Interscalar Vehicles for the African Anthropocene:
On Waste, Temporality, and Violence

Gabrielle Hecht
author correspondence to hechtg@umich.edu

Mounana, Gabon, late 1970s. Courtesy of Cogéma. Used with Permission.

Brightly painted concrete houses, equipped with running water and electricity, arranged in dozens of identical rows: this photograph depicts the newly built company town of Mounana in eastern Gabon. The road is clean, the children happy. In the late 1970s, this image aimed to represent the success of national and corporate modernity projects. By the end of this essay, I hope you will also see it as an image of the African Anthropocene.

The idea of an African Anthropocene may seem like a paradox. After all, the biggest appeal of the Anthropocene idea has been its "planetarity."[1] For some geologists, the Anthropocene signals the start of a new epoch, in which humans permanently mark the stratigraphic record with their "technofossils."[2] Other earth scientists adopt the notion to signal humanity's catastrophic effects on the planet's physical and biochemical systems. Over the last decade, the term has become a "charismatic mega-category"[3] across the humanities, arts, and natural and social sciences.[4] Inevitably, debates rage about origins and nomenclature. Did the Anthropocene begin with the dawn of human agriculture? Or with the Columbian exchange of the 16th and 17th centuries? How about the start of European industrialization in the 18th century? Some favor July 16, 1945, date of the first nuclear weapons test at Alamogordo.[5]

While geologists ponder the stratigraphic signals left by each of these options, humanists and social scientists worry about their political and ethical implications. Early start dates, for example, risk naturalizing the Anthropocene as part of "*the* human experience," depoliticizing its causes, exonerating energy-intensive capitalism.[6] Some feel that the very term obscures massive inequalities: attributing the unfolding catastrophes to an undifferentiated humanity elides crucial differences in responsibility and lived experience. Others object to claims that "the Anthropocene" signals a *new* awareness of ecological harm; the history of 19th century climate science and industrial pollution shows that previous evidence and warnings were politically sidelined.[7] Still others object that "the Anthropocene" attributes too much agency to humans, sidelining non-human forces. This array of concerns has prompted alternative proposals, such as "Capitalocene."[8] Or "Chthulucene," the monstrous metaphor used by the ever-humorous Donna Haraway to invoke "myriad temporalities and spatialities and myriad intra-active entities-in-assemblages—including the more-than-human, other-than-human, inhuman, and human-as-humus."[9]

Wrestling with these counterpoints is invigorating, but alternative nomenclatures seem unlikely to gain much traction. (It's hard to imagine the International Commission on

---

[1] Elizabeth DeLoughrey, "Satellite Planetarity and the Ends of the Earth," *Public Culture* 26 (2): 257-280.

[2] The International Commission on Stratigraphy, a standard-setting body within the International Union of Geological Sciences, is currently considering whether to adopt "the Anthropocene" as the formal designation for a new geological epoch. On technofossils, see Jan Zalasiewicz, Mark Williams, Colin N. Waters, Anthony D. Barnosky, and Peter Haff, "The technofossil record of humans," *Anthropocene Review* Vol. 1, (1) 2014: 34-43.

[3] Elizabeth Reddy, "What does it Mean to do Anthropology in the Anthropocene?" Posted April 8, 2014 on blog.castac.org.

[4] Two wildly different examples: Will Steffen, Jacques Grinevald, Paul Crutzen, and John McNeill, "The Anthropocene: conceptual and historical perspectives," *Phil. Trans. R. Soc. A* (2011) 369: 842-867 and Elizabeth Ellsworth & Jamie Krause, *Making the Geologic Now: Responses to the Material Conditions of Contemporary Life* (Punctom Books, 2013).

[5] Two contrasting approaches to dating are Jan Zalasiewicz et al., "When did the Anthropocene begin? A mid-twentieth century boundary level is stratigraphically optimal," *Quarternary International* 383 (2015): 195-203 and Simon L. Lewis & Mark A. Maslin, "Defining the Anthropocene," *Nature* 519 (12 March 2015): 171-180. For a quick overview of dating debates, see Richard Monastersky, "The human age," *Nature* 519 (12 March 2015): 144-147).

[6] Andreas Malm, "The Anthropocene Myth," posted 30 March 2015 on Jacobin. https://www.jacobinmag.com/2015/03/anthropocene-capitalism-climate-change/

[7] Christophe Bonneuil & Jean-Baptiste Fressoz, *L'Événement anthropocène: La Terre, l'histoire, et nous* (Le Seuil, 2013).

[8] Jason Moore, *Capitalism in the Web of Life* (Verso, 2015).

[9] Donna Haraway, "Anthropocene, Capitalocene, Plantationocene, Chthulucene: Making Kin," *Environmental Humanities* 6 (2015): 159-165.

Stratigraphy adopting the "Capitalocene" to designate a new geological epoch.) Critics of the Anthropocene are justifiably concerned that the idea can be used to revive dangerous fantasies about humans' ability to control nature.[10] Still, for many of the Anthropocene's most prominent proponents, the term is a way of signaling human responsibility, not asserting control. They use "the Anthropocene" to acknowledge (not deny) the importance of politics, to invite a broad conversation about our earthly condition.[11] The Anthropocene is a time to make friends, not foes.[12]

How can we incorporate critique while retaining the concept's political power, along with its potential to spark new narratives, methodologies, and forms of knowledge? Three analytic moves underpin my exploration of this question. First, I treat **scale** as both an analytic category and a political claim. Scale drives the Anthropocene assertion, which holds that our planet has recently experienced a "great acceleration" in the metabolism of its materials. But in accepting the invitation to dramatically expand our spatial and temporal scales, we must consider the political and ethical work accomplished by scalar choice. This essay offers a way to hold the analytic and political aspects of scale in productive tension.

My second move is to treat the Anthropocene as the apotheosis of **waste**. This relates to scale, of course. Much of what has massively increased is the quantity, extent, and durability of discards: consider the planetary production of particulates, the millennial futures of microplastics and radioactive waste. Furthermore, monitoring discards is a key technique of Anthropocene epistemology: it's *how* we know the geological, atmospheric, and biophysical impact of human activity.

But we must never forget that the violence associated with this apotheosis is not merely planetary – it also has particular, differential manifestations. Hence my third move: putting the Anthropocene in **place**. I gloss this move as the "African Anthropocene," but my goal is decidedly *not* to propound continental essentialism. I do not aim to identify the characteristics of an "African" Anthropocene in clear distinction to (say) an "Asian" or a "European" one. Rather, I seek productive paradox, a means of holding the planetary and the particular in the same frame, of "grounding"[13] the Anthropocene.[14] What Anthropocene stories emerge when we take African places as points of departure?

---

[10] The *Ecomodernist Manifesto*, for example, has attracted media attention by promoting a "good Anthropocene," in which humans can simply engineer their way out of the mess; the pamphlet seems disturbingly oblivious to power dynamics, human limitations, and the lessons of history. J. Asafu-Adjaye et al., *An Ecomodernist Manifesto*, posted April 2015 on http://www.ecomodernism.org/. An excellent set of responses to the manifesto are collected in *Environmental Humanities* 7 (2015).

[11] See, for example, Johan Rockström "The Anthropocene, Control and Responsibility: A Reply to Andy Stirling," posted 29 October 2015 on the STEPS Centre blog: http://steps-centre.org/2015/blog/johan-rockstrom-on-the-anthropocene. Fredrik Albritton Jonsson offers a helpful review of such debates, concluding that "the concept of the Anthropocene should be understood as an attempt to move beyond conventional scientific norms of objectivity and neutrality." Fredrik Albritton Jonsson, "Planetary Politics," *Public Books*, June 15, 2015. http://www.publicbooks.org/nonfiction/planetary-politics.

[12] Bruno Latour, "Telling friends from foes in the time of the Anthropocene," in Clive Hamilton, Christophe Bonneuil, and François Gemenne, *The Anthropocene and the Global Environmental Crisis* (New York: Routledge, 2015).

