12.

Exchanging Fire: A Planetary History of the Explosion

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"Earth-shaking invention"

"If Experience did not both Inform and Certify us, Who would believe, that a light black Powder should be able, being duly manag'd, to throw down Stone-Walls, and blow up whole Castles and Rocks themselves," pondered natural philosopher Robert Boyle late in the seventeenth century.[1] What shocked and intrigued Boyle, historian Haileigh Robertson notes, was not just the brute force of exploding gunpowder but the sense-defying rate of the reaction that took place.[2] Upon ignition, he calculated, gunpowder expanded in an instant to some 50,000 times the original size of its grains.[3] While Boyle was seeking to unravel the mysteries of the volatile compound, the explosive power of gunpowder continued to wreak destruction. Death or grievous injury delivered at imperceptible speeds by incomprehensible forces was becoming part of European life.

While speeds that defy the human senses have attracted much attention in the context of digital media, social thinkers engaging with environmental issues tend to reflect more on the challenges of slow and persistent change. Philosopher Isabelle Stengers urges her readers to embrace the painstaking working up of under-recognized problems rather than latching onto those blatantly disastrous events that already "have the power to force unanimous

[1] Boyle, *The Christian Virtuoso* (1690) cited in Haileigh Robertson, "Imitable Thunder: The Role of Gunpowder in Seventeenth-Century Experimental Science" (PhD diss., University of York, 2016), 86.
[2] Robertson, "Imitable Thunder," 85–86.
[3] Robertson, "Imitable Thunder," 104–105.

recognition".[4] Likewise, literary studies scholar Rob Nixon would prefer us to be moved more by the "slow violence" of long-term environmental degradation and toxicity than by the eye-catching spectacle of "(f)alling bodies, burning towers, exploding heads, avalanches, volcanoes, and tsunamis."[5]

For social thinkers who are drawn to transformations at the planetary scale – the impacts on Earth systems and lithic strata announced by the Anthropocene hypothesis – the inclination to attend to deeply protracted processes can also be strong. Such concerns are often framed by acknowledgement that our home disciplines have insufficiently prepared us for the extremely *longue durée*. I suspect I'm not alone in feeling the pull and poignancy of paleontologist Stephen Jay Gould's reflection that "(d)eep time is so difficult to comprehend, so outside our ordinary experience, that it remains a major stumbling block to our understanding."[6]

Yet developments in the Earth and life sciences over the last half century have also made it clear that there's more to Earth history than immensely drawn-out timescales and durations: Gould's own theory of punctuated equilibrium contributing significantly to the idea that biological evolution combines gradual and rapid change.[7] With its focus on thresholds or tipping points in the operating state of planetary systems, Earth system science inherits and amplifies this concern with multiple tempos of transformation. In a related sense, the task of identifying synchronous and planet-wide impacts of human activity in the Earth's rocky crust – required for the formalization of the Anthropocene hypothesis – is drawing geologists into engagement with changes far more rapid than most have previously reckoned

[4] Isabelle Stengers, "Including Nonhumans in Political Theory: Opening Pandora's Box?" in *Political Matter: Technoscience, Democracy and Public Life*, eds. Bruce Braun and Sarah Whatmore (Minneapolis, MN: University of Minnesota Press, 2010), 3–33.
[5] Rob Nixon, *Slow Violence and the Environmentalism of the Poor* (Cambridge, MA: Harvard University Press, 2011), 3.
[6] Stephen Jay Gould, *Time's Arrow, Time's Cycle* (Cambridge, MA: Cambridge University Press, 1987), 2.
[7] See Nigel Clark and Bronislaw Szerszynski, *Planetary Social Thought: The Anthropocene Challenge to the Social Sciences* (Cambridge: Polity Press, 2021), 19–23.

with. While it is still open to revision, the Anthropocene Working Group's preferred candidate for a signal that marks the end of the Holocene is radionuclide fallout from post-World War II testing of thermonuclear warheads.[8] Which is to say that a panel comprised mostly of researchers who are "overwhelmingly concerned with ancient, pre-human rock and time" may well pivot its case for a new geological epoch around the consequences of events that are over in microseconds.[9]

There is a backstory to the interest of Anthropocene exponents in big explosions. Atmospheric chemist Paul Crutzen, who named and helped frame the Anthropocene concept, was one of the progenitors of the nuclear winter hypothesis. A nuclear war, he predicted, would result in massive wildfires generating photochemical smog that could "change the heat and radiative balance and dynamics of the earth and atmosphere" with devastating impact on surviving humans.[10] This scenario was an important precursor of the idea that human action could not only impact on the overall Earth system but could do so abruptly. It's also worth recalling that much of the scientific evidence leading to the confirmation of the plate tectonic hypothesis in the early 1960s came from seismographic stations set up to detect Cold War nuclear explosions. At the same time, tracking radioactive debris from nuclear weapons testing as it moved through the atmosphere, hydrosphere and biosphere made a major contribution to understanding the interconnectivity of the Earth system.[11]

While a radionuclide marker may fulfil the criteria of a clear geosynchronous signal in nascent geological strata, Anthropocene scientists need to be careful about the way this evidence is framed and presented. Activists and their academic allies will likely ask what the

