeometallurgist Theodore Wertime reflects that it was the 'plutonic subsoil' that yielded the most vital

materials of the pyrotechnic crafts (1983: 448), reminding us that subterranean heat is implicated in the genesis of the minerals to which the heat of the surface will be applied. Just as the material life of the earliest hominins cleaved to volcanic and seismic hotspots, so too were the originary sites of ancient metallurgy clustered around tectonic plate junctures: zones where "cracks and faults in the crust …. allowed metal-rich magmas and fluids to ooze up from deep within the Earth towards the surface" (Stewart, 2005: 112).

By four thousand years ago high-heat artisans, though they had no gauge to tell them, had already learned to stoke their kilns to 1200-1300 °C degrees, a temperature that geologists have since identified as the maximum heat of lava (Rehder, 2000: 54). More than just tapping into the mineral riches of the 'plutonic subsurface', the mining-metallurgical complex, we might argue, had captured the dynamic forces of the inner Earth (Xxxxx, Gormally and Tuffen, 2018). With no way of knowing that similar processes take place in active volcanoes and in the subsurface chambers in volcanic regions where upwelling magma collects, pyrotechnic artisans used their kilns to melt and recrystallise rock, to metamorphosise minerals, to form new compounds, to decompose and concentrate metallic ores (Xxxxx, 2018b). And in this way, just as Paleolithic humans folded fire into underground spaces, their descendants stumbled on a upon a means of enfolding the geopower of the molten Earth into the everyday spaces of their towns, village and cities

When the 'archeologists' of state power examine the rise of hierarchical social formations and the emergence of city-states, the tendency is still to focus on control of an agricultural surplus and of the land and bodies that produced it. But harnessing the biopower of humans, animals and plants had a vital supplement: the fire-enabled channeling of geopower. Wertime and fellow pyrotechnic theorists have long insisted, ancient civilizations were underpinned as much by the novel products of kiln and furnace as they were by intensive cropping. As Wertime observes:

> Metals … established the norms of weight and value and monetary trust for urban life as well as standards of utility for cutting, thrusting, digging, and killing. They became catalysts of social life for men even as they had been catalysts of energy exchanges for cells in the biological organism (1973: 680).

Men indeed. When ceramics helped spawn metallurgy, the pyrotechnic arts shift from the domain of female to male artisans. Heightened gender divisions of labour, however, were but one aspect of the intensified social differentiation and stratification that accompanied the rise of the 'state form' (Scott, 2017: 13). So complex and multifaceted are these

transformations that teasing out the contribution of the fire-subsurface nexus remains a daunting task. What can said with confidence is that large-scale, bureaucratically organized production in the ancient world was dependent on economic exchange and finance – which was underpinned by extensive inter-regional metal trade and industrial scale metallurgy (Yener, 2000:27; 67; Ratnagar, 2001). To this we can add that the eye-catching products of the fiery arts functioned as "aesthetic visual displays of identity" that helped people to position themselves amidst the unprecedented density and complexity of urban life (Roberts et al., 2009: 1019).

Viewed in this way, the politics proper to the state form has always been a pyropolitics: a series of contests over the extractive resources that were fed into the furnace, and a set negotiations, conflicts and seductions that were played out with and through the products of fire-driven technology. Through the lens of the fire-subsurface complex, the territorial exertions of early states, from Anatolia to Mesopotamia, the Indus Valley to Ancient China appear as much a matter of cutting through as cutting across the landscapes: vertical statecraft being every bit as significant as its horizontal counterpart. Historian Jack Goody insists that that "a legal distinction (or a jural one in the absence of a written code) between the soil and sub-soil … seems to have begun in the valleys of Mesopotamia" (2012: 22), which would have the political-legal demarcation of surface and subsurface already in place five to six thousand years ago – a time when the spatial demarcation of state power was still shifting and rudimentary. Not only was mining the economic and strategic mainstay of the Greeks and other empires of antiquity, Goody goes on to argue, but "(t)he very boundaries of the Roman Empire… were the result of the distribution of metals" (2012: 80).

The labour underpinning city-state geopower, we should not forget, was grueling, hazardous and most often coerced. Beset by flooding, fire, rockfall, toxic gases and debilitating particulate matter, mines were and are dangerous places to work. Pyrotechnic workshops – where artisans labored a slender firewall away from volcanic temperatures were also inherently risky. Under the intense pressure of rapid thermochemical reactions, kilns could rupture and burst - escaping molten matter causing death and grievous injury and bringing blazing ruin to artisanal quarters or entire towns (Goudsblom, 1992; 110-111).

