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*David Sainz Sainz & Rosa Mecha López**

The Geography of Rare Earths: Asymmetric Distribution, Power Rivalry and Western Strategic Autonomy



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Abstract:

The geographical distribution of rare earth elements constitutes one of the most asymmetric power structures in the contemporary international system. China controls approximately 60-70% of global production and over 90% of refining capacity, granting it economic coercive leverage over industrialised democracies that it has already demonstrated a willingness to exercise. This analysis examines, through thematic mapping based on official data, the main dimensions of that asymmetry across four scales: the global distribution of reserves and trade flows, increasing competition in the Arctic, Sino-American rivalry in the Pacific, and the vulnerability of the European Union and Spain. The conclusions suggest that Western dependence is not merely structural but the result of short-term political inertia that can and should be corrected through investment in domestic capabilities, source diversification, and strategic coordination among allies.

Keywords:

Rare earths, strategic autonomy, dependence on China, critical supply chains, Arctic, resource geopolitics, European Union, Spain.

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Introduction

Rare earth elements—seventeen metallic elements with exceptional magnetic, conductive, and energy-storage properties—have ceased to be merely a technical and industrial concern and have become one of the central pillars of twenty-first-century geopolitical competition. Their presence is indispensable in wind turbines, electric vehicles, advanced defence electronics, and artificial intelligence. Increasingly, whoever controls their supply can influence the pace and direction of the global energy and technological transition[1].

This control is currently highly concentrated. China not only possesses the world's largest identified reserves, but has also established an almost monopolistic position over the stages of chemical separation and refining—the stages that generate the greatest added value and the greatest degree of dependency for importing economies. The export restrictions imposed in 2010 against Japan and the control measures implemented in 2025 in response to US technological restrictions have demonstrated that this position can be instrumentalised as a tool of pressure[2]. No serious analysis of supply security can afford to ignore these precedents.

Against this backdrop, the European Union and its Member States—including Spain—find themselves in a situation of structural dependency that is attributable not solely to geology, but also to decades of policy decisions that prioritised low-cost access over resilience. The Critical Raw Materials Act, adopted in 2024, represents an important regulatory turning point, but the gap between the stated objectives and actual industrial capacity remains considerable[3].

This analysis examines, through thematic mapping based on updated official data, the spatial distribution of rare earth elements and its geopolitical implications at four scales: global, Arctic, Indo-Pacific, and European-Spanish. The objective is not merely descriptive: it is to identify the vectors of vulnerability and the available levers for action through which Spain and the EU can reduce their exposure at a time when competition

[1]KIGGINS, R. D. (Ed.). (2015). The political economy of rare earth elements: Rising powers and technological change. Palgrave Macmillan.
[2]KIGGINS, R. D. (2015), op. cit.; PECK, D. (2023). La geopolítica de las tierras raras y los recursos escasos. En Anuario Internacional CIDOB 2023 (pp. 77-79). CIDOB.
[3]European Commission. (n.d.). *Critical Raw Materials Act*. Directorate-General for Internal Market, Industry, Entrepreneurship and SMEs.

for critical materials is intensifying at an unprecedented pace. The five maps underpinning this analysis—compiled using data from the USGS, the National Snow and Ice Data Center, Marine Regions, the World Bank Group, and the CNIG—constitute the central analytical tool rather than merely providing visual support.

