RARE/EARTH
The Geopolitics of Critical Minerals and the AI Supply Chain

Institute for Advanced Study
Wolfensohn Hall
June 2, 2025

Opening Remarks
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As prepared for delivery.

Good afternoon, I am Alondra Nelson, the Harold F. Linder Professor here at the Institute for Advanced Science, in the School of Social Science, where I lead the Science, Technology, and Social Values Lab.

Welcome to a discussion about the hidden architecture of artificial intelligence—one that stretches from environmental degradation and copper mining in Chile to the lithium extraction sites of Central Africa and well beyond. We are here to discuss the intersections of artificial intelligence, critical minerals, and the geopolitics connecting data centers in Virginia to cobalt mines in the Democratic Republic of Congo—connections that many of us, until recently, never thought to make, and that scholars must do much more to understand.

AI, critical minerals, geopolitics. These are the themes of a workshop getting underway here tomorrow, bringing together researchers from academia, civil society, and policy, experts who have spent years studying the social and political implications of mining alongside those who dissect the intricacies of AI and technology's place in society.

This convening emerges from research I've been conducting with Dr. Tatiana Carayannis and Marie-Therese Png over the last year. I thank them both for their collaboration on this research and on the workshop planning.

I want to recognize the nearly two dozen colleagues who have traveled here for this workshop or who bring to our meeting knowledge of these dynamics in the United Kingdom, Taiwan, Malaysia, Central Africa including the Democratic Republic of Congo, in Latin America, including Ecuador, Chile, and Colombia, and across the United States. Before we proceed, let me acknowledge the support of the organizations that made this research and this meeting possible: the Ford Foundation, the Heising-Simons Foundation, and the Nelson Center for Collaborative Research here at the Institute for Advanced Study.

Whenever I speak of AI, I offer this working definition adapted from the Organisation for Economic Co-operation and Development (OECD): a machine-based system that infers, from the input it receives, how to generate outputs including "predictions," recommendations, decision-making suggestions, content such as text, images, and sound, and forms of so-called "reasoning." AI systems vary in their levels of autonomy and adaptiveness after deployment; some are static, others iterative.

When we turn to critical minerals, we encounter another kind of definitional challenge. Governments regularly revise their critical minerals lists based on changing geopolitical circumstances, supply vulnerabilities, and technological needs. Critical mineral classifications vary, with different countries and government agencies developing their own criteria, resulting in multiple, often conflicting lists of what materials are deemed essential. This definitional flexibility is itself illuminating—it reveals that what counts as "critical" depends entirely on who is doing the counting, what they're counting toward, and how global power dynamics shift their strategic calculations.

What we do know is this: the materials essential for AI infrastructure—copper, lithium, cobalt, gallium, and a host of rare earths elements—are increasingly the subject of what political scientists Henry Farrell and Abraham Newman call "weaponized interdependence."[1] That is, countries are discovering that their control over critical resources can be wielded as instruments of geopolitical influence, turning economic dependencies into tools of statecraft, levers in trade wars, and weapons of national security.

[1] Henry Farrell and Abraham L. Newman, "Weaponized Interdependence: How Global Economic Networks Shape State Coercion," *International Security* 44, no. 1 (2019): 42–79, https://doi.org/10.1162/isec_a_00351.

This contemporary dynamic recalls political economist and IAS School of Social Science faculty member Albert Hirschman's insight in his book, *National Power and the Structure of Foreign Trade* about how trade dependence can become political leverage —the notion that asymmetric economic relationships create opportunities for influence that extend far beyond commerce itself.[2] Nations that once seemed peripheral to cutting-edge technological advancement, many in the Global South, now find themselves at the center of new forms of power, not because they've suddenly developed Silicon Valley-style innovation hubs, but because they sit atop the raw materials that make Silicon Valley possible.

Indeed, the very AI we are told is supposed to dominate and drive our collective imagination of the future—with all its promises, dreams, hypes, and nightmares—sits at the center of a transforming conception of global political economy. We are told this future begins and ends with what technologists call the "AI stack": semiconductors at the foundation, data centers in the middle, applications at the surface. But social scientists know that every technological stack is also a *social* stack, and this particular stack extends far beyond the boundaries that engineers typically draw.