[8] Jan Zalasiewicz, Colin Waters, Colin Summerhayes et al., "The Working Group on the Anthropocene: Summary of Evidence and Interim Recommendations," *Anthropocene* 19 (2017): 55–60.
[9] Jan Zalasiewicz, Will Steffen, Reinhold Leinfelder, Mark Williams and Colin Waters "Petrifying Earth Process: The Stratigraphic Imprint of Key Earth System Parameters in the Anthropocene," *Theory, Culture & Society* 34, nos. 2–3 (2017): 85.
[10] Paul Crutzen and John Birks, "The Atmosphere after a Nuclear War: Twilight at Noon," *Ambio* 11, nos. 2–3 (1982): 123.
[11] See Joseph Masco, "Bad Weather: On Planetary Crisis," *Social Studies of Science* 40, (2010): 7–40; Paul Edwards, "Entangled Histories: Climate Science and Nuclear Weapons Research," *Bulletin of the Atomic Scientists* 68 (2012): 28–40.

mobilisation of radioactive traces to authenticate an epochal scientific claim means for place-based communities who have suffered the lasting ecological, physiological and psychic effects of superpower military-industrial competition – what its implications are for the Pacific Islanders, Native Americans, Aboriginal Australians, Kazaks, and others upon and above whose unceded customary lands atomic weapons were detonated. We can anticipate such questions because social thinkers and critical practitioners have already been taking the science of the Anthropocene to task for both inadequately considering its own situatedness and partiality, and for failing to give enough credence to a multiplicity of other ways of experiencing or knowing the Earth.[12] In short, while social critics may affirm the need for disclosing the physical violation of planetary processes, they have called out Anthropocene science for its own implication in the epistemic violence that has long characterized encounters between the West and the wider world.[13]

In this chapter, I take the event of the explosion as an occasion for engaging at once with physical and epistemic violence. But I want to put a twist on this by focusing not on the brutal era of European colonial conquest or the subsequent planet-threatening superpower rivalry, but on an earlier set of life-threatening encounters that are a condition of possibility of the heavily weaponized global histories that followed. There is no A-bomb without "conventional" explosive weapons, and there are no conventional missiles, bombs and guns without gunpowder. And this is a line of development that takes us far from Europe.

Historians trace the discovery of a chemical mix that ignites rapidly enough to create an explosive release of energy to ninth century China.[14] Not only did the Chinese concoct gunpowder, they also – decisively and extensively – realized its potential as a weapon. When

[12] See for example Eva Lövbrand, Silke Beck, Jason Chilvers, Tim Forsyth, Johan Hedrén, Mike Hulme, Rolf Lidskog and Eleftheria Vasileiadou, "Who speaks for the future of Earth? How critical social science can extend the conversation on the Anthropocene," *Global Environmental Change* 32 (2015): 211–18.
[13] See Clark and Szerszynski, *Planetary Social Thought*, 35–38.
[14] Joseph Needham, *Science and Civilisation in China, Volume 5: Chemistry and Chemical Technology, Part 7: Military Technology – The Gunpowder Epoch* (Cambridge: Cambridge University Press, 1986), 1.

historian Joseph Needham opens his magisterial forty-three year study of explosive technics with reference to the "earth-shaking invention of gunpowder,"[15] he is well aware of the work of Boyle and compatriot researchers, and of the tumultuous impact of explosive weaponry on the battlefields of Europe. His primary concern, however, is with the invention and deployment of gunpowder in China.

My aim here is to take the "earth-shaking" power of gunpowder quite literally – as Needham seems to have intended. In conceiving of the explosive force of gunpowder as a geologic or planetary event, I draw on certain insights of the contemporary Earth and life sciences. At the same time, by following weaponized gunpowder from East to West and tracking its experiential and subjective impacts on a pyrotechnically ingenuous Europe, I want partially to unsettle the epistemic confidence of the modern West that still underpins today's big stories about the how the Earth works and what to do about it.

My case for the geological eventfulness of gunpowder emerges out of what I take as a central provocation of Anthropocene geoscience for social thought: the incitement to think with and through a dynamic, self-differentiating Earth and to acknowledge that our species or genus is capable of bringing new kinds of functionality to the operation of this planet.[16] More specifically, I pick up on writer Jack Kelly's observation that the split-second combustion of gunpowder is an entirely new kind of fire: one that "does not exist anywhere in nature."[17] Attending to gunpowder not simply as a significant juncture in military or technological history but as an event in planetary history helps us to grasp its potential for disrupting Earth and life processes. More than this, an appreciation of the utter novelty of explosive fire alerts us to the challenges it poses to the human sensorium and to the cultural or cosmological orderings through which subjects collectively seek to make sense of their worlds. And it is in

[15] Needham, *Science and Civilisation in China*, 2.
[16] See Clark and Szerszynski, *Planetary Social Thought*, 23–32.
[17] Jack Kelly, *Gunpowder: Alchemy, Bombards, and Pyrotechnics: The History of the Explosive that Changed the World* (New York: Basic Books, 2004), vii.

this regard, I argue – with the help of military and pyrotechnic historians – that the unexpected arrival of gunpowder weaponry and its compacted development in Europe relative to China had profound repercussions on European subjectivity and epistemic formations.

I will not be making a case that the material traces of exploding gunpowder in either its military or civil applications would make a good marker for the onset of the Anthropocene. But I do want to suggest that thinking through the movement of a novel anthropogenic fire from East to West complicates the tenaciously Western-centered narrative of most Anthropocene science – while also potentially contributing to its laudable concern with planetary dynamism and change. In a related sense, I argue, facing up to the shock and trauma arising especially, but not uniquely, from the abbreviated experience of gunpowder in Europe, offers insights into the particular ways Europeans later amassed and unleashed firepower. Finally, circling back on questions of unfolding climatic and Earth system change, I suggest that the fraught experience of learning to function in proximity to the force of the explosion might offer clues about the apparent willingness of so many people to tolerate the threat of runaway planetary heating.