The geography of Rare Earths: an asymmetrical power order

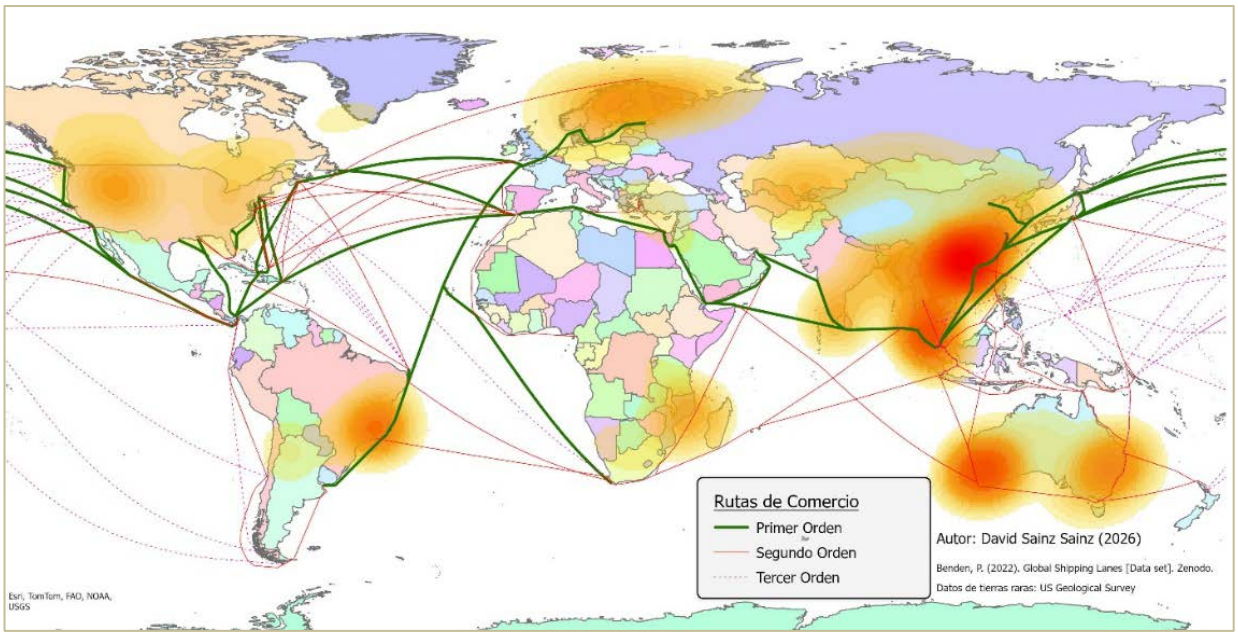


Figure 1: Density of areas with proven rare earth reserves and first-, second-, and third-order maritime shipping routes. Own elaboration. Sources: USGS (Mineral Commodity Summaries 2026); Benden, P. (2022). Global shipping lanes [Zenodo].

Map 1 represents, through a heat map, the density of sites with proven or exploited rare earth reserves at the global scale, overlaid with the main international maritime routes, classified into three tiers according to their importance. The resulting spatial distribution is far from geopolitically neutral: it constitutes the material foundation of a profoundly asymmetric power structure. China emerges as the dominant hub, with a high-density area reflecting both its proven reserves and active production, which accounts for approximately 60–70% of the global total[4].

[4]U.S. Geological Survey. (2026). Mineral commodity summaries 2026 (Version 1.2, April 2026).

The most strategically relevant asymmetry, however, lies not in the reserves themselves but in processing. Chemical separation and refining—technically complex, energy-intensive processes that generate highly toxic waste—are monopolised by China, which accounts for more than 90% of global capacity. The country's major carbonatite deposits in the north—in particular the Bayan Obo deposit in Inner Mongolia, which contains the largest known concentration of rare earth elements—and the ion-adsorption clay deposits in the south provide the geological foundation for this dominance. Countries with their own reserves, such as Australia (Mount Weld) and the United States (Mountain Pass), export low-value-added concentrates to the Chinese hub, where they are processed into oxides, metals, and technological components before being distributed worldwide.

This structure reproduces a classic pattern of unequal exchange: whoever controls the intermediate stages captures most of the economic value and technological power[5]. Countries possessing primary reserves are relegated to subordinate positions within the supply chain, while China captures the highest profit margins and, above all, the bargaining power derived from controlling an input that no country can dispense with in the short term[6].

This position is not accidental. China has built it through decades of sustained state investment and a pricing policy that rendered Western production economically unviable during the 2000s. The result is a structural dependency among advanced economies that China has demonstrated its willingness to exploit as an instrument of coercion. In 2010, it restricted exports to Japan in the context of a territorial dispute over the Senkaku Islands; in 2025, it introduced new export controls in response to the technological restrictions imposed by Washington. Both episodes have demonstrated that interdependence can, under certain circumstances, become a lever of pressure[7].

The trade routes depicted on the map reveal the second layer of vulnerability. The convergence of flows towards China through the Strait of Malacca and the South China

https://doi.org/10.3133/mcs2026; Dushyantha, N. et al. (2020). The story of rare earth elements (REEs). Ore Geology Reviews, 122, art. 103521.

