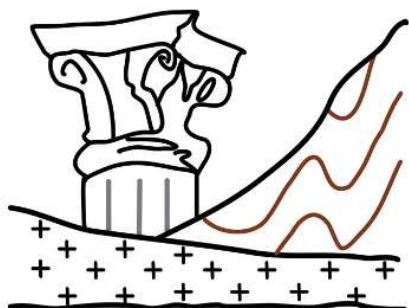
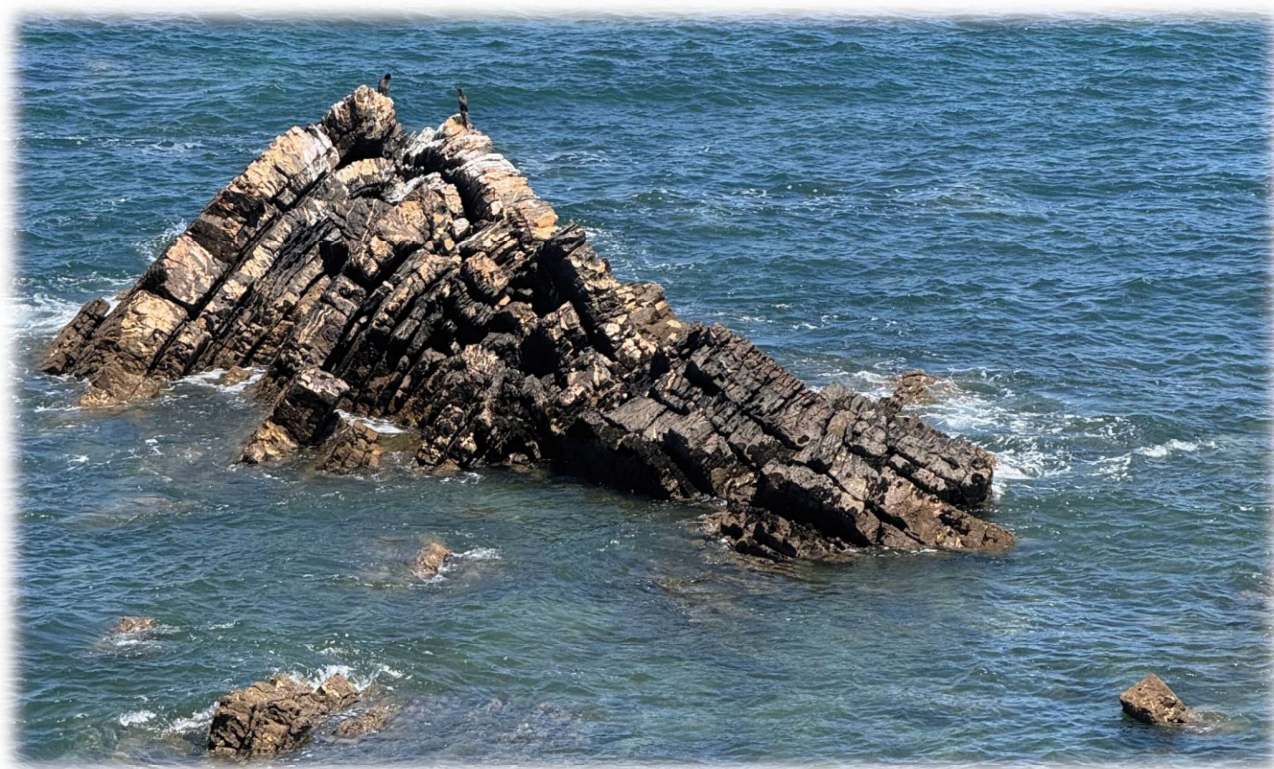




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From geology to criticality: understanding raw material supply constraints

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Resumo

Critical and strategic raw materials (CRM/SRM) have become central to the energy transition, digitalisation, and defence, elevating mineral supply to a strategic concern for Europe. While supply vulnerabilities are often framed in geopolitical or economic terms, this contribution emphasises that geology constitutes the fundamental and least flexible constraint underpinning mineral criticality. The uneven global distribution of CRM results in persistent spatial concentration of supply and structural dependencies that cannot be rapidly resolved through policy or market mechanisms. Many CRM occur predominantly as companion or by-product elements, linking their availability to the production of major host metals and decoupling supply from direct demand signals. This intrinsic rigidity limits the effectiveness of short-term mitigation measures such as market substitution and highlights the long lead times required to bring new mineral resources into production. As a result, mineral criticality should be understood as a structural and enduring condition of the energy transition rather than a temporary disruption. The European Union's evolving raw materials strategy, culminating in the Critical Raw Materials Act, represents an ambitious attempt to address these vulnerabilities through domestic production targets, recycling, diversification, and strategic partnerships. However, implementation remains constrained by geological realities, declining discovery rates, complex mineral systems, social acceptance challenges, and extended permitting timelines. These factors underscore the need for realistic expectations aligned with geological timescales. In this context, geological knowledge infrastructure emerges as a strategic asset. Geological Survey Organisations play a pivotal role in reducing mineral criticality by generating, integrating, and disseminating unbiased, pre-competitive geoscientific data. By operating at the early stages of the exploration–development continuum, they absorb geological risk unattractive to private investment and provide the foundation for robust mineral intelligence, exploration targeting, and evidence-based policy making. Strengthening coordination among geological surveys and sustaining long-term investment in geological data are therefore essential for enhancing Europe's resilience and strategic autonomy in critical and strategic raw materials.