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Mineral Policy Institute

Fact Sheet
Gallium (Ga)

What makes a mineral 'critical'? *Gallium (Ga) is a soft, silvery-white metal. It is famous for its low melting point of 29.78°C, which causes it to turn liquid in a human hand. However, it also has an extremely high boiling point of 2,403°C. This combination gives gallium one of the largest liquid ranges of any metal.*

Importance to economic and technological development: *Liquid gallium-based alloys are used as high-performance coolants for advanced electronics, such as computer chips and highpower semiconductors, because they are far more effective at transferring heat than water.*

FOR EXAMPLE:

- *Gallium Arsenide (GaAs):* Used in smartphones (RF ampliNiers), 4G/5G connectivity, laser diodes, and high-efNiciency solar cells.
- *Gallium Nitride (GaN):* Foundational for next-generation technology, including 5G/6G infrastructure, EV chargers, and AI data centres.

Gallium based compound semiconductors outperform traditional silicon in applications requiring high power, high frequency, and high-temperature tolerance.

Vulnerable supply chain: Its strategic vulnerability comes from its source: gallium is not mined directly. It is almost exclusively recovered as a byproduct (or 'companion mineral') from two main industrial processes:

- *Bauxite Processing:* Extracted from the caustic "Bayer liquor" used to refine bauxite ore into alumina (for aluminium).
- *Zinc Processing:* Recovered from the residues of zinc ore smelting.

This "byproduct" status is its fundamental flaw. Gallium supply is not determined by the demand for high-tech electronics; it is dictated by the global market demand for aluminium and zinc. Gallium is officially designated as critical by the United States, the European Union, and Australia.

THE SECURITY DEPENDENCY

- *Essential & Hard to Replace:* GaN is critical for advanced military systems, including AESA radar and electronic warfare. Because there are few easy substitutes for these high-performance applications, gallium is essential for modern national defence.
- *A Critical Vulnerability:* This defence dependency is extremely vulnerable because the supply chain is highly concentrated. China produces approximately 98% of the world's low-purity gallium.
- *"Weaponised" Supply:* This control functions as a geopolitical lever. In 2023-24, China "weaponised" this dependency by imposing export bans in response to Western technology restrictions.
- *Geopolitical Shift:* The USA and allies, including Australia, are now scrambling to end their dependency on China by creating alternative supply, including by 'fast tracking' environmental approvals.

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Australia, the US and Japan recently announced a critical minerals deal. *As part of this deal, the Australian government will commit $AUD 307million to establish a gallium reNinery at Alcoa's Wagerup facility in Western Australia's Southwest. Coming amidst unprecedented community backlash against Alcoa's bauxite expansion proposal, the deal is a perfect example of how quickly the narrative can change.*

ENVIRONMENTAL RISKS

The "just transition" Conflict: gallium is vital for "green" technologies like EVs, batteries and solar panels, but its primary extraction method is tied to one of the world's most environmentally damaging industrial processes.

1. *The Bauxite Mining Footprint* Open-pit strip mining leads to deforestation, biodiversity loss, habitat fragmentation for endangered species, high water consumption and risks contaminating local drinking water supplies.
2. *The "Red Mud" Legacy* The Bayer process, used to refine bauxite into alumina, generates a massive and toxic waste slurry known as "red mud".

Massive Scale: For every 1 tonne of alumina produced, 1.0 to 1.8 tonnes of red mud is generated. There are over 150 Mt of red mud produced globally every year, and around 30Mt in Australia in 2024.

Extreme Hazard: Red mud is highly caustic and alkaline. A dam failure, like the 2010 Ajka disaster (Hungary) can be catastrophic, destroying entire ecosystems.

Toxic Components: The waste contains heavy metals like arsenic and chromium. It is also radioactive as the process concentrates uranium and thorium.

Health Risks: Studies of Australian refinery workers show excess mortality rates from mesothelioma and other cancers.
Gallium could be extracted from existing 'red mud' waste rather than contributing to new demand.

ALTERNATIVES TO NEW MINING

The severe environmental and geopolitical risks have spurred a search for alternative solutions.

Degrowth: A movement advocating for shrinking, rather than growing economies, particularly in wealthy nations. The goal is to use fewer of the world's dwindling resources and prioritise well-being over high GDP, arguing that endless growth is incompatible with planetary boundaries.

"Technospheric Mining" (Recycling): Extracting resources from human-made stockpiles (the "technosphere") rather than from new geological deposits. This includes mining end-of-life electronics (e-waste), industrial process residues, and old mine waste, such as tailings. For gallium, this involves recycling LEDs and semiconductors, as well as re-processing the red mud.

Technological Substitution: A race to "design out" the reliance on gallium. E.g. Silicon Carbide (SiC) is a direct competitor for many of the same applications as GaN. Researchers are also investigating new materials, such as boron nitride.

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