Genealogy of the Explosion

Philosopher Yuk Hui's recent study of the relationship between cosmology and technology hinges around China's humiliating defeat by the British in the mid-nineteenth century Opium Wars.[18] As Hui depicts the Chinese experience of being outgunned by the European power: "(t)he two Opium Wars in the mid-nineteenth century had destroyed the civilisation's self-confidence, and thrown it into a whirlpool of confusion and doubt."[19] The extended period that followed became known in China as the century of humiliation. More immediately, Hui

[18] Yuk Hui, *The Question Concerning Technology in China: An Essay in Cosmotechnics* (Falmouth: Urbanomic, 2016).
[19] Hui, *The Question Concerning Technology in China*, 152.

recounts, some Chinese intellectuals responded to the rout of the Opium Wars with a slogan of "learning from the West to overcome the West."[20]

In an important sense, however, the West's moment of military triumph was itself a learning from the East that eventually enabled a partial "overcoming" of the East. As Hui notes in passing and other scholars have examined in detail, gunpower was a Chinese invention that calamitously returned home, intensified and augmented, some half a millennium after it had found its way to Europe. While hardly cause to belittle a civilization, the idea that the Chinese squandered their concoction of volatile black powder on fireworks – widely circulated in the nineteenth and twentieth centuries – has been roundly dismissed as a myth that served to bolster Europe's sense of its own technological bravado. "Early modern warfare" counters military historian Peter Lorge, "was invented in China during the twelfth and thirteenth centuries."[21]

The conventional western narrative has it that ninth century Taoist alchemists stumbled across the volatile mixture while seeking elixirs of eternal life. However, neither the serendipitous nor the supernatural aspects of this storyline should go unquestioned.[22] What we do know is that by combining charcoal, sulfur, and nitrates in the right proportion and exposing the mix to flame, researchers concocted a fire that burned with extreme speed. The pyrotechnic compound came to be known as *huo yao* or "fire drug" suggesting that medicinal uses were at least in contention.[23] But Chinese military engineers, already masters of flaming arrows and other incendiary weapons, were quick to apply the exceptional flammability of the black powder to the demands of warfare.[24]

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[20] Hui, *The Question Concerning Technology in China*, 153.
[21] Peter Lorge, *The Asian Military Revolution: From Gunpowder to the Bomb* (Cambridge: Cambridge University Press, 2008), 1.
[22] Lorge, *The Asian Military Revolution*, 8.
[23] Needham, *Science and Civilisation in China*, 108.
[24] Tonio Andrade, *The Gunpowder Age: China, Military Innovation and the Rise of the West in World History* (Princeton, NJ: Princeton University Press, 2016), 112.

The escalation and differential development of explosive weaponry is a staple of military history. Historians and social theorists, however, have devoted less effort to situating gunpowder within a more general history of fire or combustion – perhaps reflecting a relative paucity of an integrative concern with fire in western thought. "Fire" is the vernacular term for the chain reaction, triggered by an ignition source, through which chemical energy is converted into thermal energy in an oxygen-saturated environment:[25] "deflagration" being the technical term for the heat-releasing or exothermic process whereby heat produced ignites still more fuel.[26]

In the case of gunpowder, 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, this release of pure oxygen accelerates the conversion of fuel into hot gas into a few thousandths of a second, resulting in deflagration of such rapidity that it has no natural equivalent.[27] When this extremely high-speed exothermic reaction takes place in a confined space, the result is sudden, vigorous release of energy, or an "explosion." Explosions routinely occur in the natural world, such as when volatile plant oils ignite during wildfires or when volcanoes build up uncontainable pressure, but like the split-second combustion that drives it, exploding gunpowder has no earthly predecessor. Indeed, with the help of environmental historian Stephen Pyne, we might think of near-instantaneous combustion and the rapid release of energy it entails as the first entirely new form of fire since terrestrial biomass began to burn during the Devonian Period some 400 million years ago.[28]

Having first exploited its incendiary properties, Chinese military engineers began to explore both the propellant and explosive capabilities of *huo yao*. But as Lorge recounts,

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[25]Vaclav Smil, *Energy* (Oxford: Oneworld, 2006), 10.
[26] Kelly, *Gunpowder*, viii.
[27] Kelly, *Gunpowder*, vii, 5–6.
[28] Stephen J. Pyne, *World Fire: The Culture of Fire on Earth* (Seattle: University of Washington Press, 1997), 3–7; *Vestal Fire: An Environmental History, Told through Fire, of Europe and Europe's Encounter with the World* (Seattle: University of Washington Press, 1997), 16–17.

progress was initially slow on both practical and conceptual levels. "The intellectual component is important," he stresses, "because it required the acceptance of a completely new idea in weaponry: the explosion."[29] Once researchers began to embrace the multiple possibilities of split-second combustion, an extraordinary array of military uses for the pyrotechnic mixture was trialled – including gunpowder-delivering birds and kites, flaming rockets, exploding pots and flame-spouting lances. The names given to these weapons – "flying incendiary club for subjugating demons," "ten-thousand fire flying sand magic bomb," "burning heaven fierce fire unstoppable bomb" – convey at once the exuberance of this experimental wave and the shock effect they were intended to produce.[30]

Over the turbulent centuries of the Song Dynasty this profusion of weaponry was narrowed down to what we would now recognise as guns, bombs, grenades, and rockets.[31] As historian Tonio Andrade sums up: "in the hundred years from 1127 to 1279, the second part of the Song dynasty, 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." [32]

