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RAW MATERIALS FOR AI

This zine has been researched and produced by the AI + Planetary Justice Alliance (AIPJ), and published in November 2025 as part of the project "Below the Algorithm". Its author and designer is Sara Marcucci, who would like to thank Ambika Varma and Beatrice Bacci at AIPJ for their thoughtful review.

The drawings in this zine are meant to be representative rather than perfectly technical: they don't aim to depict every detail with full accuracy, but instead to capture the main components of AI hardware and communicate their relationship to minerals in an accessible way.
We always love to connect with people doing similar work: to share feedback by email or to get in touch, please contact sara@aiplanetaryjustice.com.

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MINERALS POWERING AI HARDWARE

Photo credits: Shutterstock, Rebel Red Runner

Artificial intelligence may seem ethereal, but it relies on very concrete materials. The powerful computers and data centers running AI are built from chips, cables, and cooling systems – all made of minerals and metals mined from the Earth.

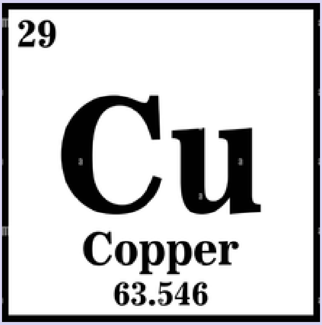
For example, one analysis notes “the AI revolution runs on rocks, specifically a handful of critical minerals that power everything from advanced semiconductors to massive data centers.”

Behind every AI device are minerals like copper, silicon, and rare earths, that conduct electricity, manage heat, and store data. This report highlights the most important of these minerals and explains, in plain terms, how they are used in AI hardware. Our aim is not to be fully comprehensive, but to give a visual taste of what is below an algorithm.

COPPER

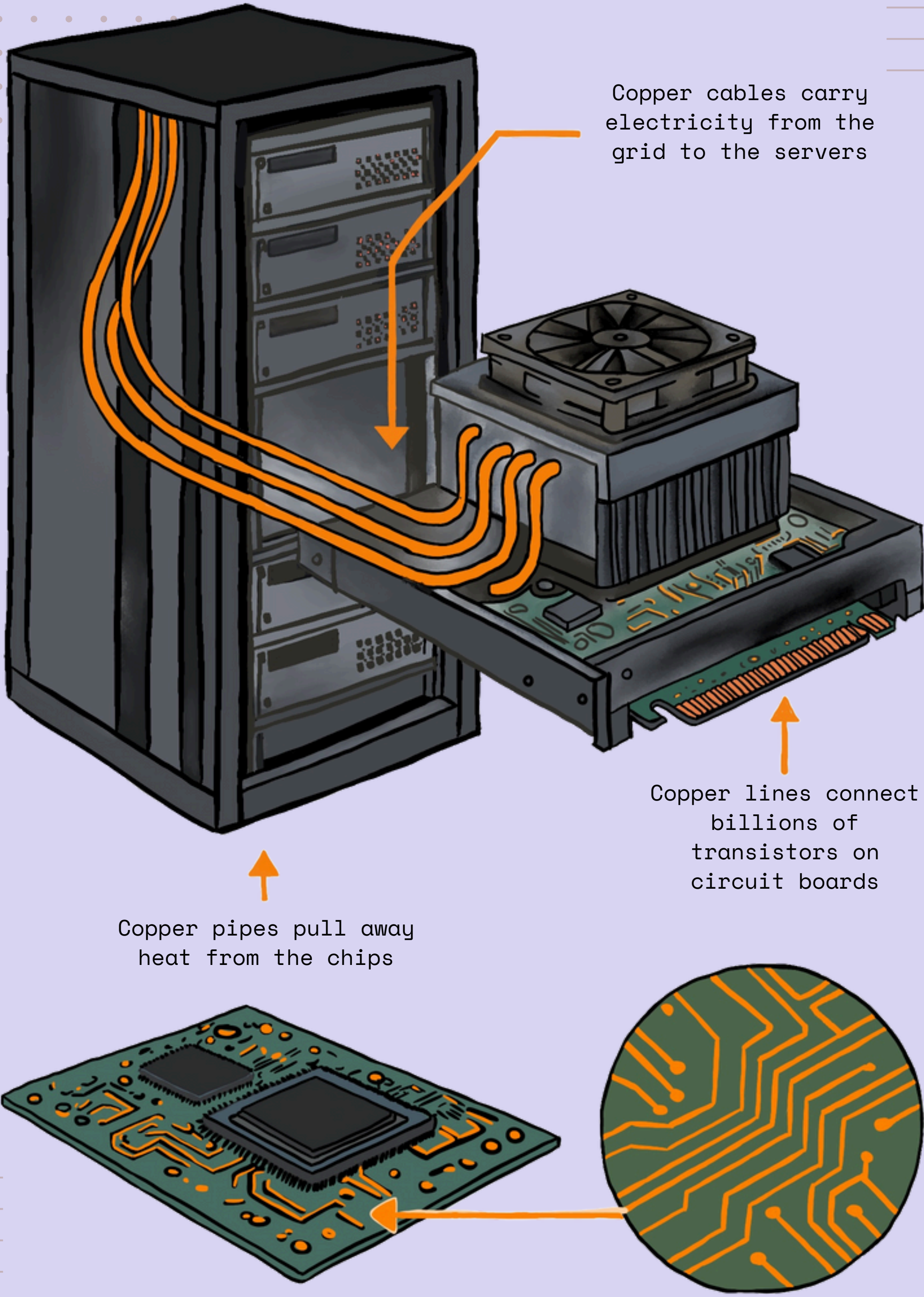
CONDUCTOR OF ELECTRICITY AND HEAT

Copper is one of the most important metals in AI infrastructure. It is an excellent conductor of electricity and heat, so it is used throughout data centers and computer hardware. For example, data centers require vast amounts of copper for power networks, circuit boards and cooling systems. A single large data center can use thousands of tons of copper just in its power distribution and wiring.