My own work on the social dimensions of emerging technologies has consistently shown how innovations that appear purely technical are always embedded in broader systems of power, inequality, the market, and social relations—and AI proves no exception to this pattern. When we examine the full AI ecosystem, we discover not just material dependencies but human ones: for example, the data workers, many based in Africa and Asia, who label images, moderate content, and the clean datasets that train AI systems, performing the invisible cognitive labor that makes machine learning possible.

Consider the full architecture of AI dependency: a single large-scale data center requires over a thousand tons of copper for its power networks, circuit boards, and cooling systems. The semiconductors that power machine learning demand gallium, germanium, and indium. The batteries that store energy for these

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[2] Albert O. Hirschman, *National Power and the Structure of Foreign Trade* (1945; repr., Berkeley: University of California Press, 2018), chapter 2.

operations need lithium and cobalt. Each of these materials has a geography, a politics, a set of communities whose lives are reorganized around their extraction.

When we map these dependencies honestly, the "AI stack" begins to look less like a technical diagram and more like what Kate Crawford likens in her book, *Atlas of AI,* to a novel form of global empire[3]—one that requires the subordination of landscapes and communities across the world to serve the computational ambitions of a relative few–and the algorithmic aspirations of perhaps many.

This reshuffling of global dependencies occurs against a backdrop that would have been unimaginable just a few years ago. The current presidential administration's decision to freeze foreign aid and dismantle USAID represents more than budgetary politics. It signals the decline of a development and aid paradigm that has structured international relations for decades, including how scholars have typically conceived of and studied foreign affairs and analyzed global policy.

What's more, the weakening of multilateral organizations from the United Nations to the World Trade Organization—institutions that, however flawed, at least gestured toward global cooperation–creates a vacuum in which new forms of power can emerge. Ironically, this happens just as the UN High-Level Advisory Body on Artificial Intelligence, on which I had the privilege to serve, released its "Governing AI for Humanity" report calling for enhanced international cooperation and inclusive governance frameworks.[4] The report emphasized that AI's very nature—its reliance on globally sourced data, materials, and computing power—makes international cooperation essential, yet we find ourselves in a moment when such cooperation is increasingly difficult to achieve.

In this context, starker truths about how technological advancement actually works are revealed. In US politics, we see Ukraine negotiating minerals-for-security deals and Greenland being eyed for territorial acquisition not only because of its location

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[3] Kate Crawford, *Atlas of AI: Power, Politics, and the Planetary Costs of Artificial Intelligence* (New Haven: Yale University Press, 2021).

[4] United Nations Secretary-General's High-level Advisory Body on Artificial Intelligence, *Governing AI for Humanity: Final Report* (New York: United Nations, September 2024), https://www.un.org/sites/un2.un.org/files/governing_ai_for_humanity_final_report_en.pdf.

but also because of potential access to its critical mineral deposits.[5] We see Chile's lithium salt flats transformed into industrial extraction zones, and the Democratic Republic of Congo—one of the planet's most resource-rich countries—finding itself simultaneously indispensable to and marginalized from the technological revolution it literally powers.[6]

This geography of extraction extends, crucially, to communities within the United States as well. In Boxtown—a Southwest Memphis neighborhood founded by formerly enslaved people—residents are witnessing the wealthiest man in the world consume their air and water to power AI systems. The xAI facility operates 35 gas turbines without required pollution controls, likely making it the largest industrial polluter in Tennessee, in a community where cancer rates already exceed the national average by a factor of four.[7] Across Nevada's lithium-rich landscapes, we see a parallel pattern: an intensifying demand for natural and energy resources giving rise to domestic extractivism, subordinating local environments and communities to serve distant computational needs.[8]

The social scientist in me is struck by how familiar these patterns are, and how novel. We have seen resource scrambles before, but never one quite like this. Previous waves of extraction—whether of gold, oil, or coltan for early electronics—occurred in a world where technological innovation and resource extraction seemed to occupy separate spheres. Yet we can take account of history