As explosive weaponry was refined and standardized, so too did it begin to travel beyond its originary site. How guns and gunpowder reached Europe and the Islamic empires remains uncertain, though it seems likely that the expansion of Mongol rule over Eurasia played a part.[33] Preceded by reports or hearsay of explosives, firearms seem to have arrived in Europe in the early 1300s. In the words of Needham: "all the long preparations and tentative experiments were made in China, and everything came to Islam and the West fully

[29] Lorge, *The Asian Military Revolution*, 42.
[30] Andrade, *The Gunpowder Age*, 29.
[31] Lorge, *The Asian Military Revolution*, 42.
[32] Andrade, *The Gunpowder Age*, 31; see also Nigel Clark, "Vertical Fire: For a Pyropolitics of the Subsurface," *Geoforum* 127 (2021): 364-372.
[33] Jack Goody, *Metals, Culture and Capitalism: An Essay on the Origins of the Modern World* (Cambridge: Cambridge University Press, 2012), 207, 258.

fledged, whether it was the fire-lance or the explosive bomb, the rocket or the metal-barrel hand-gun and bombard."[34]

Informed by Pyne's pyrocentric thinking, I am proposing that we view this event not simply as a case of accelerated technology transfer, but as the arrival of a novel kind of combustion: a fire not simply strange to Europeans but relatively new to the planet. Such a reading suggests the value of reversing Hui's concern with the shockwave induced by European military technology in China in the nineteenth century – by inquiring into the impact of explosive firepower from China on a pyrotechnically naïve Europe. Or as Needham sagely concludes his study, in the early fourteenth century "the Western world was set upon the fateful road to all the techniques of managing explosions."[35]

Explosive Exposure

It took time for the pyrotechnic powder arriving in Europe to fully ignite. Tracking the response of late medieval Europeans to the explosive mixture, historian Kelly DeVries suggests it was first apprehended as "a mysterious substance which imitated God's power."[36] As its use spread, scholars sought to integrate gunpowder more fully into the prevailing episteme – that encompassing field in which earthly processes mirrored heavenly ones, and the microcosm reflected the macrocosm.[37] In the resultant accommodation, literary theorist Roy Wolper elaborates, "thunder and lightning are God's presence in the sky; gunpowder is God's presence on earth"[38] – a reception aided by the uptake of the fiery explosion into the popular spectacle of firework displays.[39] But as Wolper adds, gunpowder's glaring

[34] Needham, *Science and Civilisation in China*, 568.
[35] Needham, *Science and Civilisation in China*, 579.
[36] Kelly DeVries, "Gunpowder and Early Gunpowder Weapons" in *Gunpowder: The History of an International Technology*, ed. Brenda Buchanan (Bath: Bath University Press, 1996), 131.
[37] See Michel Foucault, *Discipline and Punish: The Birth of the Prison* (London: Penguin, 1991), 19.
[38] Roy Wolper, "The Rhetoric of Gunpowder and the Idea of Progress," *Journal of the History of Ideas* 31, no. 4 (1970): 597.
[39] Simon Werrett, *Fireworks: Pyrotechnic Arts and Sciences in European History* (University of Chicago Press, Chicago, 2010), 59–64.

destructiveness grated against easy assimilation. By the early seventeenth century, natural philosopher Francis Bacon was actively recontextualizing the explosive powder. Transplanted from battlefield to laboratory, gunpowder came to figure more generally for the hidden potentials of nature that waited to be unbound by Bacon's experimental method.[40]

At the time when Bacon's major works were published, gunpowder had been working its way into European warfare for almost three hundred years, and of late had nearly seen off the British Parliament. Needham relays what he sees as a rather timeworn narrative that gunpowder weaponry's capacity to breech castle walls and unseat knightly cavalry played a significant role in the undermining of European military aristocratic feudalism. He is clearly more interested in reminding us "how unstable Western medieval society was in comparison with that of China":[41] a point later military historians have reinforced.

Resonating with Needham, Lorge argues that while the weaponization of *huo yao* in China took place in the context of an extensive, centralized bureaucratic system that was already over a thousand years old, the late medieval Europe into which gunpowder found its way centuries later was a fractious throng of principalities and kingdoms. His more general point is that weapons alone, wherever they are deployed, do not transform a society or polity: what matters most are the forms of social organization through which military technologies are adopted, developed and deployed.[42] As Lorge explains:

> The wealthy, mature, and stable societies of Asia, though subject to political developments and upheaval, gradually incorporated the new weaponry without great social change. Matters were much different in the poor, undeveloped, unstable societies of Europe. There the introduction of new weaponry coincided with a

[40] Robertson, "Imitable Thunder," 32–34.
[41] Needham, *Science and Civilisation in China*, 16.
[42] Lorge, *The Asian Military Revolution*, 5.

dramatic period of demographic and economic growth, and political consolidation.[43] But this comparison leads Lorge to at least partially revise his own prioritization of socio-political variables. For he goes on to suggest that in the European case the demands of gunpowder warfare actually pushed polities – unknowingly – in the direction of the bureaucratized institutions and logistical networks characteristic of China. "[I]t took the invention of systems and practices similar to those of China," he concludes, "before European governments and armies began most fully to exploit the use of guns in war."[44]

What happens, then, if we take this idea of a certain convergence between emergent European governance systems and their much older Chinese predecessors and layer in the idea that the trigger event is a new form of terrestrial fire? Lorge is right to draw attention to the conceptual demands posed by the explosion as "a completely new idea in weaponry", but the challenge is still more profound if we conceive of the coming of ultra-fast deflagration as an event in *planetary* history: as a novel elemental force with which certain human subjects have had to learn to coexist. And it is in this regard, I argue, that the greatly accelerated European encounter with split-second deflagration relative to the Chinese experience matters.