Copper cables carry electricity into servers, and copper pipes and coils carry heat away from processors. Inside computer chips, copper forms the microscopic wires that link billions of transistors together. In short, copper keeps AI hardware powered and prevents it from overheating.

Photo Credits: John Mortimore


Copper cables carry electricity from the grid to the servers
Copper lines connect billions of transistors on circuit boards
Copper pipes pull away heat from the chips

SILICON

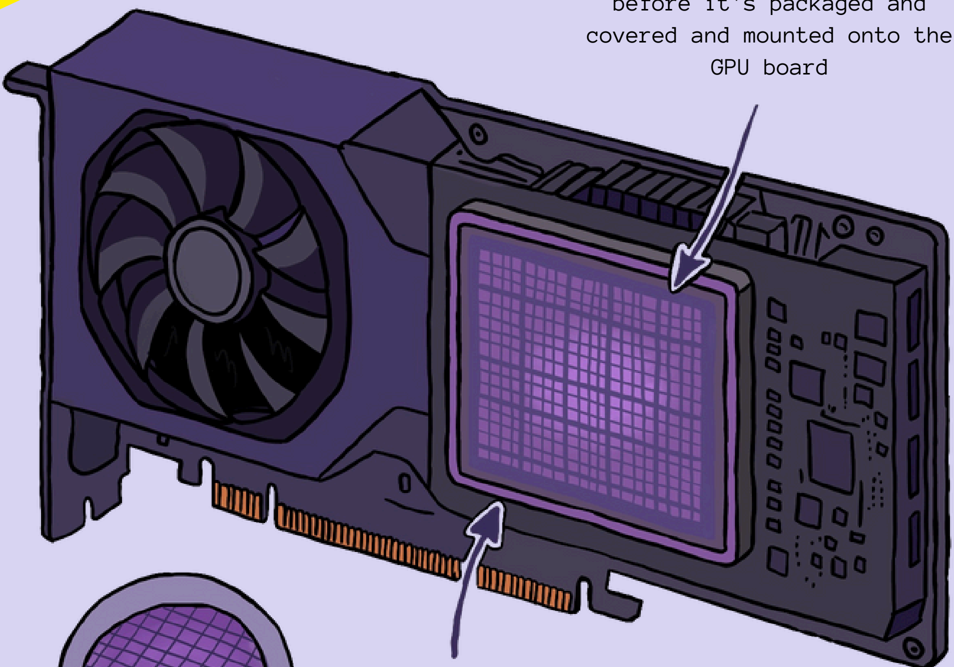
THE CHIP SUBSTRATE

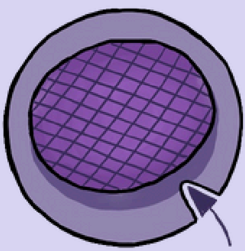
Silicon is the fundamental material of almost all computer chips. Silicon's semiconductor properties allow it to switch electricity on and off in tiny transistors. Modern GPUs are made by etching circuit patterns into pure silicon wafers. Intel notes that silicon is "the most common semiconductor material" and "the main ingredient in computer chips."

Specialized AI chips – like graphics processing units (GPUs) and tensor processing units (TPUs) – are silicon circuits designed to handle complex computations. In other words, silicon forms the physical base of nearly all microchips and thus underpins the processing power of AI systems.

Photo Credits: Bigstock, Foto-Ruhrgebiet

where dozens or even hundreds of tiny identical chips are b





Computer chips start as a big, perfectly flat disk of ultra-pure silicon called a wafer, where dozens or even hundreds of tiny identical chips are built at the same time. That disk is then cut up like a tray of brownies, and each little piece becomes an individual chip that will go inside a computer or AI server.