But what was an occupational hazard of the fiery arts was to emerge over the millennium just passed as the very rationale for chambering fire. Once again, but in frightening new ways, empires would rise and fall around their capacity to concentrate firepower.

5. Empires of the explosion

There are numerous contexts in the material world where mounting pressure in an confined space can lead to an explosion, including kilns, mine shafts and magma chambers. But a *combustive* explosion – one in which the chain reactions characteristic of fire are sped up to near-instantaneous velocities is a relatively recent invention – in both human and planetary terms. It was only when Chinese alchemists in search of elixirs of eternal life chanced upon an exacting combination of sulfur, saltpeter and charcoal in the 9th Century AD that the Earth witnessed its first fiery explosion (Kelly, 2004: 2). The repercussions of this blast have been dramatic. In the words of historian Alfred Crosby: "Any attempt to understand the last millennium that omits gunpowder would be like an explanation of geology without volcanic action" (2002: 107).

What its Tang dynasty inventors referred to as *huo yao* – 'fire drug' – the English would later call 'gunpowder'. As it is now understood, sulfur and charcoal provide the volatile compound with fuel, producing heat that causes the nitrates found in saltpeter to let loose their oxygen atoms. In the right proportions, the sudden release of pure oxygen accelerates the conversion of available fuel into hot gas in few thousandths of a second, resulting in combustion of such rapidity that it has no natural equivalent (Kelly, 2004: vii, 5-6).

One of the earliest deployments of the fiery black mixture in China was ceremonial and spectacular, as pyrotechnical innovators found ways to harness its explosive power to deliver projectiles into the air and to generate dazzling bursts of light and colour (Kelly, 2004: x, 7-8; Xxxx, 2019: 6-7). Fireworks would later play a pivotal role in introducing the explosion into European public life, and in the more general advancement of the experimental study of nature (Werrett, 2010: 6-8), and should perhaps feature more prominently in Crosby's (2002) otherwise path-breaking study of airborn fire. But the point I want to stress is that well before the arrival of the thermochemical explosion on European soil, its Chinese pioneers had moved quickly to extend the usefulness of ultra-high speed, chain reaction combustion beyond beautifying the night sky.

As historian Tonio Andrade (2016) makes clear, in the centuries immediately following the black powder's discovery, Chinese imperial strategists eagerly explored and advanced its application to warfare. At first used primarily for its incendiary properties, military researchers soon recognised the destructive potential of *huo yao's* propellant and explosive

capabilities (Andrade, 2016: 112). An extraordinary array of uses for the explosive powder were tried out – novel ways of killing blossoming with all the creativity and exuberance that had gone into concocting firework displays. Gradually, this profusion of weaponry was whittled down to what we would now recognise as guns and bombs. "(I)n the hundred years from 1127 to 1279, the second part of the Song dynasty" observes Andrade, "human beings went from primitive gunpowder weapons like gunpowder arrows to a whole array of more sophisticated weapons, including fire lances, proto guns, and, by the end of the period, true guns" (2016: 31). Not only were firearms standard military issue in China several centuries before their European adoption, he adds, they were already mass produced by the 15th Century (2016: 14-16, 51-53).

Both the gun and bomb inherit the basic principle of chambered fire: the channeling of thermal energy in a robust casing. "The tougher the container", writer Jack Kelly explains "the greater the energy that accumulates and the more violent the explosion" (2004: 7). The barrel or casing that funneled the force of explosive compounds was itself the product of high-heat artisanship, and munitions manufacture in turned advanced the mining-metallurgical complex. As firearms multiplied across Europe, production of guns and ammunition greatly increased the demand for iron. By the 16th Century, European arms manufacturers were not only taking advantage of lower cost iron issuing from proliferating industrial-scale blast furnaces, but were actually driving this development (Mumford, 2010: 87-8). Again, China had led the way, with firearm production in the 12th Century already underpinned by vast ironworks employing thousands of labourers (Andrade, 2016: 33).