Historians concerned with the transitions accompanying the full embrace of firearms by European armies have taken the Thirty Years' War (1618–1648) as a turning point, with particular emphasis placed on the introduction of volley fire by linear rows of infantryman.[45] Both the growth in size of standing armies and the intensification of gunfire added their heft to a catastrophe that took the lives of some eight million combatants and civilians in Central Europe, including a third of Germany's population. Philosopher Stephen Toulmin is far from alone in viewing the Thirty Years' War as one of the most brutal and unremitting conflicts in

[43] Lorge, *The Asian Military Revolution*, 17.
[44] Lorge, *The Asian Military Revolution*, 81.
[45] Lorge, *The Asian Military Revolution*, 4.

European history.[46] Toulmin proposes that the shockwave unleashed by this conflict was pivotal in a shift in European thought from the open-minded, inclusive and frequently sensuous humanism typical of the sixteenth century to the more abstract, defensive and constricted thinking of the seventeenth century. René Descartes's dogmatic quest for certainty, he maintains, is emblematic of this narrowing of reason.[47]

As Toulmin recounts, the Thirty Years' War broke out when Descartes was in his early twenties and ended two years before his death.[48] Curious about emergent military techniques and with an interest of his own in calculating the trajectory of moving bodies, Descartes joined Maurice of Nassau's army at the opening of the war.[49] He was subsequently present at the Battle of White Mountain where four thousand Protestant troops were slaughtered in an hour or so. It was a month before this engagement, on the night of November 10, 1619, that Descartes experienced the sequence of dreams that he himself viewed as the inspiration for his celebrated scientific method.[50] As a contemporary biographer recounted: "He thought he heard a sudden, loud noise, which he took for thunder. Terrified, he immediately woke. Upon opening his eyes he noticed sparks of fire scattered about the room."[51]

Unsurprisingly, psychoanalytic thinkers have detected signs of post-traumatic stress in Descartes's visions and connected his renowned mind-body dissociation to its wartime context. Noting the young serviceman-savant's likely proximity to the discharge of explosive weapons, analyst Robert Withers adds that, being trained in medicine, he was also likely to have encountered the physiological damage inflicted by canon and musket.[52] What these

[46] Stephen Toulmin, *Cosmopolis: The Hidden Agenda of Modernity* (Chicago: University of Chicago Press, 1990), 16–17.
[47] Toulmin, *Cosmopolis*, 18–22, 56–62.
[48] Toulmin, *Cosmopolis*, 61.
[49] Robert Withers, "Descartes' Dreams," *Journal of Analytical Psychology* 53, no. 5 (2008): 691–709.
[50] Withers, "Descartes' Dreams,", 691–92.
[51] Baillet 1691, cited in Withers, "Descartes' Dreams," 691.
[52] Withers, "Descartes' Dreams," 701.

considerations of Descartes's personal experience bring to Toulmin's more general account of repercussions of the Thirty Years' War is the reminder that by the seventeenth century, physical and psychic exposure to explosive weaponry had become part of everyday life for many Europeans.

Compared with Descartes's subsequent drive for an unwavering, self-grounded cogito, Bacon's championing of hands-on, experientially-led inquiry can come across as relatively modest[53] – though we shouldn't overlook his intimation that nature's truth is revealed through violence. Science studies scholar Donna Haraway's depiction of the Cartesian "god-trick" of scientific objectivity as a flight from the complications of embodiment, situatedness and responsibility to "a realm above the fray" may be even more apposite than intended.[54] For fray it most certainly was – the relentless slaughter of the Thirty Years' War encapsulating all the horrors that a fleshy, impressionable observer might wish to flee from. More than just exposing the human body and senses to a new kind of threat, we might see the weaponized explosion at this juncture as beginning to shape an entire milieu of shocks and forces.

"(T)he canon," observes cultural historian Lewis Mumford, "was the first of the modern space-annihilating devices, by means of which man was enabled to express himself at a distance."[55] It's important to keep in mind that whereas well-trained archers singled out targets, as late as the eighteenth century, historian Priya Satia insists, "firearms were for terrorizing at a distance with *unpredictable* fire."[56] While much has been said about the role of breaking down battlefield operations into discrete, rehearsable gestures in the shaping of

[53] Toulmin, *Cosmopolis*, 129–130.
[54] Donna Haraway, "Situated knowledges: the science question in feminism and the privilege of partial perspective," *Feminist Studies* 14, no. 3 (1988): 576, 590.
[55] Lewis Mumford, *Technics and Civilization* (Chicago: University of Chicago Press, 1934; 2010), 89.
[56] Priya Satia, *Empire of Guns: The Violent Making of the Industrial Revolution* (New York: Penguin Press, 2018), 334.

the modern subject,[57] the paradox of this disciplining process was that it centered on training combatants to function in an environment configured by largely random death or injury – including that inflicted by the malfunction of one's own weapon.[58] This is an experience novelist Andrew Miller imparts through the voice of an early nineteenth century British soldier: a brutal and brutalized infantryman who knows "what it was to stand in line while the enemy guns swept away the men on either side of you, made them non-men, butcher's trash."[59]