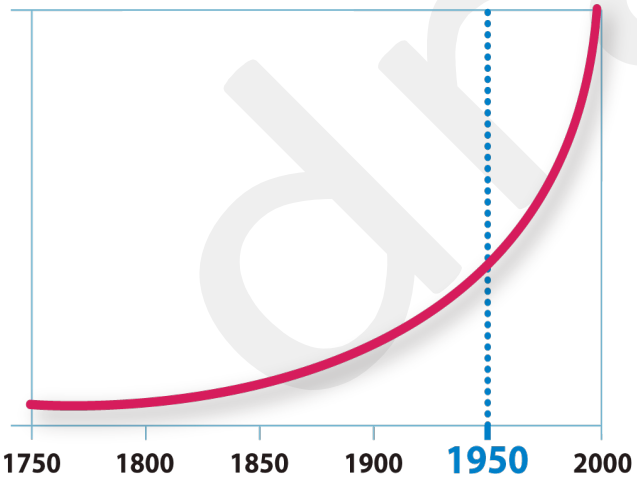
[13] Braun, Coleman, Thomas & Yusoff, 2015 Grounding the Anthropocene (Antipode Foundation website).

[14] Mark Whitehead, *Environmental Transformations: A Geography of the Anthropocene* (Routledge, 2014) and his blog "Placing the Anthropocene."

For this much is clear: in order to grasp the complex connections posited by the Anthropocene and its counterpoints, we need new stories.[15] Compartmentalization has failed. Fields such as science and technology studies and environmental history have known this for decades, and long challenged the nature/culture binary; postcolonial scholars, meanwhile, have demonstrated the binary's violent effects. Yet challenging binaries is not enough. We need to refract history through new prisms. We need wormholes through time and space, to link distant points. We need, as Rob Nixon argues, to "counter the centripetal force of the dominant Anthropocene species story with centrifugal stories that acknowledge immense inequalities in planet-altering powers."[16] We must spin out in all directions. In experimenting with centrifugal narrative, this essay pivots around Mounana, Gabon.

Interscalar vehicles

Before spinning away, however, I need to say more about scale. It bears repeating: in the Anthropocene, questions of scale are tightly bound to matters of waste. This is readily apparent in the dozens of graphs (generated by natural *and* social scientists) showing exponential increases in the rearrangement of earthly materials, especially as of the 1950s.[17] This "great acceleration" is sometimes visualized with a single curve whose only purpose is to invoke scale itself: time forms the x-axis, but the y-axis remains unmarked, denoting pure size.



The Great Acceleration, writ large. From IGBP synthesis: Global Change and the Earth System, Steffen et al 2004

[15] The call for narrative is strong among humanists and qualitative social scientists, ranging from several contributors to Hamilton, Bonneuil, and Gemenne, *The Anthropocene and the Global Environmental Crisis* to essays such as Thomas F. Thornton and Patricia M. Thornton, "The Mutable, the Mythical, and the Managerial: Raven Narratives and the Anthropocene," *Environment and Society: Advances in Research* 6 (2015): 66-86.

[16] Rob Nixon, "The Anthropocene: The Promise and Pitfalls of an Epochal Idea," posted November 6, 2014 on *Edge Effects*. http://edgeeffects.net/anthropocene-promise-and-pitfalls/

[17] See Steffen, Grinevald, Crutzen, and McNeill, "The Anthropocene" for a typical example of such graphs.

Historians have explored how the construction of scale shapes what can be seen in the Anthropocene: climate change can only be apprehended via global models; endocrine disruptions require microscopic attention.[18] Geographers, who have probably thought more about scale than anyone else, have long debated its ontology. Many now argue that scale is emergent, relational, and performative, calling attention to the politics of scale-making. Hydraulic power in Franco's Spain; agricultural projects in French West Africa; contemporary fights over Indonesia's rainforests: each of these are instances in which the production of national, imperial, regional, or global scales involved power struggles, replete with winners, losers, and brokers.[19]

Scale has often served to demarcate boundaries within and among disciplines. But the Anthropocene offers an opportunity to reverse this pattern. Julia Adeney Thomas, for example, invites fellow historians to draw inspiration from the scalar struggles of biologists: "While climatologists and paleobiologists put 'species' on the historian's map in unprecedentedly difficult ways because of the macroscales involved, other types of biology, such as microbiology and biochemistry, compound our difficulties by looking at the human on a microscale, raising perplexing issues of human solidarity and continuity."[20] To grapple with human geological agency in relation to global histories of capital and species histories of humans, as Dipesh Chakrabarty urges us to do, we should also draw inspiration from scalar struggles in the physical sciences.[21]

One challenge of multi-scalar analysis is figuring out *how* to move between scales. How do we tell stories in which the macroscopic and microscopic meet in meaningful ways? Can we do so without overly reifying scale itself — without treating scale *merely* as a fixed feature of a phenomenon? Scale is messy, not the least because it's *both* a category of analysis *and* a category of practice.[22] Scales have epistemological, political, and ethical consequences. Rather than reject these entanglements, let's exploit them. Let's move between scales while *simultaneously* attending to the history and politics of scale-making.

---

[18] Paul N. Edwards, *A Vast Machine: Computer Models, Climite Data, and the Politics of Global Warming* (Cambridge, Mass: MIT press, 2010); Nancy Langston *Toxic Bodies: Hormone Disruptors and the Legacy of DES* (New Haven: Yale University Press, 2010).

[19] The geography literature on scale is vast. Essays that most informed my thinking include: Sallie Marston, "The social construction of scale," *Progress in Human Geography* 24, 2 (2000): 219-242; Mark Purcell, "Islands of practice and the Marston/Brenner debate: toward a more synthetic critical human geography," *Progress in Human Geography* 27, 3 (2003): 317-332; Nathan F. Sayre, "Ecological and geographical scale: parallels and potential for integration," *Progress in Human Geography* 29, 3 (2005): 276-290; Eric Swyngedouw, "Technonatural Revolutions: the Scalar Politics of Franco's Hydro-Social Dream for Spain, 1939-1975," Transactions of the Institute of British Geographers, 32 (Jan. 2007) 1: 9-28; Nathan Sayre, "Scale," in Noel Castree, David Demeritt, Bruce Rhoads, and Diana Liverman, eds. *A Companion to Environmental Geography* (London: Blackwell Publishing, 2009): 95-108; Roderick P. Neumann, "Political ecology: theorizing scale," *Progress in Human Geography* 33, 3 (2009): 398-406; Danny MacKinnon, "Reconstructing scale: Towards a new scalar politics," *Progress in Human Geography* 35, 1 (2010): 21-36. Anthropologist Anna Tsing also offers useful reflections on scale in her *Friction: An Ethnography of Global Connections* (Princeton, 2005).

[20] Julia Adeney Thomas, "History and Biology in the Anthropocene: Problems of Scale, Problems of Value," *American Historical Review* (December 2014): 1587-1607.

[21] Dipesh Chakrabarty, "The Climate of History: Four Theses," *Critical Inquiry* 35 (Winter 2009): 197-222.

[22] On categories of analysis and categories of practice, see Rogers Brubaker and Frederick Cooper, "Beyond 'identity'," *Theory and Society* 29 (2000): 1-47. Adam Moore applies their argument to questions of scale in "Rethinking scale as a geographical category: from analysis to practice," *Progress in Human Geography* 32(2) (2008): 203-225.

For that, we need interscalar vehicles.

In science fiction dreams of inter*stellar* travel, characters travel distances unbridgeable by conventions of Newtonian mechanics. They arrive at impossible destinations, worlds that teach them new ways of seeing and being. Let's attempt similarly impossible journeys. What happens when we treat empirical objects as inter*scalar* vehicles, means of connecting stories and scales usually kept apart?

In this essay, I take uranium-bearing rocks as my interscalar vehicles, riding them from Gabon to France to Japan, from the 1970s to our planet's early history to the distant future. In navigating this journey through space and time, I simultaneously observe the interscalar vehicles deployed by historical actors: maps and photographs; compensation claims and warning signs; urban development and cosmological theories; atomic bombs. Interscalar vehicles – theirs and ours – have political, ethical, epistemological, and (or) affective dimensions. Attending to these dimensions historically, I maintain, points us in the directions that our centrifugal narratives should spin.