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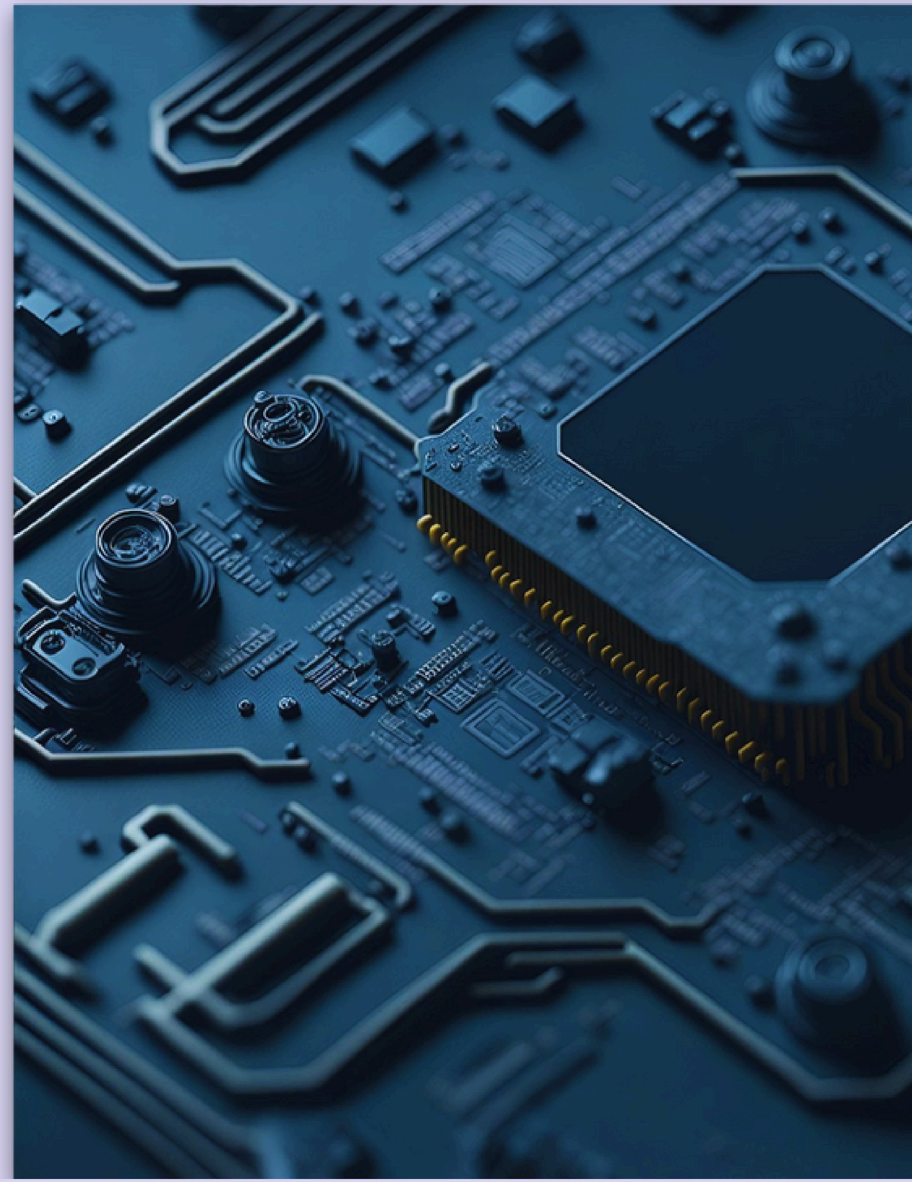
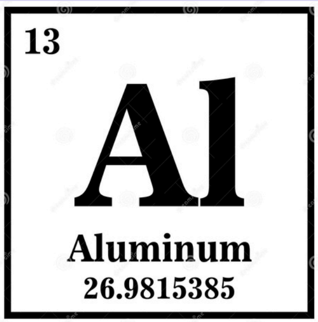


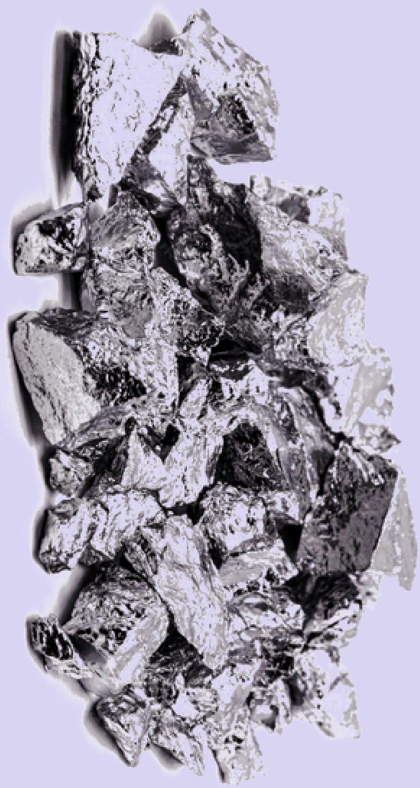
Photo Credits: Pixabay, TheDigitalArtist

ALUMINUM

LIGHTWEIGHT COOLING AND STRUCTURE

Aluminum is another key metal in AI hardware. It is much lighter than copper but still conducts heat well. As a result, aluminum is widely used in server racks, chassis, and especially heat sinks (metal fins that draw heat away from processors).