When they did not kill outright, as "blooded" soldiers knew all too well, gunpowder weapons produced horrific injuries: "wounds that could not be stitched up neatly like blade or arrow wounds."[60] The damage was not all visible. Well before formal psychiatric recognition of post-traumatic stress disorder or the "war neurosis" diagnosed by Sigmund Freud after World War I, psychic disturbance resulting from fire-armed conflict was well documented.[61] In *The Wealth of Nations* (1776), Adam Smith conveyed a sense of shock and derangement that overflows the field of conflict when he wrote of the "noise of fire-arms, the smoke, and the invisible death to which every man feels himself every moment exposed … a long time before the battle can be well said to be engaged."[62]

Nothing I have been reporting here is meant to imply that Europeans exposed to explosive weaponry were uniquely sensitive to its effects. Warfare in the East was frequent, brutal, and large scale, and as Lorge concludes of China and neighbouring powers: "Asians were just as eager to kill each other with the most effective available weapons as were Europeans."[63] Europe's nineteenth century superiority over China in firepower, as we will

[57] See Foucault, *Discipline and Punish*, 135–36; Mumford, *Technics and Civilization*, 83–84.
[58] See DeVries, "Gunpowder and Early Gunpowder Weapons," 122.
[59] Andrew Miller, *Now We Shall be Entirely Free* (London: Sceptre, 2018), 99.
[60] Satia, *Empire of Guns*, 395.
[61] See Marc-Antoine Croq, "From shell shock and war neurosis to posttraumatic stress disorder: A history of psychotraumatology," *Dialogues in Clinical Neuroscience* 2, no. 1 (March 2000): 47–55.
[62] Cited in Satia, *Empire of Guns*, 332.
[63] Lorge, *The Asian Military Revolution*, 180.

shortly see, had a lot to do with timing. But the different ways that Europe and China absorbed and processed the experience of gunpowder warfare, I suggest, also has much to do broader and deeper "civilizational" framings of fire. And thinking through fire in this way, neither starts nor ends with gunpowder.

The Field of Fire

I have been broadly following Lorge's argument that "(w)ithout the Chinese revolution in warfare there could not have been a European revolution."[64] While Europeans and the Chinese themselves have made much of western military supremacy in light of the disastrous encounters of the mid-nineteenth century, he maintains that the technological gap at the time was still relatively slight and that the success of British aggression owed more to the political disorganization of the Qing government.[65] Where military disparities were most pronounced in the skirmishes of the first Opium War, some historians have argued, was in naval power. And much of this came down to the presence of the steam-powered gunboat *Nemesis* – whose shallow draught, manoeuvrability, and general efficacy as a "workhorse" looks to have been as significant as the armaments it carried.[66]

This connection of gunpowder-based weapons with steam power is of great significance, not just for military or even social history but also for the still-unfolding history of the Earth. Just as Lorge and others have stressed the importance of situating weapons within their socio-institutional contexts, so too do we need to consider the social and civilizational framing of this novel planetary fire. This means opening up the complex issue of how Chinese researchers discovered a new mode of combustion in the first place. And in a roundabout way, it brings us to the issue of how Europeans came up with new ways of deploying an older kind of combustion.

[64] Lorge, *The Asian Military Revolution*, 7.
[65] Lorge, *The Asian Military Revolution*, 21,177; 162–68.
[66] Andrade, *The Gunpowder Age*, 256–58; Lorge, *The Asian Military Revolution*, 168.

As Needham stresses, incendiary devices and mixtures played a major role in warfare in China centuries before the invention of gunpowder.[67] This in turn, he explains, was part of a more general concern with physico-chemical experimentation in which fire was a key element. *Huo yao* was one of many discoveries arising from a spree of pyrotechnical exploration that spanned at least six centuries, a research tradition in which there was no pronounced separation between medical, alchemical, military, and ceremonial applications of incendiary discoveries – as the term "fire drug" indicates.[68] "Smokes, perfumes, hallucinogens, incendiaries, flames, and ultimately the use of the propellant force of gunpowder itself," concludes Needham, "form part of one consistent tendency discernible throughout Chinese culture from the earliest times."[69]

We should also consider China's early lead in high heat technology. By 1500 BCE, observes historian Jack Goody, Chinese artisans were attaining kiln temperatures well over 1200°C. These unprecedented heat levels enabled manufacture of glazed stoneware and the casting of bronze and iron.[70] An entire industrial complex took shape around these pyrotechnologies, Goody observes, characterized by "a large scale, labour-intensive chain of production, with ore-miners, fuel gatherers, ceramacists and foundry workers."[71] Only much later, he adds, did the high heat methods pioneered in China move westward. This millennium-and-a-half of developing high heat practice helped equip the Chinese with both the technical capabilities for channelling the force of explosive deflagration and the institutional foundations for the extensive capitalization of these capacities.[72]

If only in a preliminary way, positioning gunpowder and the experiments from which it emerged in the *longue durée* of Chinese pyrotechnic exploration helps us to see why the

[67] Needham, *Science and Civilisation in China*, 69.
[68] Needham, *Science and Civilisation in China*,108–117.
[69] Needham, *Science and Civilisation in China*, 2–3.
[70] Goody, *Metals, Culture and Capitalism*, 165.
[71] Goody, *Metals, Culture and Capitalism*, 166.
[72] Goody, *Metals, Culture and Capitalism*, 219, 257; Needham, *Science and Civilisation in China*, 39.

shockwaves of explosive warfare, alarming even in China, were still more difficult for Europeans to absorb. It's worth recalling that despite recurrent hostilities in Europe, development of gunpowder weaponry was neither rapid nor inexorable – Kelly describing "the curious stasis that gripped military technology from the end of the Thirty Years' War in 1648 until well into the 1800s."[73] What may ultimately have been more consequential over this time are the more "existential" impacts I addressed in the previous section: the constricting of reason, the dissociation of mind and body, the hardening – we might even say brutalizing – of exposed subjects.[74] For this is a matter of global significance. Capacities, dispositions, sensibilities that were honed and exercised in European domestic conflicts were also instrumental in Western colonial expansion.