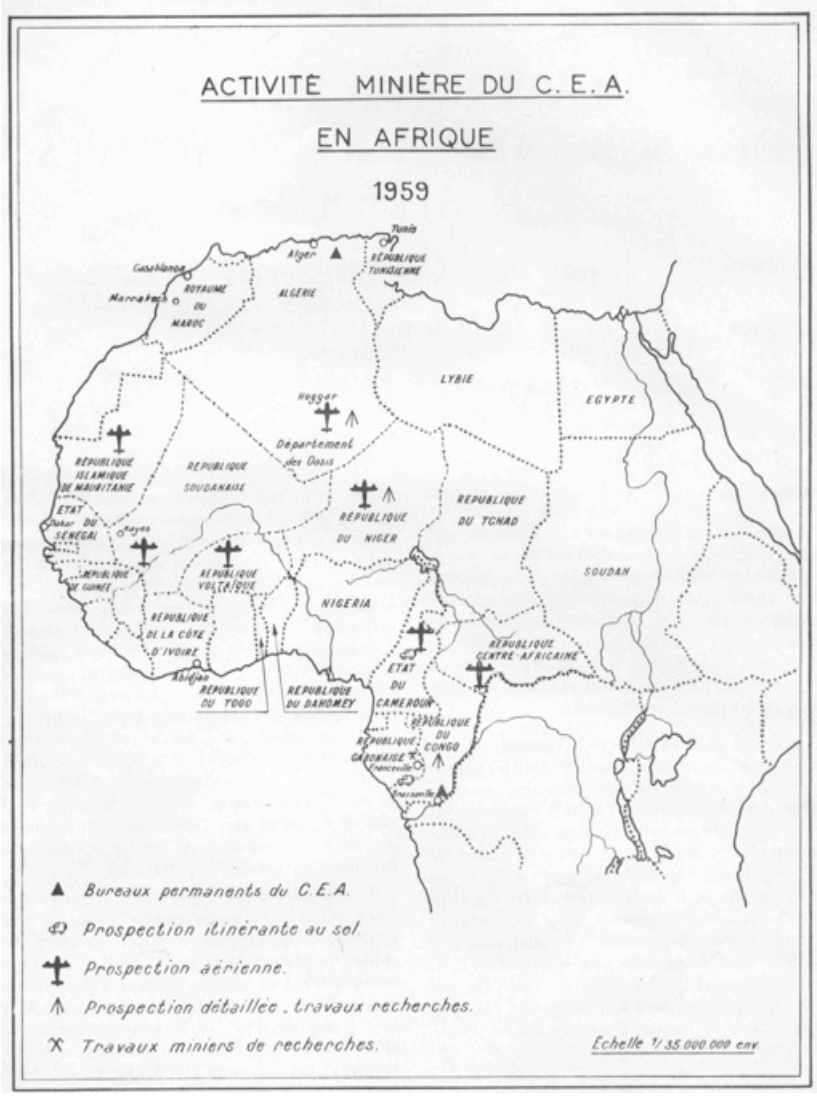
Now we can go to Mounana.

Scales of prospecting

The Compagnie Minière d'Uranium de Franceville launched its operations in 1957, just before Gabon gained independence from France. The COMUF began as a joint venture between the French Commissariat à l'Énergie Atomique (CEA) and Mokta, a colonial mining corporation. As the first shipment of uranium left Mounana for France in 1961, the (white, French, male) company managers congratulated themselves on a job well done. Ore reserves seemed ample, and a new training program promised to prepare large numbers of Gabonese men for long-term, salaried mine work. Gabonese uranium was poised to supply French atomic bombs and nuclear power plants for decades to come.

That promise alone represented a victory for the French atomic energy commission. Created at the conclusion of WW2, the CEA's top priority in its early years was finding uranium. Newly valued by the explosions at Hiroshima and Nagasaki, the mineral was initially deemed rare. France had some deposits in its metropole, but would clearly need more to power its reactors, not to mention the bombs some of its engineers longed to build. The CEA launched a massive search throughout France's African territories.

Uranium prospection in the twilight of empire could be tricky. Consider this schematic map of the CEA's prospecting activities in 1959. (Fig. 3) The image appeared in the CEA's annual report in 1960, the year when most French African colonies gained independence. The map simultaneously represents the past and imagines the future, demarcating space according to the national lines of 1960 instead of the imperial ones that still obtained in 1959. Only Gabonese ore reserves were sufficiently proven to justify a mining operation back then. But Niger and the Central African Republic showed considerable promise, and the report discussed the CEA's plans to pursue those options. Even as it acknowledged historical rupture, therefore, the map made a powerful claim to French technopolitical authority. At the cusp of decolonization, the CEA intended to continue treating Francophone Africa as a continuous resource space – its *pré carré*, a zone of privileged access. Dreams of national energy independence relied on African uranium becoming French, on the imperial scale disappearing into the national scale.



Prospecting for uranium in Africa. Commissariat à l'Énergie Atomique, *Rapport Annuel 1960*. Used with permission.

While the map represents French technopolitical aspirations at a spatial scale of 1:35 million, this photograph depicts the micro-workings of power. (Fig. 4) A prospecting team trudges through the Gabonese rainforest. The black man in front holds a Geiger counter, which crackles in the presence of sufficiently radioactive rocks. His job title is "assistant prospector": the CEA trained a cadre of about a dozen such men, selected for their French colonial education and their knowledge of the terrain. The two white men in back are the "chief prospectors." Yet the image inadvertently subverts the CEA's claim to mastery, depicting a classic example of African intermediaries' key role in the (post)colonial production of knowledge. After all, the so-called assistant is the one guiding the team through the bush and operating the key instrument.

Prospecting for uranium in Gabon, 1950s. Courtesy of Cogéma, used with permission.

Considered together, these two images exemplify the scalar politics that characterized colonialism and its aftermath. Grand claims, made credible by fine-grained pockets of practice. An insistence that large-scale territorial management resulted in individual uplift, that producing value for France would also produce value for Africans. Such promises justified postcolonial collusions between Gabonese state elites and French parastatal corporations, which later critics would identify as the hub of *la Françafrique*.[23] (The term designates corrupt relations between the French government and postcolonial African elites. The word can also be heard as *France-à-fric*; *fric* is slang for money.)

Anthropocene scholars note that industrial capitalism has long relied on "cheap nature" – the assumption that earthly materials are there for the taking.[24] This certainly describes uranium mining in Gabon, where – at least initially – extraction costs were predictable and limited: equipment, transport, wages, and food. Building materials also relied on cheap nature: rock for gravel and concrete, trees for timbering the mineshafts. Value, at all scales, came from turning earthly materials into "raw materials."

Valuing slow violence (part 1)

But uranium did not merely produce value for employees. It also produced violence. Boring holes, blasting rocks, digging tunnels: these are dangerous activities. Many locals refused to work in the tunnels because they feared the evil spirits that lurked underground. Working conditions did not dispel those fears. In 1965, a huge slab of rock came crashing down on a team of workers, killing two and injuring others. In 1970, a flood trapped five miners in an underground cul-de-sac; the image of their bloated bodies, retrieved after six days of searching, remained seared in memories for decades.[25]

Other forms of violence unfolded more slowly.[26] Blasting rock left dense clouds of dust, which took longer to disperse than the 15-minute waiting period specified by workplace regulations. "After the blast, there's a lot of dust," said Marcel Lekonaguia, who'd been in charge of blasting for several years. "It's the dust that wasted us…you swallow it, you breathe it." Protective gear did not help: "Those little masks, they didn't hold up well. They're made of paper…if it gets a little wet—paf!" The masks would dissolve, over and over, leaving him with a lifetime of respiratory ailments.[27]

---

[23] François-Xavier Verschave, *La Françafrique: le plus long scandale de la République* (Paris: Stock, 1998)

[24] Notably Moore, *Capitalism in the Web of Life*.

[25] Xavier des Ligneris to M. le Président, Memo, 'Accident Chambre 5,' 18/12/65; Xavier des Ligneris to M. le Président, Memo, 27/12/65, 'Suites de l'accident du 17 Décembre 1965.' COMUF archives. Multiple interviews, 1998, Mounana, Gabon.

[26] Here I draw on Rob Nixon, *Slow Violence and the Environmentalism of the Poor* (Cambridge, Mass.: Harvard University Press, 2013).

[27] Author interview with Marcel Lekonaguia, July 1998, Mounana, Gabon.