Much has been said about the contribution of explosive armaments to the geopolitical contouring of the modern world, and in particular their role in Europe's global ascendance. "European states were simply better at making and using artillery, firearms, fortifications, and armed ships than powers in other parts of the world and they had this advantage long before 1800", expounds economic historian Philip Hoffman (2012: 601). Or in poet Hilaire Belloc's terser formulation: "we have got/The Maxim gun, and they have not". Andrade prefers to direct our attention to the way extended episodes of political unrest and conflict were accompanied by waves of armament innovation, first in China, later in Japan and Korea, the Middle East and Europe – while stressing that war is only one variable in the complex dynamics of these periods. China's Song Warring States Period, which ended in the late 13th Century, he notes, was an era of numerous innovations, firearms among them. But Andrade also nominates the geopolitical fragmentation of Europe between 1450 and 1945 "the European warring states period"

(2016: 45). If the 'challenge and response' military rivalries of this epoch did the groundwork for Europe's overseas 'gunpowder empires', he argues, an equally strong case can be made that China's formidably armed 14th to mid 17th Century Ming Dynasty anticipated this dynamic – qualifying as "the world's first gunpowder empire" (2016: 82-3,45-6, cf Hodgson, 1974).

The gist of Andrade's argument is that the geopolitical significance of explosive weaponry has an extensive history prior to the late 15th Century takeoff of European firepower (2016: 28). The subsequent escalation of firepower has been well documented: a fearsome trajectory that takes us in a smattering of centuries from matchlock muskets to automatic assault rifles, from muzzle-loading canons to thermonuclear warheads. Over this period, the extent of empires and the reach of weapons have marched in tandem – the latter being both a matter of increasing projectile range and new vehicular means of mobilizing of firearms. "The invention of the steam engine and the internal combustion engine finally freed weapons from the limited power provided by horses", explains military historian Martin van Creveld "enabling their size, weight, and power to grow many times over" (1994: 332).

But just as ever-more intensive and extensive firepower transformed horizontal relations, so too, as we saw in the introduction, has it reconfigured the experience of verticality. In most arenas of fire-armed conflict, weapons and walls spurred each other's formidability. As fortifications grew progressively stronger, explosive charges were frequently taken underground, to undermine battlements while escaping defensive fire (Lynch 2002: 66; Mumford, 2010: 88-9). By the First World War techniques of mining and underground explosives had fused with devastating consequences: a single synchronised blast by allied sappers on May 30, 1917 in the Somme entombing 10,000 German soldiers (Herman, 2014). Propelled both by the brute force of military ordnance and its uneven distribution, World War II and many subsequent conflicts have seen extensive construction of underground tunnels, arsenals, factories command centres and civilian bunkers. This inversion of chambered fire and its milieu was not always successful, as we glimpsed earlier. "During the firestorms that were ignited by Allied bombing," notes Klinke, "many of the bunkers would be turned into furnaces, in which their inhabitants were quite literally baked to death" (2018: 40).

It should be no surprise that combative explosions eventually came to fill the sky with fire. By the logic of involution we have been tracing, the explosive weapon is by definition an enfolding of the force of chain reaction combustion whose sole purpose is to suddenly,

irruptively, unfold itself. While the threat of a milieu saturated by flame, shrapnel and projectiles was what drove Virilio's "retreat…. into the very thickness of the planet", the subsurface itself has been utterly transformed by the introduction of explosives. Just as mining has been the source of the metals that encased the explosive weapon, so too has the civilian use of explosive technology radically transformed the process of extraction.

The earliest know application of gunpowder to mining was an unsuccessful experiment in 1574 inside a lead and silver mine inland from Venice. Greater success followed in the 17th Century (Lynch, 2002: 65-68). Uptake was initially slow, both because of the cost of gunpowder and the effort required to chip or bore holes into the rock-face in which expanding gases could build the pressure needed for an explosion. But the practice of blasting to speed up mining, quarrying and canal building gradually caught on, and by the mid 19th Century commercial applications of gunpowder had overtaken military uses (Kelly 2004: 122-3, 218). The ascent of the civil explosion accelerated still faster after Swedish chemist-entrepreneur Alfred Nobel's concocting of gunpowder and nitroglycerin into an ultra-rapid explosive compound he named 'dynamite', after the Greek word for power. "The dynamite industry", reports Kelly, "grew faster than any other business in history" (2004: 229).