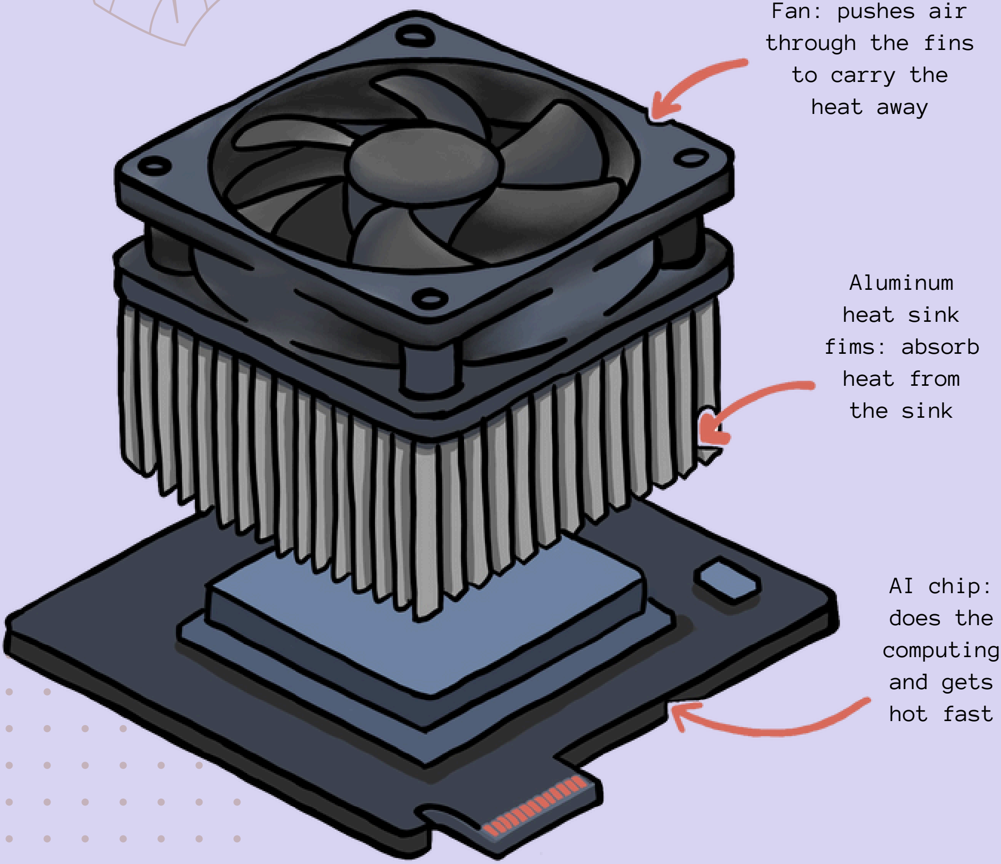




For instance, the US Geological Survey notes that typical data center heat sinks contain large amounts of aluminum (about 47%) because of its high conductivity and low weight. In practice, being very conductive and resistant to corrosion, aluminum frames and fins help keep AI servers cool and stable.

Photo Credits: Shutterstock, RHJPhtotos

COOLING

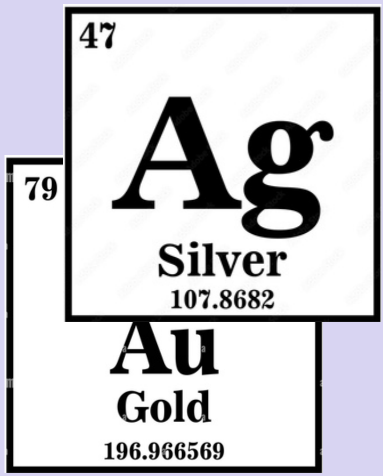


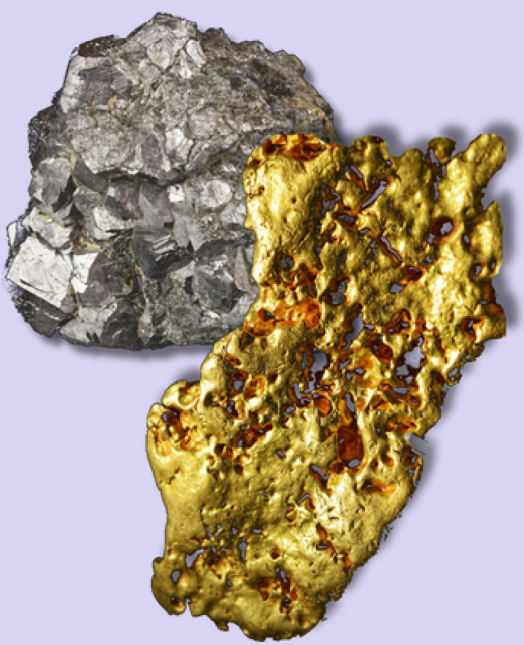
STRUCTURE

GOLD & SILVER

PREMIUM CONNECTORS

Gold and silver are noble metals with excellent conductivity. Gold is often used for tiny bonding wires and connectors on chips because it resists corrosion. Silver is even more conductive than copper, so it is used in specialized high-frequency circuits and contacts. For example, one analysis notes that



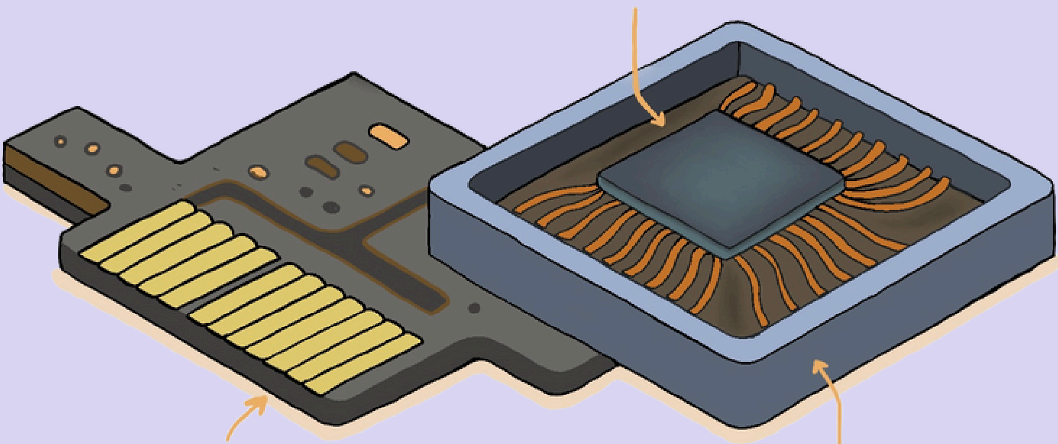


silver's "high conductivity enables faster signal transmission and greater energy efficiency" in critical electronics. However, because gold and silver are expensive, they appear only in small amounts (e.g. gold in connector pads, silver in precision circuits), whereas copper handles most of the heavy lifting.