And then there was the radiation. Invisible, odorless, and easy to forget, it came in several varieties. Gamma rays, emitted during the radioactive decay of uranium, could be tracked by individually worn dosimeters. At the end of each month, workers rendered their dosimeters, which went to France for processing. In underground shafts, however, other forms of radiation proved more insidious. Natural uranium atoms decay into radon, which decays into other elements that, when inhaled, lodge in the lungs and bombard soft tissue with radioactive alpha particles. Over time, this changes cellular structures and can lead to lung cancer. But not in everyone: the process is stochastic (another way of saying that scientists do not fully understand the synergy of its causal mechanisms). In any case, portable alpha dosimeters did not exist until the late 1980s. Radon varied unpredictably throughout the shafts, in some places reaching levels twelve times international regulatory limits. For workers, such radiation exposure was the slowest violence of all: cancers could take decades to manifest.[28]

Workers did protest. They refused to return to work for days after fatal accidents, shocked that management did not make time to mourn their comrades. News traveled, making it difficult for the COMUF to recruit new labor after major accidents. When the company doctor refused to recognize links between lung disease, dust, and radiation, some workers refused to hand over their dosimeters for the monthly check. Lekonaguia told me that held on to his dosimeter because he hoped to find other experts to interpret the results and attest to his exposure levels.

None of this, however, interrupted mining operations for very long. The COMUF counted on jobs, training, housing, and medical care to keep protest in check. It managed the social effects of workplace accidents by placing a monetary value on their violence, offering hazard premiums for underground and other dangerous work. In these and other ways, the company deployed the classic tactics of industrial development: valuing modernity above life, manufacturing consent. Hardly a unique story.

And then, for a brief time, nature stopped being cheap. To understand how, we need to get back into our interscalar vehicle, and ride the rocks to the atomic scale. As befits an Anthropocene tale, this means delving into the physics and chemistry of uranium.

Fossilized reactors

Natural uranium is primarily composed of uranium-238, an isotope whose nucleus contains 92 protons and 146 neutrons. But other uranium isotopes are also present, notably uranium-235 (still 92 protons – that's what makes it uranium — but only 143 neutrons to glue the nucleus together). The 235 isotope only comprises 0.72% of natural uranium. But it holds greater interest for engineers, because its nucleus is unstable enough to split by bombarding it with neutrons. Known as fission, this splitting releases energy and liberates more neutrons.

[28] This discussion relies on the research and analysis in Gabrielle Hecht, *Being Nuclear: Africans and the Global Uranium Trade* (Cambridge: MIT Press, 2012).

These neutrons can go on to split other nuclei. For this sequence to become a self-sustaining chain reaction, however, the ratio of U_{235} atoms must be increased: natural uranium must be enriched.[29] If you want to make an atomic bomb, you need 90% U_{235}. If you want to fuel a reactor, you can settle for 3.5% enrichment. The same plant churns out bomb and reactor fuel – the difference lies in how long the uranium feed stays in the circuit.

Preparing the feed for enrichment plants required many steps. Ore extracted from the Mounana deposits was milled at the COMUF, then shipped to France. There it passed through three different plants for additional preparation, before finally entering the enrichment plant in gas form. Each of these stages produced tailings – unwanted material whose uranium content wasn't high enough to merit further processing. Waste.

Uranium enrichment plants are huge, complex, delicate, and expensive. France's plant at Pierrelatte was devoted exclusively to making military fuel. It came online in 1967, after seven years of construction. Smooth operation required controlling impurities in the feed. At each stage of preparation, engineers took samples to ensure they met specs. This included checking the feed's isotopic composition, a routine test because – as everyone knew – the proportion of U_{235} isotope in ore was a constant. 0.7202%.

Until it wasn't. One day in May 1972, Pierrelatte engineers discovered a batch of feed with less U_{235} than normal, clocking in at 0.7171%. The discrepancy was big enough to pose both technological and financial problems. Flustered, they ran another sample: 0.7088%. Worse.[30]

At first, engineers suspected the batch had become contaminated with tailings during one of the preparation stages. Such a mistake could have geopolitical consequences. The CEA sent uranium destined for civilian purposes to the USSR for enrichment. Using Soviet enrichment services made France less vulnerable to US technological dominance while it spun up another enrichment plant to make civilian fuel.[31] The Soviets would certainly discover the depleted feed. They would be extremely unhappy if they suspected the French of trickery.

Tracing the chain of custody, however, demonstrated that the depleted uranium came from Gabon. Further investigation revealed that Mounana's Oklo deposit had been delivering depleted ore since it opened in 1970. In one core sample, the U_{235} proportion sank to an astonishing 0.44%.[32] To grasp the profound weirdness of this result, listen to radiochemist and Manhattan Project veteran George Cowan, who wrote about it for *Scientific American*:

---

[29] It is possible to create self-sustaining fission reactions with natural uranium – Canada's heavy water reactors and France's gas-graphite reactors operated with unenriched uranium – but since the 1970s, most nuclear power plants operate with enriched uranium.

[30] H. Bouzigues et al., "Contribution à la solution d'une énigme scientifique," IAEA-SM-204/36 in *The Oklo Phenomenon* (Vienna, 1975): 237-243.

[31] Gabrielle Hecht, *The Radiance of France: Nuclear Power and National Identity after World War II* (Cambridge: MIT Press, 1998, 2nd edition 2009).

[32] Roger Naudet, *Oklo: des réacteurs nucléaires fossils. Étude physique*. (Paris: Eyrolles, 1991).

> The isotopic composition of uranium is thought to be *a constant of the solar system* in any one era…. Chemical processes can make one region rich in uranium and leave another region poor; that is how the deposit at Oklo was formed. U-235 and U-238, however, are virtually indistinguishable chemically.... Indeed, the difficulty of separating the isotopes is attested to by the size and complexity of uranium enrichment plants such as those at Pierrelatte…. *There seemed to be no plausible mechanism in nature […to explain] the depleted ore*.[33]

As far as anyone knew, the only sources of depleted uranium *in the entire solar system* were human-made waste: spent reactor fuel or enrichment tailings. What could possibly account for its presence in a Precambrian rock formation in eastern Gabon?

Investigators finally settled on an explanation. The depleted uranium resulted from a series of self-sustaining fission reactions almost 2 billion years ago. (That's half our planet's lifetime.) Way back then, uranium had a different isotopic ratio. This was because U_{235} decayed faster than U_{238}. When the planet first formed, its uranium contained 17% U_{235}. By the time the Oklo deposit formed, this ratio had dropped to 3%, roughly the proportion required by most nuclear power plants. Other aspects of the geologic environment – the presence of water, the thickness and density of the uranium deposit – made conditions propitious for self-sustaining chain reactions. These had taken place in the rock bed, off and on, over a period of two million years. In September 1972, CEA experts announced their stunning conclusions to the Academy of Science in Paris: nature had made nuclear reactors nearly two billion years before humans.[34] Fission in these "natural reactors" had depleted the uranium.

Diplomatic disaster averted. But trouble now loomed on another scale. Seven hundred tons of Oklo ore had already entered the fuel cycle, and there was more to come. Because the depleted ore wasn't usable in *human*-made reactors,[35] the COMUF viewed it as waste. But it still had to be removed to reach the rich veins of marketable ore underneath, upon which the company had banked its future. Removing depleted ore cost just as much as extracting valuable ore, threatening the COMUF with bankruptcy.[36]

And there was another problem. For geologists, radiochemists, and nuclear physicists, the remaining rock formation housed *fossilized* reactors. These fossils were their interscalar vehicles into the planet's past, and they desperately wanted to keep the formation intact in order to better study it. Nature was no longer cheap. Scientific value challenged economic value. Atomic and geological action threatened international reaction. Values and scales crashed into each other.

---

[33] George A. Cowan, "A Natural Fission Reactor," *Scientific American* (July 1976): 36-47, emphasis mine.

[34] R. Bodu et al., "Sur l'existence d'anomalies isotopiques rencontrées dans l'uranium du Gabon," *C. R. Acad. Sci*., Paris, 275D (1972), p. 1731 ; M. Neuilly et al., "Sur l'existence dans un passé reculé d'une réaction en chaîne naturelle de fissions, dans le gisement d'uranium d'Oklo (Gabon)," *C. R. Acad. Sci*., Paris, 275D (1972), p. 1847.

[35] More precisely, it would have required a much longer enrichment time to be made usable – and also a finely tailed process, since the depletion levels varied throughout the ore body. Enriching this ore to suitable levels would thus have been exorbitantly expensive.

[36] Naudet, *Oklo*, pp. ix-xiv. On the bankruptcy threat, see Hecht, *Being Nuclear*.