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[5] Joanna Kakissis, "Ukraine and the U.S. Have Signed a Long-Stalled Minerals Deal," NPR, May 1, 2025, https://www.npr.org/2025/04/30/nx-s1-5382384/ukraine-us-minerals-deal. See also Sam Meredith, "Trump Is Fixated on Greenland — a Vast Arctic Island with Massive Resource Potential," CNBC, January 14, 2025, https://www.cnbc.com/2025/01/14/greenland-critical-minerals-are-big-part-of-donald-trumps-fixation.html.

[6] Daina Beth Solomon and Fabian Cambero, "Chile Selects 6 Sites for Private Lithium Projects," Reuters, September 26, 2024, https://www.reuters.com/markets/commodities/chile-selects-6-sites-private-lithium-projects-2024-09-26/. See also, U.S. Department of State, "Statement of Concern Related to Certain Minerals Supply Chains from Rwanda and Eastern Democratic Republic of the Congo Contributing to the Ongoing Conflict," July 9, 2024, https://2021-2025.state.gov/statement-of-concern-related-to-certain-minerals-supply-chains-from-rwanda-and-eastern-democratic-republic-of-the-congo-contributing-to-the-ongoing-conflict/.

[7] Bracey Harris, Jon Gerberg, and Stephanie Gosk, "Up Against Musk's Colossus Supercomputer, a Memphis Neighborhood Fights for Clean Air," NBC News, May 15, 2025, https://www.nbcnews.com/news/us-news/musk-xai-colossus-supercomputer-boxtown-memphis-tennessee-rcna206242.

[8] Maxine Joselow, "U.S. Approves Massive Lithium Mine in Nevada, Overriding Protests," Washington Post, October 24, 2024, https://www.washingtonpost.com/climate-environment/2024/10/24/lithium-mine-nevada-tiehms-buckwheat/.

to understand these dynamics more deeply. Howard French's *Born in Blackness* offers one such historical lens—reading it, one sees an account of gold in Africa, sometimes considered a critical mineral today and certainly one in the past even if not given this classification, and the geopolitics that the trade in gold unleashed across Africa and Europe.[9]

Today, the most cutting-edge technological development is directly dependent on some of the most traditional forms of extraction, creating what sociologist Immanuel Wallerstein's world-systems theory would identify as a new iteration of core-periphery relations. The countries developing AI algorithms and deploy advanced models—the United States, China, the European Union—occupy the technological core, while nations like the Democratic Republic of Congo, Chile, and Indonesia remain locked in peripheral roles as resource exporters, despite providing the materials that make AI possible. This creates a temporal collision between futures and pasts that defies our usual categories, where the most futuristic technologies depend on relationships that echo centuries-old patterns of extraction and dependency.

What makes this moment particularly complex is that the same materials powering AI development are essential for renewable energy infrastructure. Solar panels, wind turbines, and electric vehicle batteries all depend on many of the same critical minerals that data centers require, creating what Thea Riofrancos calls an "extractive appendage"—which we will discuss. In this situation, multiple industrial transitions compete for the same finite resources, potentially intensifying rather than reducing environmental and social pressures on communities.[10]

Recent estimates suggest that data centers powering AI will require an additional one million metric tons of copper by 2030, while each electric vehicle needs four times more copper than a traditional car. We are witnessing what industry

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[9] Howard W. French, *Born in Blackness: Africa, Africans, and the Making of the Modern World, 1471 to the Second World War* (New York: Liveright, 2021).

[10] Zannah Matson, "In Conversation with Thea Riofrancos," *Journal of Architectural Education* 79, no. 1 (2025): 11.

observers call a "vibe shift"[11]—the metals shortfall conversation has pivoted from electric vehicles to artificial intelligence as the primary driver of what analysts now term the next "critical mineral supercycle."[12] McKinsey estimates that AI energy demand from data centers will explode from 17 gigawatts in 2022 to 35 gigawatts by 2030—a doubled increase rather than the mere 0.5% annual growth rate that grid planners had been forecasting.[13] This creates new forms of competition between developers of technologies that were supposed to be allies in building a sustainable future.