Photo Credits: Shutterstock, Lina Design

wires that connect the silicon die to the chip package so it

Gold bond wires: ultra-thin wires that connect the silicon die to the chip package so it can receive power and send/receive signals



Gold-plated contacts: corrosion-resistant contact surfaces that keep a clean, low-loss electrical connection when the card plugs into the server

Silver solder: joins components to the board and conducts both electricity and heat efficiently

es that keep a clean, low-loss electrical co

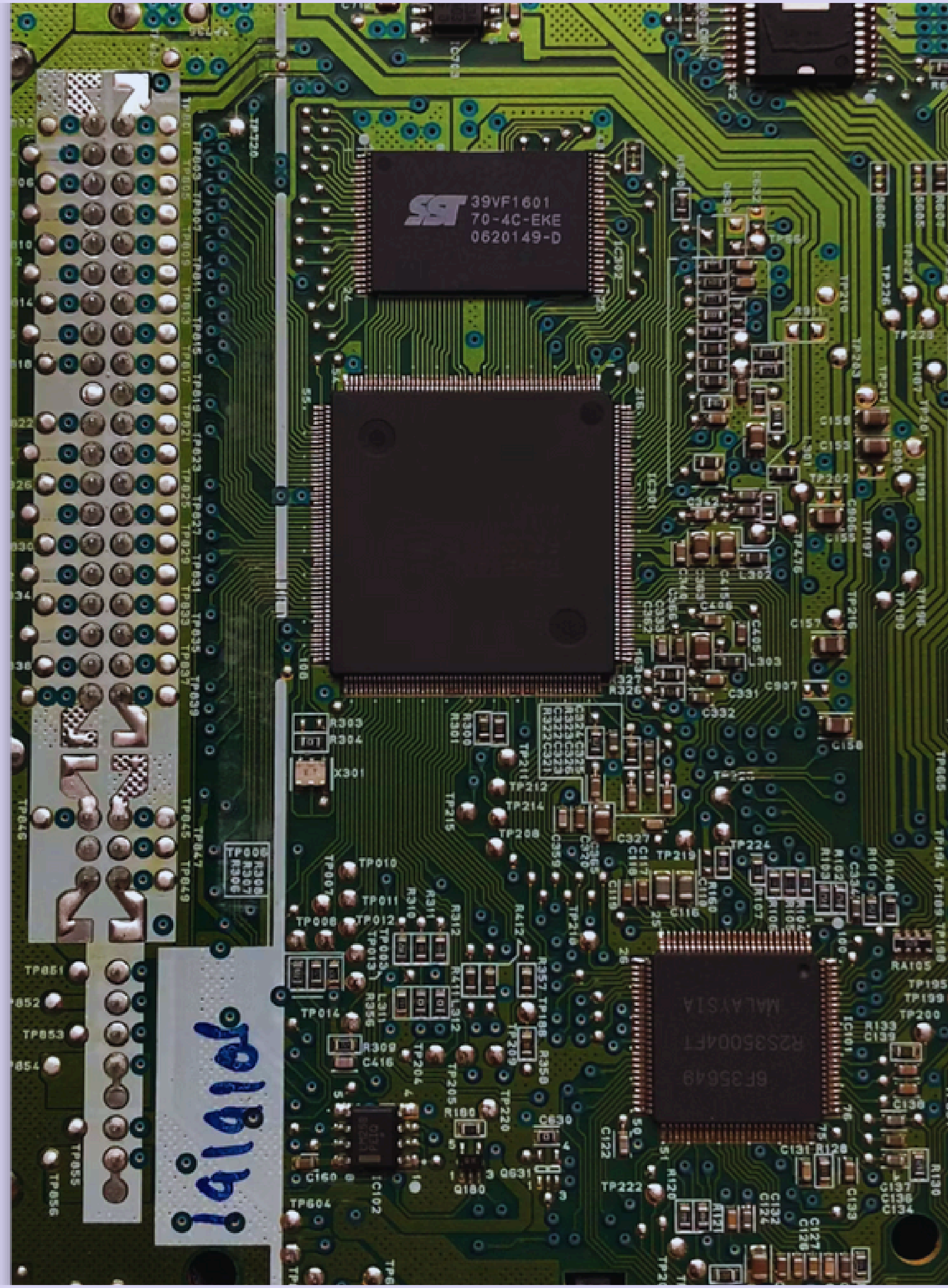
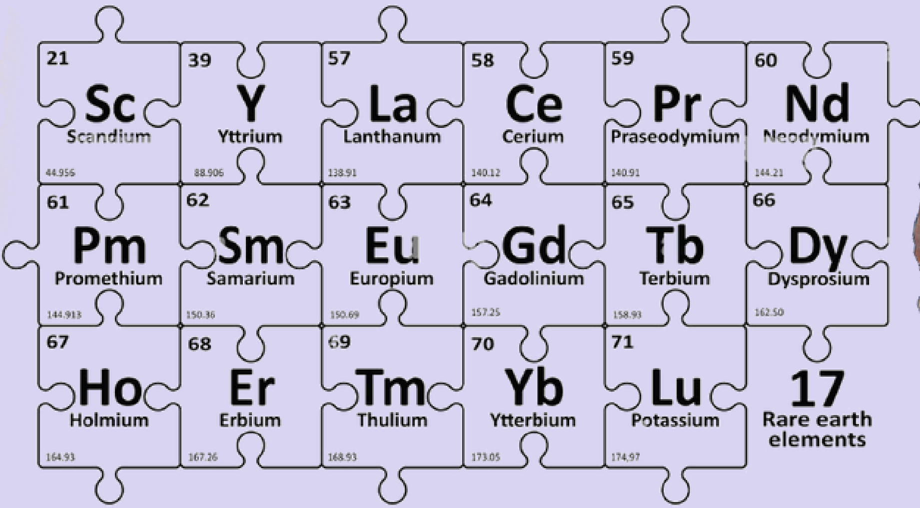