[5]DUSHYANTHA, N. et al. (2020), op. cit.; PECK, D. (2023), op. cit.

[6]RAVENHILL, J. (2014). Global value chains and development. Review of International Political Economy, 21(1), 264-274; RODRIK, D. (2018). New technologies, global value chains, and developing economies (NBER Working Paper No. 25164).

[7]KIGGINS, R. D. (2015), op. cit.; FARRELL, H., & NEWMAN, A. L. (2019). Weaponized interdependence: How global economic networks shape state coercion. International Security, 44(1), 42-79.

Sea makes these passages potential chokepoints that could be instrumentalised in times of heightened tension. The significant US presence within international trade networks partly constrains this Chinese advantage—the flows along first-order routes do not depend exclusively on the Asian hub—but that same interdependence leaves global supply chains vulnerable to deliberate disruptions[8]. The geography of rare earth elements is therefore not merely a matter of mineral distribution: it is the foundation of an asymmetric global power structure whose implications are examined in the following four sections.

[8]FARRELL, H., & NEWMAN, A. L. (2019), op. cit.; CHEN, W. et al. (2024). Interdependence in rare earth element supply between China and the United States helps stabilize global supply chains. One Earth, 7(2), 242-252.

The Arctic: the new frontier of strategic competition

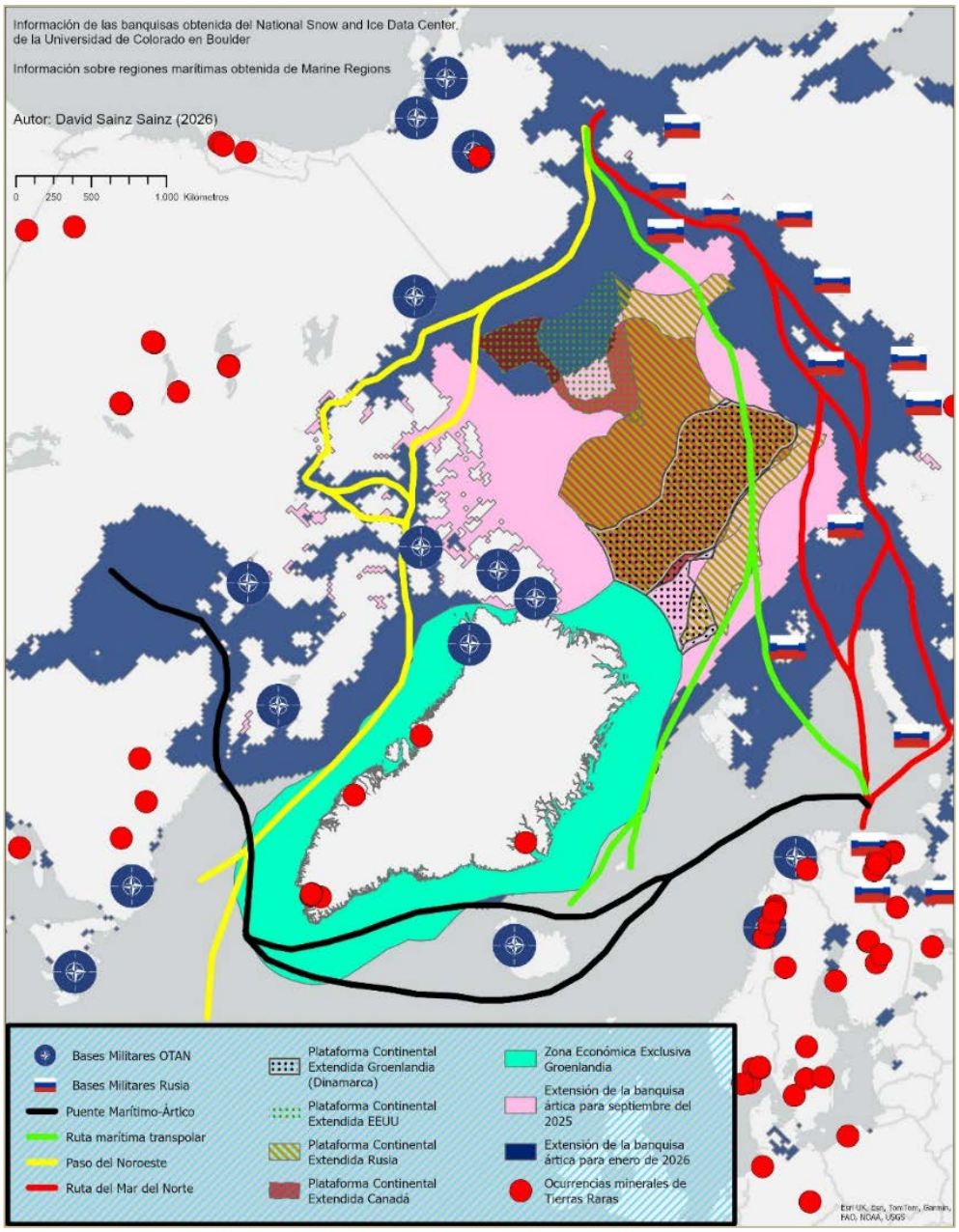


Figure 2: The Arctic. Rare earth deposits, emerging maritime routes, NATO and Russian military bases, and the extent of Arctic sea ice. Own elaboration. Sources: National Snow and Ice Data Center; Marine Regions; USGS; Stiftung Wissenschaft und Politik; Real Instituto Elcano; Agenzia Nova; Arctic Portal.

The seasonal and interannual fluctuations in Arctic sea ice are transforming a space that until recently was geopolitically peripheral into a new arena of competition over resources and shipping routes. Map 2 combines the extent of sea ice according to data from the

National Snow and Ice Data Center, the extended continental shelf and exclusive economic zone of Greenland, the four emerging Arctic maritime routes, and the distribution of NATO and Russian military presence—derived from open sources of an indicative and analytical nature[9]—together with known rare earth occurrences.