The geopolitical implications of these dependencies are only beginning to unfold. China's dominance in critical mineral processing—control over ninety percent of global cobalt refining, for example—gives it leverage that extends far beyond traditional measures of national power. Resource-rich countries that have historically been positioned as aid recipients find themselves holding assets that Silicon Valley cannot do without. Yet this apparent shift in leverage often masks deeper continuities: while peripheral nations export physical materials, core countries export the far more valuable digital technologies, governance standards, and AI systems themselves.

The traditional North-South flow of assistance is revealed to be, in many ways, a convenient fiction obscuring the South-to-North flow of essential materials, even as the most lucrative aspects of the AI value chain—algorithm development, data processing, platform control—remain concentrated in the same handful of wealthy nations that have dominated previous technological revolutions.

This reshuffling creates both dangers and opportunities. The danger lies in reproducing colonial patterns of extraction under new technological justifications—using the urgency of AI development or climate transition to justify

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[11] Blanca Begert, "Move Over, EVs. AI Needs Critical Minerals," Politico, May 7, 2024, https://www.politico.com/newsletters/california-climate/2024/05/07/move-over-evs-ai-needs-critical-minerals-00156725.

[12] The Oregon Group, "Artificial Intelligence and the Next Critical Mineral Supercycle," April 22, 2024, https://theoregongroup.com/wp-content/uploads/2024/04/Artificial-Intelligence-and-the-next-Critical-Mineral-Supercycle-The-Oregon-Group.pdf.

[13] Srini Bangalore et al., "Investing in the Rising Data Center Economy," McKinsey & Company, January 17, 2023, https://www.mckinsey.com/industries/technology-media-and-telecommunications/our-insights/investing-in-the-rising-data-center-economy.

the subordination of communities and landscapes to distant needs. The opportunity lies in recognizing that this moment of technological transition might allow for more equitable arrangements, if we can develop governance frameworks and true innovation adequate to the task.

Given the AI industry's voracious appetite for materials, this reshuffling of global dependencies represents a moment for fundamental reimagining. How do we create engagement that is genuinely mutual rather than extractive? Is it possible to develop AI governance that acknowledges the full supply chain rather than focusing only on the visible technological surface? Can we imagine accountability mechanisms that trace responsibility from algorithm to mine, from data center to extraction site, perhaps using the participatory research strategies being developed by Tamara Kneese?[14]

The panel you're about to hear grapples with these questions from multiple angles, bringing together perspectives that rarely share the same table. The goal is not to provide easy answers—the problems we're discussing resist simple solutions—but to map the terrain more honestly, to understand what's actually at stake as AI reshapes global relations of power.

Only by attending to the full AI stack—including its deeply material foundations—can we grasp the stakes of the future currently being configured. A comprehensive view is essential for envisioning alternative trajectories that might lead to more equitable and sustainable arrangements. The intensifying global demand for critical minerals is already catalyzing profound social and environmental transformations, whether or not they receive sustained analytical attention. The pressing question is what kind of change is unfolding—and whether we as researchers and citizens can develop the conceptual frameworks and political imagination necessary to shape its course.

The discussion we're beginning today is about an abiding focus of social research – power: who holds it, how it is exercised, and how it might be reimagined in the age of artificial intelligence. These are not merely technical questions about supply chains or mining regulations, but fundamental questions about the kind of world

[14] Tamara Kneese, "The Algorithmic Impact Methods Lab: Introducing Methods from the Field," Data & Society, Points, September 18, 2024, https://datasociety.net/points/the-algorithmic-impact-methods-lab-methods-from-the-field/.

that is being envisioned and developed through the use of AI, and whether its development will be guided by principles of democratic governance, public accountability, and shared benefit. And ultimately, because our Earth's resources are rare and not *in*exhaustible, answering these questions requires independent research about whether and how AI development can be pursued sustainably.

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