However momentous the earth-moving power of the explosion, another application of explosive force in a robust chamber – less directly – has had an even greater impact. In the late 17th Century, Dutch scientist Christiaan Huygens considered using the force of gunpowder – that had "hitherto served only for violent action" - to the more productive task of propelling an engine: a '*moteur à explosion*' (cited in Kelly, 2004: 116). Though Huygens never realised his plan to use a controlled series of explosive charges to propel a piston, his assistant Denis Papin took inspiration from the hypothetical 'gunpowder engine' in his experiments with the earliest steam-driven pistons (Kelly, 2004: 118).

While the use of the explosion as a motive force would await the shift form the external combustion of the stream engine to the petroleum-powered internal combustion engine, historians have long reflected on the close bond between explosive weapons, steam pistons and fossil-fueled motors (Xxxxx, 2019). In the words of cultural historian Lewis Mumford writing in the 1930s, "the gun was the starting point of a new type of machine: it was, mechanically speaking, a one cylinder internal combustion engine" (2010:88). Science historian Joseph Needham would later reiterate the importance of this relay "from gunpowder to steam", though he astutely credits the inauguration of this line of development to Chinese military inventors (1986: 558, 545).

6. Subterranean pyropolitical futures

The *moteur à explosion* is today the driving force of some 1.2 billion hydrocarbon-powered vehicles, and the trillions of tiny, precise explosions that are firing off, every hour of every day within this fleet of heat engines may well be inflicting deeper, longer-lasting damage to the world than ever did the profusion of militaristic explosive devices (Xxxxx, 2019). To orchestrate all these fiery transmutations of fossilised biomass – to keep them running, running faster – older gunpowder empires have ceded to far-reaching hydrocarbon regimes, though not without overlap and continuity. The mundane, quietly thrumming chorus of eruptions perpetuated by these newer imperiums being the crescendo of the turning inside-out of the Earth with which I began the paper.

The skyward unfurling of the deep, dark energy-rich strata of the subterrain, we know all too well, is transforming planetary climate, and as Pyne reminds us "fire … appears more profusely during times of rapid and extreme climatic change" (1994: 890). Gnawing at old-growth forest, licking at the fringes of our cities, lighting up our plasma screens, these fires are the visible face of global changes that can otherwise seem distant, abstract, imperceptible (Xxxxx and Yusoff, 2018). So fearful have many of us become of 'planetary burnout', so concerned about the irruptive, infernal character of the current juncture, that significant numbers of our contemporaries are actively planning a retreat beneath the Earth's surface – where they are hoping to sit out the coming conflagration in well-equipped, purpose-built subterranean sanctuaries (Garrett and Klinke, 2019).

Of course, they will need fire – or fire's high-tech proxies – to sustain themselves, as we have done from our very first ventures underground. Those who wish to endure the gathering crisis are already installing in their buried shelters hearths around which to convene, fire chambers to prepare food, materials and objects forged by high heat – and almost inevitably, caches of firearms and ammunition. Second generation bunker archeologists Bradley Garrett and Ian Klinke give the example of a semi-subterranean complex in rural Texas now under construction that will eventually incorporate 'three blue lagoons, 5-star spa, gun ranges, golf course, equestrian center, helipads, learning campus and 15-foot security wall' (Whitt cited in Garrett and Klinke, 2019: 1075). And so, into strongholds that would otherwise be stark and unlivable, we can discern the enfolding, amongst other things, of a condensed history of the human fire-subsurface nexus. Behind and beneath the firewalls insulating them from the outside world, each of these new

luxury doomsday bunkers is effectively a subterranean chamber of fiery sub-chambers, an enfolding of all fire's earlier involutions.

If the survivalist silo is our epoch's Paleolithic cave, if this is our Lascaux, we might wonder – what forms of geopower is it harnessing, what forces does it condense and augment, what powers and aptitudes might it pass on to those yet to come? What geopolitical or pyropolitical aesthetics of the subterranean are such endeavours channelling and activating? These are, of course, not just questions for our bunkering compatriots, but an issue for all of us living under 'skies of fire'. At the previous fire-subsurface junctures I have been tracking, what has mattered most is not some quantitative advance in depth or distance – not so much a deeper volumetric probing, visualizing and ordering -– but some kind of embrace of the geological forces that make and unmake the Earth. With each geologic enfolding, each corralling of elemental powers, we encounter and grapple with something that vastly exceeds us. That is why, when genuine involution occurs, the outcome is often an eruption of creativity: the glorious animations of cave art, the shimmering crafts of the high-heat artisan, the radiant beauty of fireworks and even the diabolic ingenuity of the earliest explosive devices. And it is because of this exorbitance, the excess of the power of fire and Earth over any its human enclosures, that what is enfolded will sooner or later escape, unfold, irrupt.