Greenland concentrates much of the strategic interest. As the world's largest island and a gateway to both the North Atlantic and the Arctic, it contains rare earth deposits of considerable potential significance—in particular the Tanbreez project in the south of the island, which contains substantial reserves of heavy rare earth elements—as well as a geographically pivotal position for controlling northern maritime routes. The explicit interest shown by the United States in the island, expressed with increasing determination since 2019, stems from this convergence of geological value and geostrategic position and should be understood within the broader context of Western efforts to secure sources of critical materials outside the Chinese hub[10].

In terms of shipping routes, the potential melting of Arctic sea ice opens up four corridors: the Northern Sea Route, the most mature and under Russian operational control through Rosatom; the Northwest Passage, logistically controlled by Canada and the United States; the Transpolar Sea Route; and the Arctic Bridge. Russia already channels 80% of Arctic maritime traffic through its northern route, which offers up to a 40% reduction in distance between Europe and Asia compared with traditional corridors. This position enables Russia to levy fees, regulate access, and project logistical influence over the transportation of raw materials, including rare earth concentrates[11].

The military deployment in the region reflects a clear dichotomy. Russia maintains an established presence in its Arctic sector—with bases along the northern coast and on islands of the archipelago—and has intensified its cooperation with China in exploration, logistics, and infrastructure. NATO concentrates its bases in the western sector—Norway, Canada, and Thule Air Base in Greenland—forming a perimeter that combines

[9]NATO Science and Technology Organization. (2017) Rare earths: Securing supply chains, materials, and technologies; Stiftung Wissenschaft und Politik (SWP); Real Instituto Elcano; Agenzia Nova. Arctic military bases: open sources of an indicative and analytical nature.

[10]CANNON, B. J., & ROSSITER, A. (2025). Rethinking and arresting Eurasian hegemony: The centrality of Central Asia to Indo-Pacific strategies. International Affairs, 101(4), 1193-1212.

[11]Data on Northern Sea Route traffic come from Rosatom and are compiled in: PECK, D. (2023), op. cit.; NATO Science and Technology Organization. (2017). Op. cit.

surveillance, defence, and privileged access to future mining projects. The progressive militarisation of the region turns resource-related tensions into a potential hybrid-conflict scenario in which disruptions to flows caused by sanctions or blockades could readily escalate into broader territorial tensions.