Photo Credits: Unsplash, alerkiv

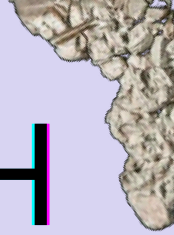
RARE EARTH MINERALS

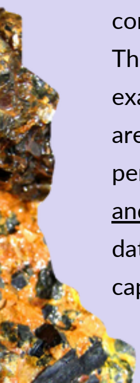
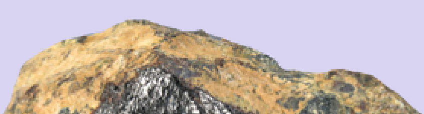
POWERFUL MAGNETS AND OPTICS



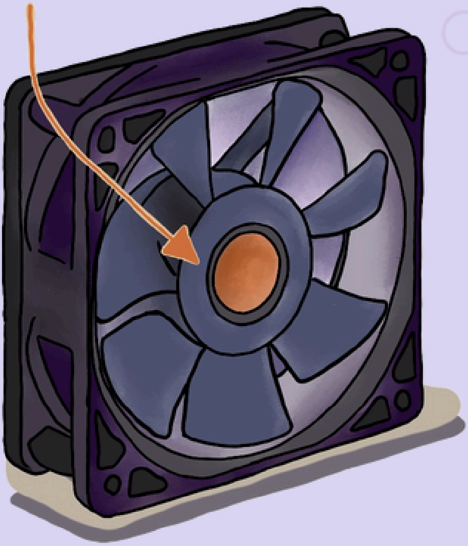
"Rare earth" refers to a group of 17 metallic elements with unusual magnetic and optical properties. They are not actually rare: they just exist in low concentrations and are hard to extract. They are crucial in AI hardware: for example, neodymium and dysprosium are used to make extremely strong permanent magnets in hard disk drives and cooling fans. These magnets allow data centers to use compact, high-capacity drives and efficient motors.

Other rare earths like terbium and europium are used in lasers, fiber optics, and display phosphors, which can appear in sensors or accelerators used by AI systems. Rare earths possess "powerful magnetic qualities" that make them excellent for GPUs, ASICs and FPGAs – the chips that drive AI. Thanks to this properties, they ultimately help build the motors, storage drives, lasers and communication devices that support AI.



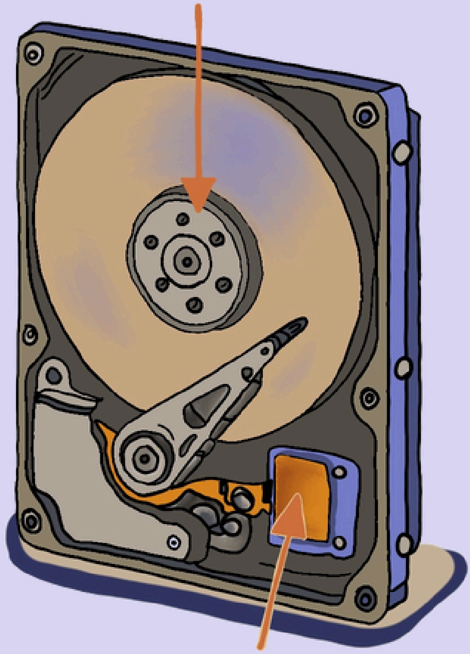




Rare earth
magnet on a fan



When the coils in the fan housing are energized, they push/pull on that magnet and make it spin, thus pushing heat away from the chips

Rare earth
magnet on a hard drive
spinning disk

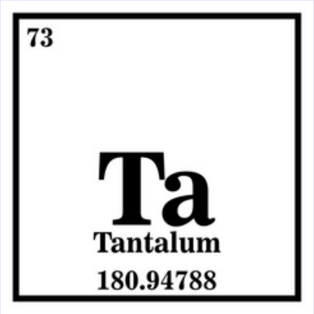


Rare earth magnet that lets the hard drive arm move incredibly fast and stop exactly where it needs to, so the system can find and read the data used for training the model

TANTALUM

HIGH-CAPACITANCE CAPACITORS AND BATTERIES

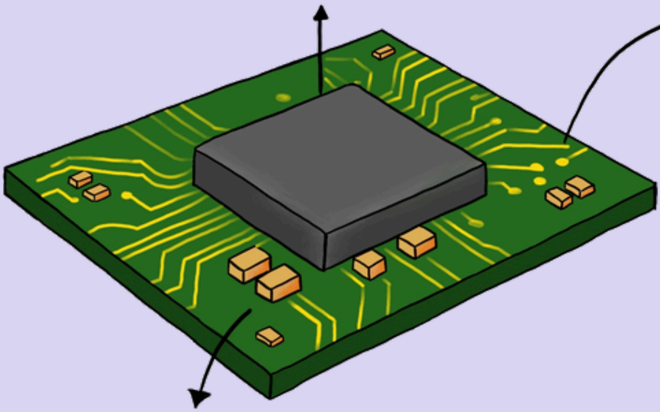
Tantalum is used in two main ways. First, it is the key ingredient in many tiny capacitors on circuit boards. Tantalum capacitors can store more electric charge in a given size than most other capacitors. This makes them ideal for stabilizing power supplies on motherboards and ensuring smooth voltage for AI processors. They are especially valued in servers and SSD storage: during sudden power dips, tantalum capacitors can quickly release stored energy to let memory write data to disk, avoiding crashes.