La Françafrique in action

State-supported capitalism — both French and Gabonese — averted wreckage from the crash. In 1972, the French state (via the CEA) was the COMUF's primary shareholder and its sole customer. But the CEA also conducted France's nuclear research. So while one division wanted to normalize its ore supply, another lobbied for preserving the fossilized reactors. In order to satisfy both constituencies, the CEA agreed to purchase the depleted ore – at a discounted price – for use as research material. This persuaded the COMUF to leave the Oklo ore body intact for a few more years.

Meanwhile, the CEA sought support for the research from President Albert-Bernard [Omar] Bongo.[37] Defying colonial-era corporate claims, the Gabonese leader had begun to advocate postcolonial sovereignty over natural resources. He also demanded that the COMUF honor its promises to bring modernity to eastern Gabon, notably by building better housing for its employees. So getting Bongo on board was crucial. By 1974, the COMUF had agreed to build the housing development pictured at the start of this essay (Fig. 1). It also accepted a capital infusion from the state, in return for giving Gabon 25% ownership in the company.[38]

Moreover, Bongo agreed to help fund a symposium on "the Oklo Phenomenon." Cosponsored by the International Atomic Energy Agency and the CEA, the conference took place in June 1975 in Libreville, Gabon's capital. Eager for validation of their bizarre conclusions, CEA scientists had shared Oklo samples with colleagues in the US, the Soviet Union, and elsewhere. The conference offered an occasion for seventy-four experts from nineteen countries to discuss their initial results.

The conference began with a trip to Mounana to see the phenomenon. Attendees traipsed to the rock face, where COMUF employees outlined the traces of the fossilized reactors. Hardly a spectacular sight, but attendees were happy to see for themselves, and to pick up a souvenir specimen *in situ*. Plus, who didn't enjoy a little pomp and circumstance? A stage in the middle of the pit, complete with palm fronds, featured speeches by "Gabonese notables," performing the national scale and reminding visitors whose territory housed the discovery.[39]

Scientists then repaired to Libreville to present their findings. Some found the conference setting surprisingly splendid: a luxury hotel, a restaurant supplied by food and wine flown in from France. George Cowan — who by then had become the director of radiochemistry research at Los Alamos, the US's premier nuclear weapons lab — reported on a lavish reception that Bongo hosted at his residence:

---

[37] Naudet, *Oklo*, p. x.

[38] This resource sovereignty story is contextualized and treated at greater length in Hecht, *Being Nuclear.*

[39] George A. Cowan, *Manhattan Project to the Santa Fe Institute* (Albuquerque: University of New Mexico Press, 2010)

> We were serenaded by an orchestra, the all-male musicians dressed semi-formally. Then the dancing began. One of the attractive native female employees from the French Embassy asked me to dance. I couldn't resist a Viennese waltz and did a few turns. The wine and toasting continued until midnight. Suddenly the musicians stripped down to loincloths and began to play wild "jungle" music dominated by percussion. The lovely French Embassy females reappeared wearing only native skirts and gyrating to the new tempo. One of them grabbed my hand and pulled me onto the dance floor. I clumsily tried to hold the deafening beat.[40]

This too was *la Françafrique* in action, with Bongo and French officials shamelessly catering to visitors' expectations of exoticism. There is no record of how embassy employees – presumably professionally trained clerical staff — felt about dancing topless with middle-aged white foreigners. Nor do we know how the five female scientists from France responded to the spectacle.

Scalar collapse

When French experts first released their conclusions, they had been greeted with skepticism. The prospect of prehistoric reactors sounded like science fiction. Journalists speculated that ancient aliens accounted for the phenomenon. Many in the international scientific community also expressed doubts. But for Japanese-born chemist Paul Kazuo Kuroda, the discovery was a vindication.

Kuroda had trained as a nuclear chemist at the Imperial University of Tokyo, joining the faculty there in 1944. Despite a ban on radiochemistry research by the American occupation forces, Kuroda pursued this work after the war. In 1949 he sailed to the US in search of research collaborations, only to discover that his nationality excluded him from projects with security ramifications. He eventually joined the faculty at the University of Arkansas, where his research led him to predict the existence of natural nuclear reactors in 1956.[41] He'd been dismissed as a crackpot. "Scientists were saying that if this idiot is an indication of the program" at Arkansas, he later wrote, "there must be nothing there at all."[42] The Oklo discovery changed everything: Kuroda went from eccentric to prophet overnight.

Kuroda's paper in Libreville used evidence from Oklo to hypothesize about the origins of the earth's elements. He first began to speculate about natural nuclear reactors in the earth's

---

[40] Cowan, *Manhattan Project to the Santa Fe Institute,* Kindle Locations 1029-1035.

[41] P. K. Kuroda, *J. Chem Phys.* 25 (1956): 781. Kuroda wasn't the first to make this hypothesis; as precedent, he cites G. W. Wetherill and M. G. Ingram in *Proceedings of the Conference on "Nuclear Processes in Geologic Settings,"* Williams Bay, Wis., Sept. 21-23 (1953): 30.

[42] Quoted in April M. Robertson, "Paul Kazuo Kuroda (1917-2001)," *Encyclopedia of Arkansas* (2011). Accessed 1/18/16 on http://www.encyclopediaofarkansas.net/encyclopedia/entry-detail.aspx?entryID=6619.

early history "one day in August 1945, while standing in the ruins of Hiroshima."[43] He would invoke this moment repeatedly in later publications, writing that he "became overwhelmed by the power of nuclear energy…The sight before my eyes was just like the end of the world, but I also felt that the beginning of the world may have been just like this. Would it not be possible that nuclear chain reactions occurred on the earth then?"[44] The Oklo find validated his prediction, and Kuroda boldly spun out its cosmological implications. Over the course of time, he speculated, the ancient fission reactions "could've been one of the most important factors in creating mountains and continents thousands of feet below the surface."[45] Indeed, his calculations suggested that the solar system itself was much older than scientists had previously thought.[46]

Kuroda's strategies for positioning himself and his work collapsed time scales. All of terrestrial time could be expressed in a single, atom-splitting moment. Placing himself in post-bomb Hiroshima, at the birth of nuclear exceptionalism, Kuroda introduced geopolitics, pain, and redemption into texts that were otherwise filled with equations and tables. He also laid claim to a special experience: Japanese scientists might not have designed the atomic bomb, but witnessing its effects firsthand brought unique insight, not merely into the potential for apocalyptic future, but also into the deep cosmological past. Kuroda's rendition used the bomb itself as an interscalar vehicle.

Contemplating the Libreville conference today, the bomb as interscalar vehicle bridges space as well as time — and with no small measure of irony. For Kuroda did not attend the conference personally. Instead, his paper was presented by George Cowan, the Manhattan Project veteran and Los Alamos radiochemist. The two men had probably met over their shared interest in radioactive fallout. Cowan had spent years tracking fallout patterns from US nuclear weapons tests. Kuroda, meanwhile, had studied fallout from China's 1965 atomic test, which he'd compared to the probable fallout path of the first-ever atomic explosion at Alamogordo. The bomb that Cowan had worked on. The explosion that preceded Hiroshima. The event that some use to mark the official start of the Anthropocene.

Oklo rocks also served as interscalar vehicles into the far future. One of the strangest aspects of the phenomenon: many of the fission products from these ancient chain reactions had moved very little, if at all. This relative immobility sparked a question. Could Oklo serve as a "natural analogue" for geological storage, shedding light on how buried nuclear waste would behave over the very long term?

Geologists and nuclear power advocates around the world got excited. Waste from weapons manufacturing and power plants was mounting. Activists argued that in the absence

---

[43] P. K. Kuroda, "Fossil nuclear reactor and Plutonium-244 in the early history of the solar system," IAEA-SM-204/4 in *The Oklo Phenomenon* (Vienna, 1975): 479-487.

[44] P. K. Kuroda, *The Origins of Chemical Elements and the Oklo Phenomenon* (New York: Springer-Verlag, 1982), p. 2-3.

[45] April M. Robertson, "Paul Kazuo Kuroda (1917-2001)," *The Encyclopedia of Arkansas History and Culture*, posted 9/13/2011 on http://www.encyclopediaofarkansas.net/encyclopedia/entry-detail.aspx?entryID=6619.