For the European Union, Arctic dynamics present an opportunity for diversification that cannot be overlooked. The deposits in Greenland and those in Fennoscandia—in particular Norway's Fen deposit, whose development is progressing slowly—represent potential sources of rare earth elements within the sphere of allied countries, capable of being integrated into European supply chains independently of the Chinese hub. The key question will be whether the EU can respond with the speed and investment ambition that the situation requires. If it fails to do so, this space will be left in the hands of bilateral initiatives that may not fully align with the interests of the bloc[12].

[12]PECK, D. (2023), op. cit.; European Commission. (n.d.), op. cit.

The Pacific: critical routes and Sino-American rivalry

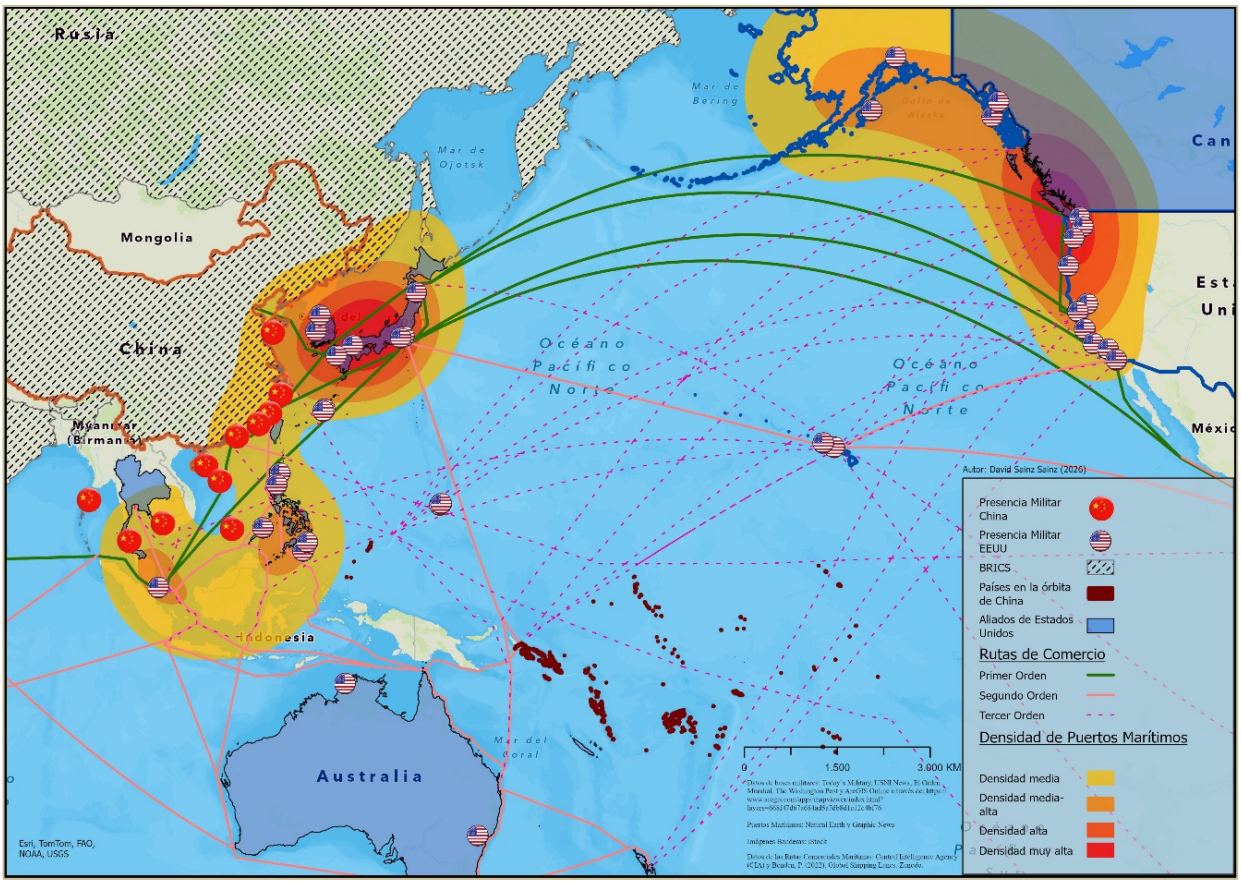


Figure 3: Hierarchised Pacific trade routes, port density, and the strategic and military positioning of the United States and China, including spheres of political and diplomatic influence. Own elaboration. Sources: Natural Earth; Graphic News; Benden, P. (2022), op. cit.; U.S. Department of Defense; USNI News.