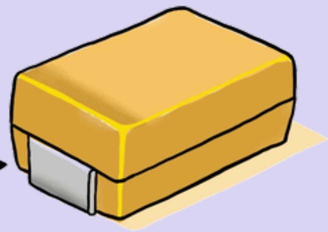


Second, tantalum appears in chip manufacturing itself. Very thin films of tantalum (or tantalum compounds) are deposited on silicon wafers to act as a diffusion barrier. These tantalum layers prevent copper wiring from contaminating the silicon and also endure high temperatures. In fact, without tantalum, semiconductors may malfunction because tantalum films protect the silicon and ensure reliable chip operation.

Photo Credits: Theodore W. Gray

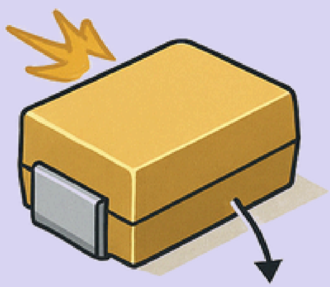
Tantalum capacitors: These sit right next to the AI chip and act like tiny power shock absorbers, keeping its power supply clean and stable





The capacitors' metal ends are soldered directly onto the board so that stored energy flows straight into the chip's power line

When the AI chip suddenly pulls a lot of power, these capacitors dump stored energy in an instant so the chip doesn't glitch or shut down

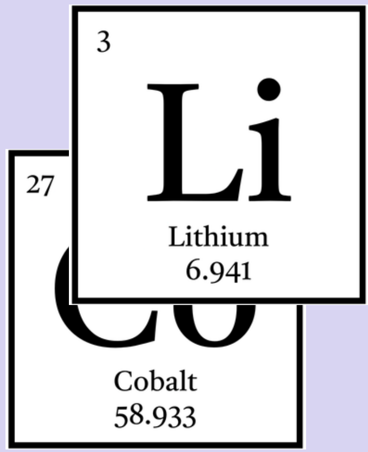


Made with tantalum: this part can store a lot of electrical charge in a very small package, which is why it's used in high-performance AI hardware

COBALT & LITHIUM

BATTERY POWER AND ADVANCED WIRING

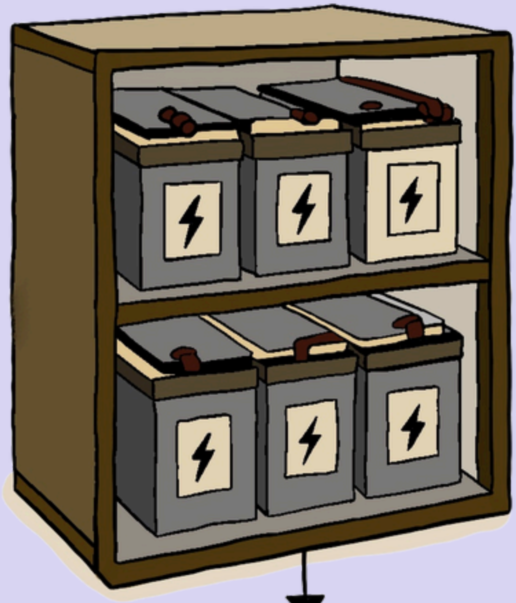
Cobalt is best known as a critical component of lithium-ion batteries. Many AI data centers and edge devices use battery backup systems (UPS) or portable power systems that rely on lithium-ion cells, which usually contain cobalt in the cathode.



Cobalt gives these batteries high energy density and stability, so a server farm can ride out brief power interruptions. Additionally, recent chip technologies are beginning to use cobalt in the wiring of the smallest transistors. Cobalt's conductivity and stability at tiny scales sometimes make it a candidate to replace copper in advanced chips such as GPUs.

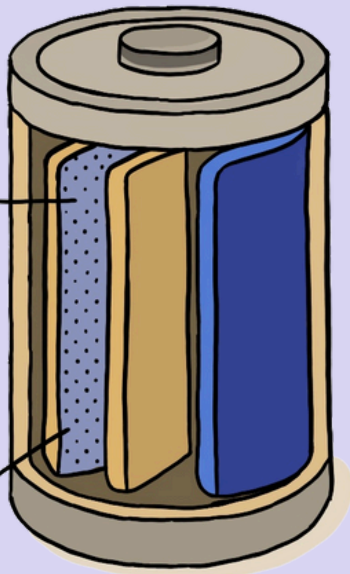
Photo Credits: Cobalt: Freepik, neetonweb.
Lithium: Time magazine

lt cathode provides high-energy capaci



Cobalt cathode provides high-energy capacity: The cathode layer often contains cobalt in many lithium-ion chemistries used for high energy density. That cobalt makes the battery able to store a lot of energy in a relatively compact volume

This cabinet represents the battery backup system (UPS) in a data center. Backup lithium-ion batteries keep AI servers running during power dips. This is important because AI data centers need to be operational 24/7



Lithium anode stores and releases energy: Lithium moves back and forth between anode and cathode when the battery charges and discharges. That movement is what actually delivers power to the AI hardware when the main power blips

moves back and forth between anode and

GALLIUM & GERMANIUM

SPECIALIZED SEMICONDUCTORS

Besides silicon, other semiconductor materials play key roles, such as gallium and germanium. Gallium is used in compounds like gallium arsenide (GaAs) and gallium nitride (GaN), which outperform silicon in high-frequency and high-power applications. For example, GaN chips are critical for high-speed wireless transmitters (5G) and for efficient power converters used in data centers. GaAs and GaN also appear in some high-performance AI chips and photonic devices.