[46] Kuroda, *Origins of Chemical Elements*, chapters 5 and 6.

of storage solutions, nuclear power development should stop. Some of the waste would remain dangerously radioactive for tens of thousands of years – a time scale far beyond human engineering capacity. Sealing the waste in airtight vessels seemed like an obvious first step, but it was equally evident that "no man-made container [could] last indefinitely."[47] What would happen after the canisters cracked? How far would their contents travel? In grappling with such questions, "the most striking fact concerning the Oklo phenomenon is that nature successfully managed to store as much as 10 metric tons of fission products in the ground for two billion years."[48] Many of Oklo's fission products were also found in human-made nuclear waste. Maybe this remote part of Gabon could help solve the "wicked problem" of nuclear waste disposal? Several papers in Libreville explored this possibility.

Oklo-as-natural-analogue also entailed strategic scalar collapse. But while Kuroda sought a window onto the deep *past* in order to understand the origins of the solar system, other geologists and chemists saw that past as a window onto the far *future*. Making that future knowable could legitimate a technopolitical *present* powered by nuclear energy.

Experts emerged energized from the Libreville conference, ready to plunge into more research. Gabon's newly appointed minister of scientific research vocally supported the prospect of Gabon becoming a destination for cutting-edge research.[49] But scientists had forgotten that their research material was in an active mine. With a heavy heart, the CEA's Roger Naudet reminded them that the party was over. The COMUF had already sacrificed profits by postponing extraction for three years, but now operations had to resume. Today, his rueful words read like an Anthropocene lament:

> The place we saw during the beautiful inaugural ceremony will remain a memory without a future. These extraordinary 'fossilized reactors,' the likes of which we will doubtless never find again, and about which we still have so much to learn, will be irremediably destroyed.[50]

The COMUF did destroy the Oklo reactors in the course of mining. But research continued, thanks to the thousands of core samples taken in those early years. De-situated samples became a metonym for de-situated science: the IAEA's second conference on the subject was held in Paris, not Libreville. Naudet eventually produced a 700-page textbook on Oklo. Two other fossilized reactor zones were later found, both near Oklo; none have been found outside

[47] R. D. Walton, Jr. & G. A. Cowan, "Relevance of Nuclide Migration at Oklo to the Problem of Geologic Storage of Radioactive Waste," IAEA-SM-204/1 in *The Oklo Phenomenon* (Vienna, 1975): 499-507.

[48] Walton & Cowan, "Relevance of Nuclide Migration at Oklo."

[49] F. Owono-Nguema in "Table ronde sur l'avenir des recherches," *The Oklo Phenomenon* (Vienna, 1975): 633.

[50] R. Naudet in "Table ronde sur l'avenir des recherches," *The Oklo Phenomenon* (Vienna, 1975): 631.

Gabon.[51] Meanwhile, "natural analogues" became an important tool for research into geological burial of radioactive waste.[52]

Taking the narrative in any of these directions would keep us in the Anthropocene, but make us lose our grounding in Africa. In our eagerness to think with the Anthropocene — to probe the deep past and the far future — we mustn't forget about the (relative) present, the recent past, and the near future. Not to mention the people who actually inhabited the area. So instead, let's conclude our story by staying in Gabon, and sticking with the rocks themselves as our primary interscalar vehicle.

Valuing slow violence (part 2)

For local residents, the fossilized reactors produced different scalar dynamics, in which violence remained central. Consider this remark from Dominique Oyingha, an elected official who'd grown up in the area and whose brother worked for the COMUF:

> The whole village washed themselves at Okeloleni, drank at Okeloleni. That place where we drank and washed, there was an atomic reactor….[Many people died, and] we knew it wasn't normal…At the time, people accused each other of witchcraft….Only when the COMUF did its mining did we see that we really were in danger-danger.[53]

There are several ways to interpret Oyingha's comment. We could conclude that when locals learned that their area had housed fossilized reactors since time immemorial, they transferred their explanations for low fertility and short lifespans from each other to the rocks. That's what company managers did, when—under pressure from local officials—they commissioned a study of radiation levels around Mounana in 1986. The study took great pains to establish "background levels," radiation present before mining began – a dubious exercise at best, given that extraction had begun in 1959. [54]

Unsurprisingly, these levels were high. Defining them as "background," however, meant they could be dismissed as having "always" been present. Nature, not the company, was to blame for abnormal demographic and health patterns. In French regulatory schemes, only exposure over the background level counted toward a person's dose. And there were no

---

[51] J. Janeczek, "Mineralogy and geochemistry of natural fission reactors in Gabon," in P. C. Burns and R. Finch, eds., *Uranium: Mineralogy, Geochemistry and the Environment: Mineralogical Society of American Review in Mineralogy*, v. 38 (1999): 321-391; K. A. Jensen and R. C. Ewing, "The Okélobondo natural fission reactor, southeast Gabon: Geology, mineralogy, and retardation of nuclear-reaction products," *GSA Bulletin* (Jan. 2001), 113 (1): 32-62. My thanks to Rodney Ewing for these references.

[52] For example: William Miller et al., *Geological Disposal of Radioactive Wastes and Natural Analogues: Lessons from Nature and Archaeology* (Pergamon, 2000) and Ardyth M. Simmons and John S. Stuckless, "Analogues to Features and Processes of a High-Level Radioactive Waste Repository Proposed for Yucca Mountain, Nevada," Professional Paper 1779 (Reston, Virginia: US Geological Survey, 2010).

[53] Author interview with Dominique Oyingha, July 1998, Mounana, Gabon.

[54] N. Fourcade to V. Jug, 20.2.87, Objet: État radiologique site de COMUF/Mounana, Envoi de rapport. COMUF archives. UF/DT-n. 29-VJ/JM, V. Jug to H. Basset, 9 mars 1987, Objet: COMUF/État radiologique site de Mounana. COMUF archives.

Gabonese health data from before mining, no demographic background against which abnormal outcomes could be formally compared: in short, no control groups.

Another way to read Oyingha's comment would be to focus on the last phrase: *Only when the COMUF did its mining did we see that we really were in danger-danger*. Oyingha himself had become suspicious early on. His brother Marcel Lekonaguia worked at the COMUF; we met him a few pages back, when he described the dust produced by blasting. In the late 1960s, Oyingha took his brother to the Congo, where another uranium mine had recently shut down. Doctors there confirmed the brothers' sense that dust inhalation accounted for the respiratory trouble, and that uranium exposure presented special health dangers. But when the two men returned to Mounana and confronted the mine doctor, they were met with scorn. "Are you crazy? ...Who told you that uranium made people sick?" Oyingha laughed as he remembered this response. He respected the doctor, whose hospital offered free medical care to everyone in the region. But he did not really expect acknowledgement of occupational disease. The brothers eventually obtained a leave of absence for Lekonaguia to recover a bit – but no etiology, not even a diagnosis, and certainly no compensation.[55]

Danger-danger had many sources, as locals knew all too well. Wastewater from mining and milling flowed into local rivers, where women soaked their manioc (a regional staple that required prolonged immersion to become edible). In 1983, locals filed an official complaint with the provincial government: alarming numbers of dead fish were appearing, residents worried "that their lives [were] in danger," and monitoring and medical care did not adequately address these problems. Disputing these assertions, management insisted that the real problem was that villagers who didn't work for the COMUF – and therefore didn't live in the company town – wanted access to the same benefits. Responsibility for potable running water belonged to the state, but if the company "made an effort" anyway, it would "certainly circumvent many of the complaints."[56] The fundamental dynamics of the Anthropocene played out once again, as management touted small-scale modernity to elide large-scale waste-making.

International standard practice dictated that mine waste should be treated or contained. Increasing scrutiny certainly made it necessary to do *something*. Managers decided to proceed in stages, "depending on [external] pressure." Dreading "heavy maintenance and surveillance obligations if Gabonese regulations eventually came close to those…in Europe,"[57] the company reluctantly built a tailings dam to contain the waste in 1990 – three decades after operations began. When I visited eight years later, I saw no warning signs. Both the (French) associate director of the mine and the (Gabonese) operator who toured me around the plant insisted that children "just knew" to stay away from the tailings.

---

[55] Author interviews with Dominique Oyingha and Marcel Lekonaguia, July 1998, Mounana, Gabon.

[56] Martin Magnana (Gouverneur de la Province du Haut-Ogooué) to Directeur Général de la COMUF, 11 avril 1983, n. 231 PHO/CAB and Note de renseignements n. 15 du 7/04/1983. COMUF archives.