Map 3 depicts the density of maritime ports and Pacific trade routes, again hierarchised by importance, together with the distribution of Chinese and US military presence and the associated spheres of political and diplomatic influence.

The Pacific concentrates the world's most strategically important trade routes for the movement of critical materials. First-order routes directly connect the US East Coast with the major port hub of Northeast Asia—Japan, South Korea, and mainland China—via the South China Sea corridor. Port density along this corridor reflects the region's economic centrality, but also its vulnerability: the Straits of Malacca and Taiwan are chokepoints whose disruption—through military escalation, blockade, or sanctions—could bring entire

industrial supply chains to a standstill within weeks[13].

The US military deployment in the Pacific is precisely a response to this vulnerability. The network of bases and security agreements with Australia, Japan, South Korea, the Philippines, and other regional partners positions Washington at key points controlling maritime flows, safeguarding the freedom of navigation on which the security of allied economies largely depends. This security architecture, built over decades of diplomatic and military investment since the mid-twentieth century, has no equivalent in China's global projection of power, whose dominance in the resource sphere is not yet matched by a comparable capacity to control flows on a global scale[14].

Russia's presence in the vicinity of these routes—as Beijing's strategic partner within the BRICS framework—adds a further dimension of risk that the map helps to illustrate. The Sino-Russian alignment does not currently entail joint control over Pacific flows, but it expands the potential perimeter of friction and complicates the geometry of the Western response. For economies dependent on these routes—including the EU—Pacific stability is a global public good whose provision cannot be entirely outsourced to Washington; rather, it requires an active contribution from the European bloc to the security architecture that underpins it[15].

Economic interdependence between China and the West in the rare earth sector has so far acted as a partial buffer against tensions. Trade flows between the two blocs generate mutual benefits that neither side has an interest in eliminating abruptly. However, the experience of 2010 and the restrictions introduced in 2025 demonstrate that Beijing does not hesitate to instrumentalise this interdependence when it calculates that the geopolitical benefit outweighs the economic cost. Western democracies cannot afford to assume that commercial rationality will prevail indefinitely[16].

[13]FARRELL, H., & Newman, A. L. (2019), op. cit.
[14]CANNON, B. J., & ROSSITER, A. (2025), op. cit.; Mackinder, H. J. (1904). The geographical pivot of history. The Geographical Journal, 23(4), 421-437.
[15]POZSAR, Z. (2022). Money, commodities, and Bretton Woods III. Credit Suisse Research Institute.
[16]FARRELL, H., & NEWMAN, A. L. (2019), op. cit.; CHEN, W. et al. (2024), op. cit.