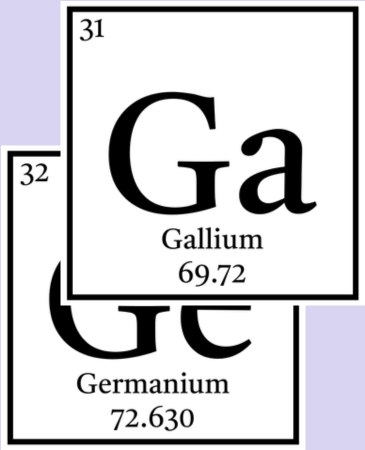
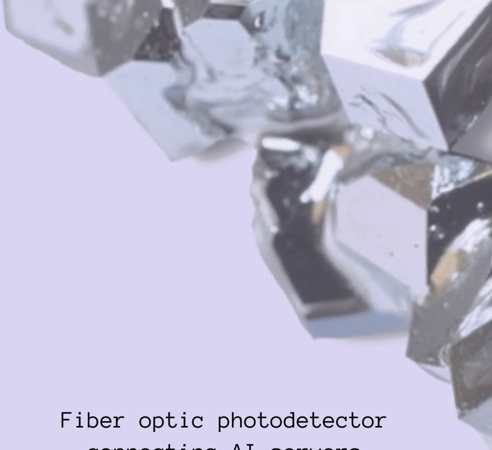
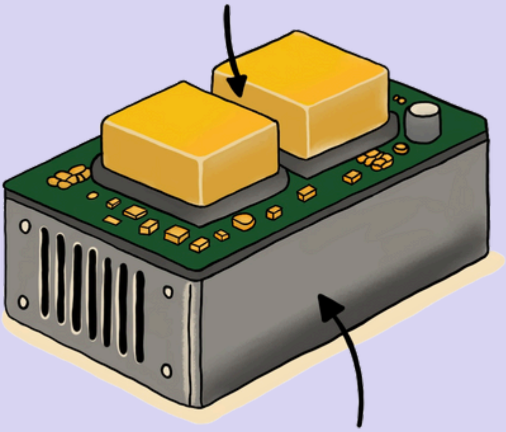


Photo Credits: Germanium: Jumk.de Webprojects. Gallium: Thomas Nguyen

Germanium offers very high electron mobility, so it is used in high-speed integrated circuits and fiber-optic components. In particular, fiber-optic transceivers often use germanium-based photodetectors to transmit AI data over long distances with low loss. Along with those, elements like indium (in indium phosphide chips) and palladium (in capacitors) support AI hardware. For instance, indium phosphide is used in fiber-optic communication hardware, while palladium appears in multi-layer ceramic capacitors that filter signals.

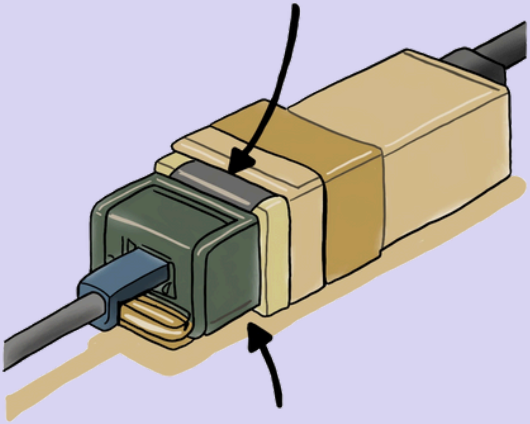


Gallium nitride power electronics. Gallium is physically inside those high-efficiency transistors

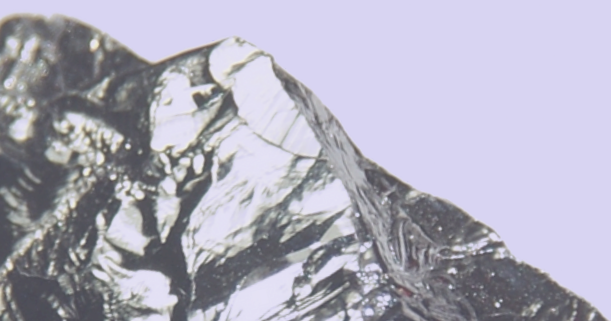


Power conversion module feeding AI accelerators. This box sits between incoming power and the AI chips, conditioning the electricity. Gallium power modules turn incoming electricity into the clean, high-current power AI chips need, without wasting as much heat

Fiber optic photodetector connecting AI servers



Germanium photodetectors turn laser light from fiber cables into data, so AI servers can talk to each other at high speed



SO... WHAT NOW?

Photo credits: Unsplash, Jandira Sonnendeck

As we close this zine, we want to acknowledge that the idea of "minerals powering AI" can still feel abstract. It's easy to talk about data, models, and algorithms without ever picturing the metals and components that make them possible. This zine is a small attempt to bridge that gap: by visually breaking down some of the main parts of AI hardware, we hope to make it easier to see the concrete, physical pieces that depend on minerals taken from the Earth.

This is not a comprehensive guide to every material or component in the AI supply chain. Instead, we aimed at prioritizing some of the key minerals and hardware parts and offers an initial overview: an accessible starting point, rather than a complete, technical map.

From here, as part of our "Below the Algorithm" project, we will publish other resources that dive more deeply into the planetary justice impacts of mining for these minerals. The reality is that extracting and processing them often comes with severe social and ecological harms, and their supply chains are complex, opaque, and deeply uneven. Our goal is to keep tracing these connections – between chips and mines, between servers and soils – so that conversations about AI also reckon with the worlds it rests on.

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