[57] V. Jug to J. Moine, 28.5.86. Also V. Jug, "Dispositions prévues en vue de la protection de l'environnement, » 25.3.85 and VJ/MJM, « Traitement des eaux d'exhaure mines » and « Etapes de mise en place du traitement des effluents usine, » 25 mars 1985. COMUF archives.

Mining ceased in 1999. With few prospects of salaried employment, COMUF veterans focused on the wasting of their land and their bodies. Many remained convinced that mining accounted for their ill health. But could they prove it? Could they hold the company accountable?

To answer these questions, Mounana residents engaged in their own politics of scale. They reached north, beyond national territory, to NGOs in Niger and France that advocated on behalf of sick uranium workers. Joining forces, these groups sent a small group of scientists, doctors, and lawyers to investigate in 2006. The team took independent environmental readings and interviewed nearly 500 COMUF veterans.

The resulting report testified to toxic contamination. Protective gear had not been mandatory. Work clothing got washed at home. "We were so unaware of the risks that we smoked and ate at the workplace, and since we never wore protective gloves, we ate and inhaled whatever was on our hands and in the air." Employees did not receive reports of their radiation exposures. The Gabonese state had performed no inspections. Company clinicians had no training in uranium-related occupational health, no access to dosimetric readings. The report estimated that the COMUF had generated over seven million tons of waste: some dumped directly into rivers, some buried under a thin layer of dirt, and some piled in the tailings pond.[58]

And some of the waste rock was used to build the well-ordered houses in the photograph that launched this essay – as well as the marketplace, the maternity clinic, and the school. The problem? Although revalued as construction gravel, the rock was not devoid of uranium. Nor was this uranium inert on the atomic scale. It decayed. Many buildings had radon levels well over internationally recommended limits.

The materials of modernity had become instruments of slow violence. Shelter turned into toxic infrastructure. Behold an African Anthropocene.

An African Anthropocene

Toxic infrastructures are hardly unique to Africa. Radioactive houses aren't even unique to Gabon. At the very moment of Mounana's erection as a model of modernity in the 1970s, one-third of the houses in Grand Junction, Colorado were being slated for demolition or remediation. Built with tailings from the uranium mills that powered that town's growth in the 1950s, they too were bursting with radon. Nor was Grand Junction alone. Ninety miles further south, some homes in Uravan had radon levels over 700 times regulatory limits. In 1975, a survey demanded by the Navajo Tribal Council found radioactive buildings strung out from Shiprock to Tuba City.

[58] Samira Daoud and Jean-Pierre Getti, "Areva au Gabon: Rapport d'enquête sur la situation des travailleurs de la COMUF, filiale gabonaise du groupe Areva-Cogéma." Sherpa, 4 avril 2007 (quote on p. 7).

Some observers might be tempted to conclude that this shocking simultaneity represents another example of how "Africa" lags "behind." That would be wrong. If anything lags in this story, it's the mining company, which ignored the drama unfolding across the Colorado Plateau. Or perhaps managers were simply ignorant. Neither archives nor interviews offer an answer. And while Grand Junction and a few other towns have undergone Superfund remediation, contamination of the Navajo Nation's water supply by abandoned uranium (and coal) mines continues. All too often, we witness the triumph of capitalism-plus-colonialism (perhaps the deadliest combination of -isms in human history). All too often, knowledge fails to travel, or to stick…or, quite simply, to matter. As other historians have also shown, pollution *despite* knowledge is a central dynamic of our time.[59]

So the simultaneity should serve instead as a sentinel: an indicator of the inequalities that underpin the making of modernity at every scale. Free building materials (recycled waste) enabled the COMUF to enact the state's development ambitions, while providing water services deferred protests about pollution. Precisely *because* Gabonese regulations were not up to European standards, the mine could avoid "heavy maintenance and surveillance obligations" that would drive up its costs. The uranium that it churned out for four decades fed the motors of metropolitan modernity, enabling France to become the largest per capita producer of nuclear power in the world.

Into this sadly familiar story came the fossilized reactors. At Oklo, geology and capital came together with special force. The discovery occurred at the spatial and temporal confluence of capital and colonialism, nationalism and nuclearity. Driving the phenomenon was an utterly *non*-human agency, simultaneously geological and atomic, accomplishing something that humans, in their infinite hubris, had believed only they could do. Yet the discovery also underscores the power of *human* agency (geological and atomic). Oklo encapsulates the terrifying scalar collapses and explosions of which we've become capable. Precambrian rock took two million years to generate the materials that a human-built nuclear reactor can pump out in one. Now there's a scale for Anthropocenic acceleration: 2,000,000:1.

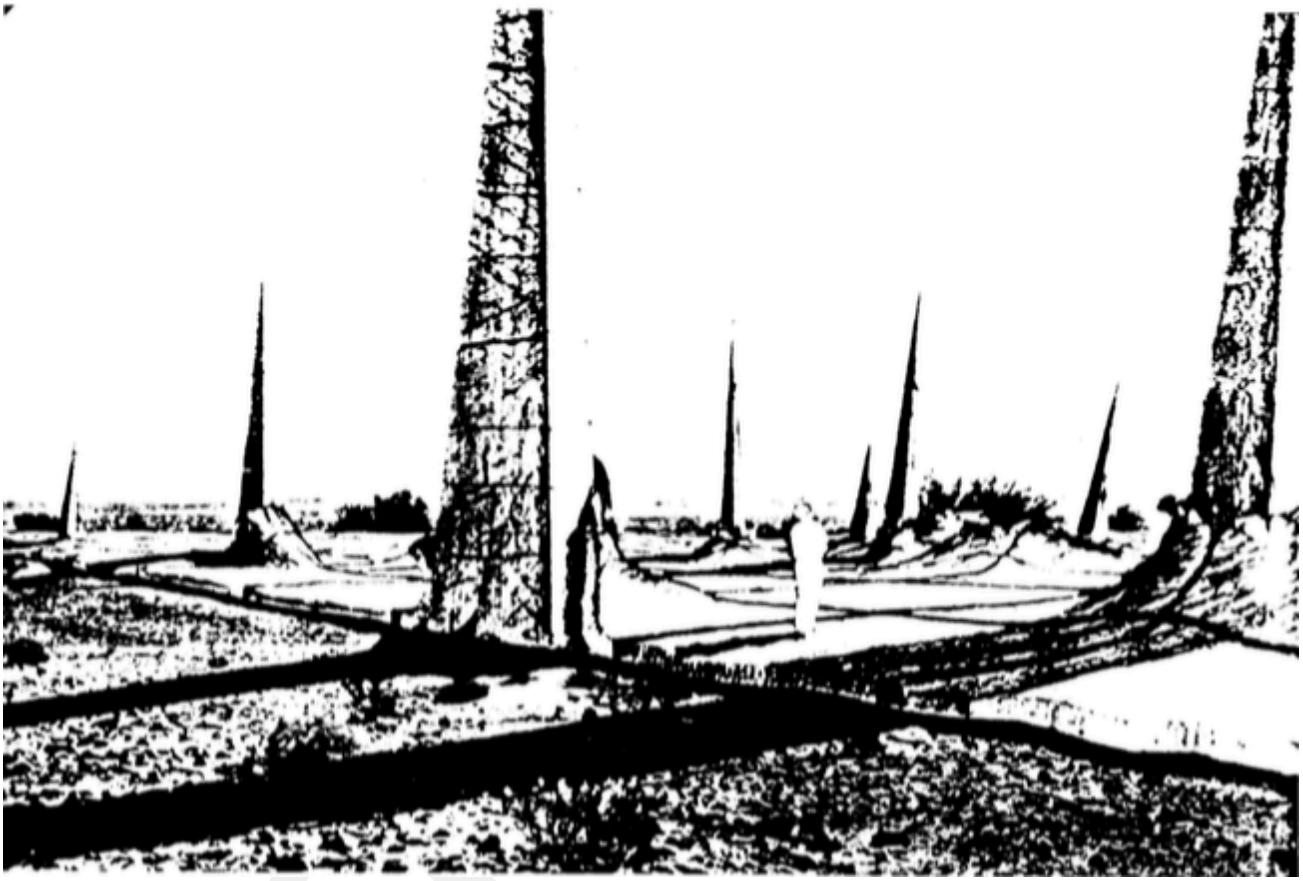
Like all earthly materials, those that power such acceleration do not disappear – not even when they explode. They change form and scale, but they're still there, some more noxious than ever for our species (and others). Cast as natural analogue, Oklo had value for thinking about that problem, though not for solving it. Studying the path of its fission products made for fascinating science, but the analogy had serious limits: the sites under consideration as waste repositories had very different geological properties. When it came to nuclear waste planning, Oklo offered a research paradigm, but not a solution.