As I touched upon earlier, describing the movement of projectiles played a significant role in the development of Descartes's scientific method: his interest in moving bodies falling somewhere Galileo's insights on the parabolic curve traced by cannonballs and Newton's extrapolation from projectiles to planetary motion. In this regard, Kelly argues, concern with the accuracy of artillery played a significant role in establishing the western scientific premise that the object world followed predictable pathways – although it took several centuries to markedly improve battlefield targeting.[75] In relation to fire more generally, what we need to recognise here is the distance thought and practice is travelling from the idea that fire is a versatile force that transmutes matter to the association of explosive weaponry with a single, determinable trajectory.

There is still a tendency, prevalent in Anthropocene scholarship, to put the stress on the massive expansion of power and capability that results from combusting fuels to drive heat engines. What the shift from a more metamorphic conception of fire to viewing

[73] Kelly, *Gunpowder*, 146.
[74] Nigel Clark, "Infernal Machinery: Thermopolitics of the Explosion" *Culture Machine*, 17 (2019) http://culturemachine.net/vol-17-thermal-objects/infernal-machinery/. Accessed December 6, 2021.
[75] Kelly, *Gunpowder*, 140–41; Clark, "Infernal Machinery."

explosive fire as the driving force of linear motion brings into relief, however, is the profound narrowing or constriction that is taking place in the imaginary of fire.[76] In the West, this momentous reduction reaches its fulfillment in the thermodynamic thinking that is closely associated with the ascent of new industrial heat engines. As physicist Ilya Prigogine and Isabelle Stengers observe:

> Fire transforms matter; fire leads to chemical reactions, to processes such as melting and evaporation. Fire makes fuel burn and release heat. Out of all this common knowledge, nineteenth century science concentrated on the single fact that combustion produces heat and that heat may lead to an increase in volume; as a result combustion produces work.[77]

Yet historians have also noted more direct links between engines that use fire to do "work" in this restricted sense with the European experience of exploding gunpowder. As Mumford observed 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."[78] Needham fills out this storyline – tracking a history of projects aimed at applying gunpowder to useful weight lifting or piston driving tasks that goes back at least as far as the early sixteenth century.[79] Scientist-inventor Christiaan Huygens' project with the French Academy of Sciences in the 1670s is pivotal. As Huygens wrote:

The force of cannon powder has served hitherto only for very violent effects … and although people have long hoped that one could moderate this great speed and impetuosity to

[76] Nigel Clark and Kathryn Yusoff, "Combustion and Society: A Fire-Centred History of Energy Use," *Theory, Culture & Society* 31, no. 5 (2014): 203–226; Nigel Clark, "Fiery Arts: Pyrotechnology and the Political Aesthetics of the Anthropocene," *GeoHumanities* 1, no. 2 (2015): 266–284
[77] Ilya Prigogine and Isabelle Stengers, *Order Out of Chaos: Man's New Dialogue with Nature* (New York: Bantam Books, 1984), 102.
[78] Mumford, *Technics and Civilization*, 88.
[79] Needham, *Science and Civilisation in China*, 544–568.

apply it to other uses, no one, so far as I know, has succeeded.[80]

It was Denis Papin, initially working under Huygens on the *moteur à explosion*, who recognized that steam power offered a "less violent" route to creating the vacuum that could drive a piston.[81] Papin set research and development on a path towards external combustion – the use of fire-heated boilers to drive engines. Though not with gunpowder as its motive force, the internally combusting *moteur à explosion* would be momentously revived some two centuries later as the driving force of the automobile. But prior to the return of internal combustion, the external combustion of the steam-powered heat engine joined forces with gunpowder to devastating effect.

As military historian Martin van Creveld explains: "(t)he invention of the steam engine … freed weapons from the limited power provided by horses, enabling their size, weight, and power to grow many times over."[82] Or in the case of a gunboat like *Nemesis* it greatly increased speed, work rate, and maneuverability. At the same time, steam power combined with explosive deflagration to dramatically accelerate mineral-energetic extraction. Steam engines pumped water from mines and transported extracted materials, and explosions opened up rock faces and facilitated large-scale infrastructural development.[83] In turn this compounding of two distinct forms of combustion amplified the ability of western interests to forcibly gain access to the land and resources of other peoples across the globe. But we should also be mindful that the readiness to unleash this convergent and concentrated firepower on other life-worlds may itself manifest the tempering, brutalizing effect of the European subject's intensive exposure to the explosive inferno.

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[80] Needham, *Science and Civilisation in China*, 557.
[81] Papin […] cited in Peter Valenti, "Leibniz, Papin and the Steam Engine: A Case Study Of British Sabotage of Science," *American Almanac* (1996) http://members.tripod.com/~american_almanac/papin.htm. Accessed December 6, 2021.
[82] Martin Van Creveld, "The Rise and Fall of Military Technology," *Science in Context* 7, no. 2 (1994): 332.
[83] Kelly, *Gunpowder*, 122–23, 218; Clark, "Vertical Fire."

Anthropocene Echoes of the Explosion

As climate activist Greta Thunberg famously exhorted world leaders: "I want you to panic … I want you to act as if our house is on fire."[84] Timely words. But we might ask whether the apparent willingness of certain sectors of the global population to dwell in the shadow of a rapidly heating planet bears some relationship to several centuries of painful accommodation to an explosive milieu; to the risk of having their "house" not merely burnt down but blown apart.