This means that if we are to couch responses anywhere near adequate to the current planetary predicament, they cannot solely be matters of our own survival. To live on through a rupture in the geoclimatic conditions that have prevailed for the last ten or so millennia is necessarily to find new ways of apprehending, engaging, encompassing and elaborating upon a fast-shifting physical milieu. Unable to extricate ourselves from our originary implication with rock and fire, any pyro- or geopolitical intervention in the present can only ever be a further turn in the involutionary spiral. As such, if they endure at all, our fire-lit geomorphic gestures are also offerings to futurity: benefactions or malefactions to whoever and whatever is yet to come. Maneuvering between the wonders of the Lascaux cave art and the geopolitical quandaries of the present, Kathryn Yusoff offers a vivid evocation of what is at stake:

> Time, like light, is what is drawn through the geologic. A force is pulled through the darkness of prehistory to presuppose a future…. Something private and possible is created that will erupt into the world to give a new dimension of thought, in a geologic epoch distinct from our own (2016: 43).

Like lithic strata that are slowly laid down, buckled and folded by powerful forces, and eventually return to the surface, geosocial forms crafted through heated exchanges with minerality across multiple human generations can submerge, deform, resurface. Or they can become so taken for granted that they remain hiding in the light. A big part of my rationale for performing an immoderately deep and inevitably shady archeology of human fire-subsurface interchanges has been to hold open the range of possibilities before us. This is about recognising that outbursts of improvisation and experimentation at critical junctions in the past may be infused with unrealized potentiality, that the embodied and sensuous rock-fire mergers that have been actually pursued are far from exhausting possible pathways. And it is to hazard that anxiously withdrawing to the subsurface with a grab bag of temporary life-sustaining devices and materials may not be the only or best option for negotiating Earth system thresholds.

Looking back over the long history of artisanship, metallurgist and science historian Cyril Stanley Smith exhorts us to be open minded and curious in our experiments with "minerals, fire, and colors": not only because of the multiple possibilities that inhere in different materials but because the world itself is shifting and changeable (1981: 203). "Discovery requires aesthetically motivated curiosity, not logic," Smith muses, "for new things can acquire validity *only by interaction in an environment that has yet to be*" (1981: 325, my italics). Elizabeth Grosz says something very similar about politics. "Politics", she observes "is an invention, a labour of fabrication, of experimentation … that links it to …the joy of artistic experimentation with no predictable end"'(2004: 260).

Certain kinds of politics, certain state forms and territorialisations, I have been arguing, have configured themselves around particular fire-subsurface relations. Readers familiar with political theorist Timothy Mitchell's examination of the relationship between fossil fuels and modern political and economic orders may have detected one of my inspirations here. The question Mitchell poses towards the end of *Carbon Democracy* resonates with Yusoff's notion of geologic being, Grosz's concept of geopower and with much of what I have been trying to say about modes of assembling fire and rock. "With what forces, human and nonhuman, do we want to form alliances?" he asks. "To what powers do we want to be subject ourselves?"'(2011: 239).

Faced with an increasingly fiery planet, I want to ask, what would it mean to *advance* rather than retreat "into the very thickness of the planet"? If the inferno of total *war* is a fearsome prospect then what might a more total fiery *creativity* or *play* look like? Reducing

the dependence many of us have on fossil hydrocarbons is indeed a matter of urgency, but extinguishing terrestrial fire is not an option. The operative question of any pyropolitics or geopolitics to come may be less that of how to power current modes of existence without combusting fossil biomass, and more that of what else we should make of the fire our planet has bestowed upon us. Slowing the pace at which we are destratifying the planet's lithic crust may also be necessary, but renouncing the hominin habit of traversing, transmuting and recombining the stratified body of the Earth may be the least promising way of dealing with a rapidly changing physical world. If there is to be a light at the end of the tunnel, perhaps we will only reach it by appreciating the light and the heat that was there at the tunnel's beginning.

Acknowledgements

Many thanks to Chih Yuan Woon and Klaus Dodds, organisers of the 2019 Geoforum Workshop *Designing, Digging, Excavating and Living: Subterranean Geopolitics,* and to fellow conference participants. My thanks also to Shiuh-Shen Chien and two anonymous reviewers for their feedback on the paper.

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