Managing temporal excess is a major concern for those seeking a solution for nuclear waste burial. It's not just that 10,000 years (or longer – plutonium's half-life is 24,000 years) exceeds human *design* horizons. That sort of time scale exceeds human *language* horizons.

---

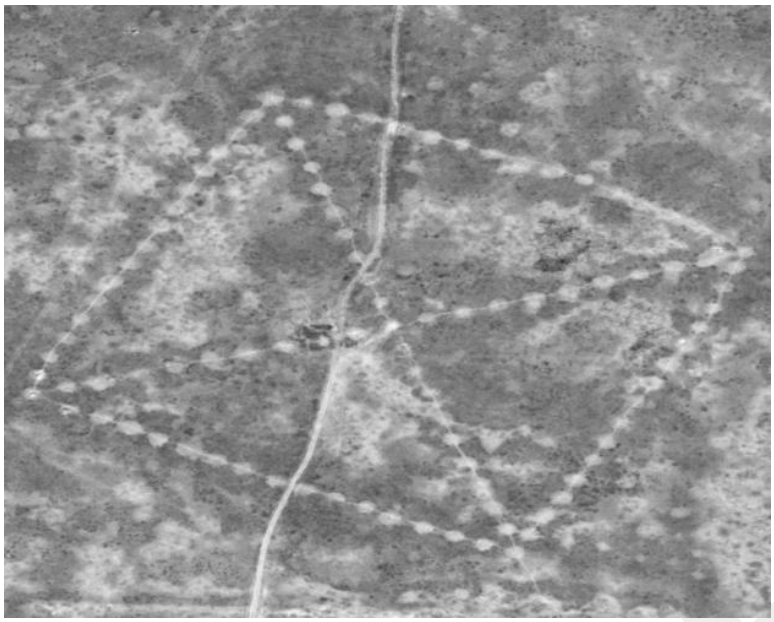
[59] Soraya Boudia and Nathalie Jas, eds., *Powerless Science? Science and Politics in a Toxic World* (New York: Bergahn Books, 2014); Fabien Locher & Jean-Baptiste Fressoz, "Modernity's Frail Climate: A Climate History of Environmental Reflexivity," *Critical Inquiry* 38 (Spring 2012): 579-598; Bonneuil & Fressoz, *L'événement anthropocène*; Hecht, *Being Nuclear*.

How to make waste repositories legible to humans millennia in the future? How to prevent our descendants from digging into these sites for resources? Such projection into the future doesn't just require reckoning with geology; it also requires reckoning with representation. Attempts to address such questions have involved anthropologists, archaeologists, philosophers, artists, and linguists. Interdisciplinary committees have imagined two- and three- dimensional signage to warn "future generations," the most famous of which is this field of thorns:



A Warning for Future Generations. Spikes Bursting Through Grid (concept by Michael Brill and art by Safdar Abidi, part of the field of thorns series). From Kathleen M. Trauth, Stephen C. Hora, and Robert V. Guzowski, "Expert Judgment on Markers to Deter Inadvertent Human Intrusion into the Waste Isolation Pilot Plant," Sandia Report SAND92-1382, November 1993.

Inevitably in such discussions, someone invokes the Giza pyramids to demonstrate that taboos against plunder stop working after a while. Of course, memory had some continuity around Giza; locals knew the structures contained treasures. So instead, consider the 8000-year-old geoglyphs recently discovered on the steppes of Kazakhstan. Today, their patterns are only visible from space, in satellite imagery.



Geoglyphs in Kazakhstan. NASA.

Archaeologists assume that nomads made these colossal earthworks, but can only guess at their purpose. Were the geoglyphs an early form of media? Did they contain a message? We'll never know.

Most of those tasked with communicating with "future generations" have the best of intentions. They have to try; they have to hope. What else is there? But let's face it: any warning signs they imagine are more reliably read as technopolitical signifiers in the present (look! we've figured out how to talk to our millennial descendants, so it's okay to bury the waste!) than as effective media for the far future.

Meanwhile, seeing the Anthropocene from Africa forces us to consider present-day signage. A scandal broke out in French and Gabonese media over Mounana's radioactive buildings. In response, Areva (the corporation that took over France's nuclear fuel cycle early this century) reached a deal with the NGOs that commissioned the study. A "health observatory" would be created to monitor the situation, governed by a stakeholder commission. Former workers would be tested, and those found to have occupational disease would receive treatment and compensation. The most heavily contaminated buildings would be demolished, and new dwellings built. And signs would be posted. One showed a woman with a basket of manioc on her back, squatting by the river, a red diagonal line crossing the pictogram: no soaking. Others

consisted only of spray-painted letters indicating which buildings were slated for demolition. The ephemerality of such signage did not match the endurance of the contamination.

Contaminated house in Mounana, Gabon, 2009. The letters indicate that it's slated for demolition.

Nor did the reality of remediation match its promises. Areva certainly claims to have accomplished the mission, calling the COMUF "the first rehabilitated uranium site in central Africa."[60] Production facilities have been dismantled. But further action has lagged. The construction of replacement dwellings is slated to begin in 2016 – nearly a decade after the

[60] "COMUF, premier site uranifère réaménagé d'Afrique centrale." http://www.areva.com/FR/activites-604/comuf-premier-site-uranifere-reamenage-d-afrique-centrale.html, accessed 28 January 2016.

alarm was sounded. A map of contaminated areas – in Areva's words, "zones with usage restrictions" — was drafted in late 2015.[61]

Most significant of all: Since the establishment of the health observatory in 2010, no one in Mounana has been deemed to suffer from uranium-related illness. The lack of a cancer registry makes statistical demonstration of disease incidence impossible. (How do you prove work caused excess illness if you don't know the baseline?) The clinic does not have adequate access to equipment or resources. After a protracted legal battle in France, the families of two former French employees who died of cancer have received compensation. So far, however, not a single Gabonese veteran of the COMUF can say the same.

Fed up, former workers obtained an audience with their prime minister in January 2016.[62] Their first attempt to rescale their claims had bypassed the national level because Gabon's government had consistently favored *la Françafrique* over its own citizens. It remains to be seen whether this new rescaling attempt will have a different outcome.[63]

Extraction (of all kinds) has powered the large-scale rearrangement of substances that constitutes the Anthropocene. But to see beyond that generality – and beyond an equation of earthly materials with raw materials — we need to grapple with particularity. Thinking with the Anthropocene expands our vision of time and space. Thinking with an *African* Anthropocene helps us remember moments and places. It reminds us of who pays the price for humanity's planetary footprints.

In closing, a plea: Don't read this narrative as a uniquely nuclear fable. While radioactive rocks have properties that make them particularly propitious interscalar vehicles, they are far from the only candidates. Carbon molecules, gut bacteria, insecticides… the possibilities are endless. What makes something an interscalar vehicle is not its essence but its deployment, its potential to open our imaginations. In his eloquent elegy for the human species, Roy Scranton identifies the central mission of humanistic inquiry in the Anthropocene: to "practice and cultivate understanding the intimate, necessary connection of all things to each other."[64] Interscalar vehicles can help us do that, even as we race towards extinction.

---

[61] Areva press release, 24 November 2015. http://www.areva.com/FR/actualites-10682/deuxime-clis-mounana-en-2015.html, accessed 28 January 2016.

[62] "Litige contre Areva: les ex-employés de la Comuf sollicitent l'intervention de la primature," *Le Nouveau Gabon*, 27 January 2016. http://www.lenouveaugabon.com/sante/2701-9867-litige-contre-areva-les-ex-employes-de-la-comuf-sollicitent-l-intervention-de-la-primature.

[63] Things don't look promising. A post on Gabon's Ministry of Mines and Industry website from 13 October 2015 focuses primarily on prospects for new mines. Its discussion of health and environmental consequences is a nearly perfect echo of Areva's: remediation accomplished, monitoring ongoing, no problems to report. http://www.mines.gouv.ga/9-actualites/1501-uranium-de-mounana-des-indices-encourageants-pour-les-activites-de-la-comuf-/ accessed 28 January 2016.

[64] Roy Scranton, *Learning to Die in the Anthropocene* (City Lights Books, 2015): 117.