It's worth recalling that the historical juncture which Anthropocene scientists identify as the most likely threshold of the new geological epoch immediately follows the endpoint of what Andrade refers to as "the European warring states period" that he sees as stretching from 1450 to 1945.[85] By the time that a half-millennium of recurrent conflict came to a close, Europe's explosive firepower had reached such levels that entire populations found themselves inhabiting, in Walter Benjamin's words, "a field of force of destructive torrents and explosions: a total environment of bomb blasts and firestorms capable of reducing entire cities to ash and rubble.[86]

Slow violence may be important, I've been arguing, but we still have work to do to make sense of an imperceptibly fast violence so deeply insinuated in the contemporary world that it is often barely registered. While trillions of tiny explosions still propel most of the global fleet of land-based vehicles, bigger but often unseen detonations continue to tear great volumes of rock fabric apart. Anthropocene geologists point out that anthropogenic mixing or "turbation" of rock fabric has so outstripped the impacts of any other organism that it has "no

[84] Greta Thunberg, "'Our house is on fire': Greta Thunberg, 16, urges leaders to act on climate," *The Guardian*, January 26, 2019, https://www.theguardian.com/environment/2019/jan/25/our-house-is-on-fire-greta-thunberg16-urges-leaders-to-act-on-climate. Accessed December 6, 2021.
[85] Andrade, *The Gunpowder Age*, 45.
[86] Walter Benjamin, *Illuminations* (New York: Harcourt, 1968), 84; see also Clark "Vertical Fire."

analogue in the Earth's 4.6 billion year history."[87] Again, Needham is prescient in appreciating the historical role of the fiery explosion in destratifying the Earth, citing Boyle's observation that a "few barrels of gunpowder" suffices to blow up "many hundred, not to say thousand, tonnes of common rock."[88] By the mid-nineteenth century commercial application of gunpowder for mining and civil engineering had overtaken military uses. Chemist Alfred Nobel's concoction of an explosive that was "more violent, brisant and shattering than propellant gunpowder" greatly accelerated this trend,[89] and the dynamite industry, Kelly adds, "grew faster than any other business in history."[90]

This of course is not simply "anthropic" rock turbation but a very particular social interaction with geological formations – as we can glean from horror and outrage with which so many of the planet's peoples have apprehended the western eagerness to turn the Earth inside out. But the traumatic history of Europe's truncated encounter with gunpowder prompts us not simply to ask how its mighty earth-moving capabilities were achieved, but to consider the connections between lived exposure to explosive violence and the unprecedented intensity of the West's drive to blast open the Earth. This question also relates to the social toleration of exceptional fatality rates of mine workers, both within Europe and its colonial extractive frontiers.

Explosive extraction has disaggregated the Earth's lithic strata to such a degree, geoscientists have observed, that it is unsettling the logic of superposition – the sequential lithic layering through which geologists conventionally interpret the Earth's deep history.[91] In this way, planetary changes triggered by a part of humanity undermine our very ability to make sense of the events scientists are attempting to measure and model. At the same time,

[87] Jan Zalasiewicz, Colin Waters and Mark Williams, "Human bioturbation, and the subterranean landscape of the Anthropocene," *Anthropocene* 6 (2014): 3–9.
[88] Cited in Needham, *Science and Civilisation in China*, 538.
[89] Needham, *Science and Civilisation in China*, 537.
[90] Kelly, *Gunpowder*, 229.
[91] See Zalasiewicz et al, "Human bioturbation."

the power of the weaponized explosion has underpinned the global imposition of social and material relations that have eroded the capacity of many peoples worldwide to live with and respond to the changing conditions of their own environments.[92]

While the planetary volatility that Anthropocene science seeks to substantiate may have begun to react back upon its own onto-epistemological surety, critical social thinkers allege that it has not yet impacted sufficiently to destabilize the geosciences' assumption of global authority. In short, the Anthropocene geostory has yet to properly connect the physical violation of Earth systems and structures it documents with the epistemic violence that accompanies speaking on behalf of a world of exposed and marginalized others – a charge that may well be intensified by the choice of a radionuclide marker and the way this is presented. But the "earth-shattering" explosions that the Anthropocene hypothesis is foregrounding, I have argued, open up a history of fiery exothermic reactions, a genealogy which points to a deep, enduring entanglement of physical and epistemic violence in the becoming dominant of the West.

We cannot replay European history without gunpowder. And perhaps Western thought itself still lacks the conceptual tools for making sense of the sudden arrival of a new kind of planetary combustion – not least because this thought is itself forged and scarred by the confrontation with an alien fire. Jacques Derrida writes of knowledge beginning from incomprehension and exposure: of "the wound or inspiration which opens every speech and makes possible every logos or every rationalism."[93] But some rationalisms, some epistemes, may be more scarred than others. Something deep, disturbing and persistent occurred when a strange new fire descended on European lands that had no sociocultural or cosmological niche for it. And if the coming of the anthropogenic explosion was indeed a geological event,

[92] See Kyle Whyte, "Indigenous climate change studies: Indigenizing futures, decolonizing the Anthropocene," *English Language Notes* 55, nos. 1–2 (2017): 153–62.
[93] Jacques Derrida, *Writing and Difference* (London: Routledge, 1978), 98.

then learning to manage explosions otherwise, which must include managing with a lot fewer runaway exothermic events, might itself constitute another event in Earth history.