The European Union: peripheral vulnerability and regulatory response

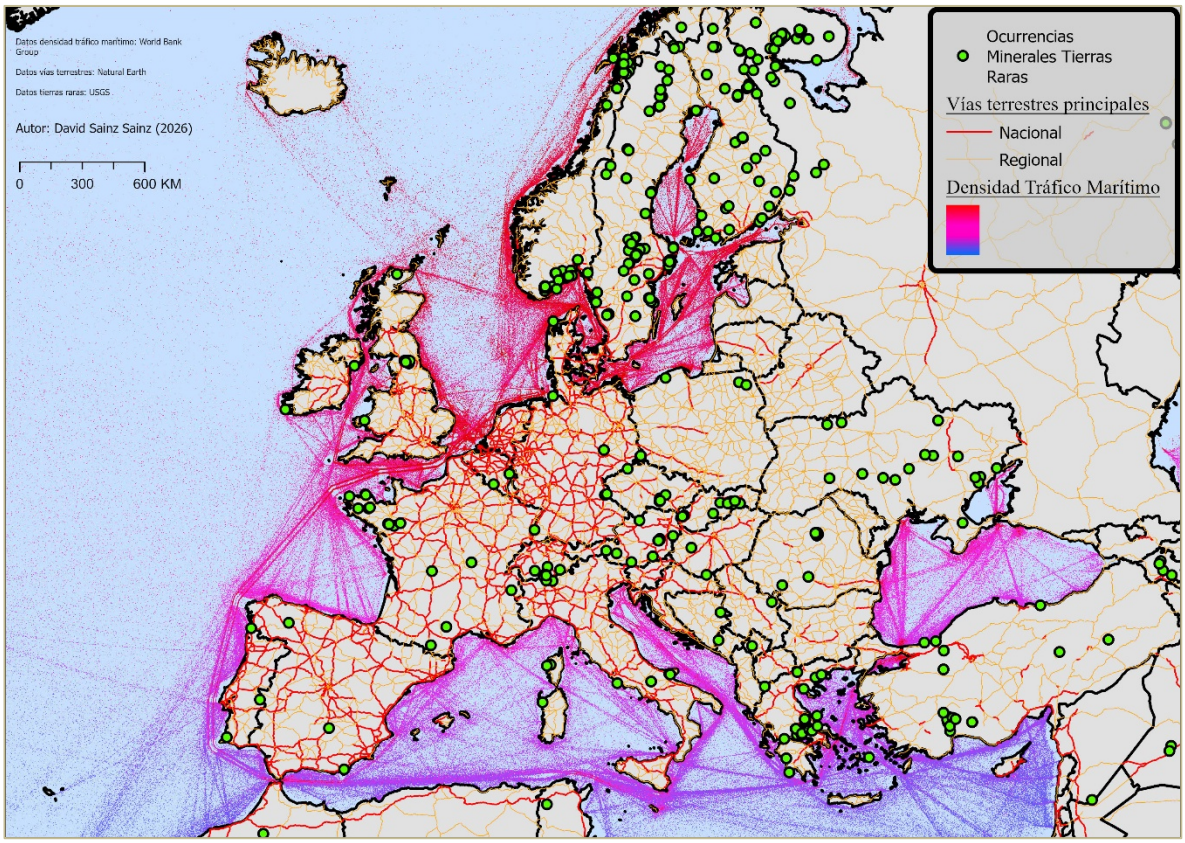


Figure 4: Maritime traffic density in European waters, terrestrial transport networks, and the location of known rare earth mineral occurrences. Own elaboration. Sources: World Bank Group; Natural Earth; USGS.

Map 4 combines maritime traffic density in European waters, the main road and rail networks, and the location of known rare earth occurrences. The result is a picture of almost total dependency. The European Union consumes approximately 10–15% of the world's rare earth elements, with demand concentrated in strategic sectors—including electric vehicle motors, wind turbines, and defence electronics—and has neither active mining production nor significant industrial capacity for refining and chemical separation[17].

The deposits identified within European territory—concentrated mainly in Sweden, Finland, and Norway—remain largely at the exploration stage or are held back by excessively lengthy permitting processes, social opposition, and environmental standards

[17]European Commission. (n.d.), op. cit.; Dushyantha, N. et al. (2020), op. cit.

which, while legitimate in their purpose, are not calibrated to address the geostrategic urgency of the present moment. The paradigmatic case is Sweden's Per Geijer deposit, operated by LKAB and regarded as the largest in Europe: the permitting process, initiated in 2022, is not expected to be completed before the 2030s, a time horizon that is out of step with the pace of geopolitical competition for critical materials[18].

The map also reveals an internally significant geographical imbalance of strategic importance: the high density of maritime traffic in the Baltic and North Atlantic represents a genuine logistical advantage for Fennoscandia—where occurrences are more abundant—but the lower density of terrestrial transport networks in the region introduces an additional layer of complexity. Without significant investment in connecting infrastructure, northern deposits risk becoming isolated from production and processing centres in continental Europe. This creates a characteristic geographical paradox: Europe has competitive maritime routes, but the distance between its inland deposits and these flows increases the cost of exploitation compared with established Asian routes.

The so-called discovery bias—greater investment in geological exploration in the Nordic countries than in southern and eastern Europe—also introduces an asymmetry into the map of the region's internal potential that the available data do not yet allow to resolve. Occurrences in central Europe and Ukraine could alter this picture if systematic exploration were undertaken, but the absence of rigorous economic assessments leaves them in the realm of geological speculation[19].

The European response has evolved towards a clearer regulatory ambition. The Critical Raw Materials Act, adopted in 2024, establishes binding targets for 2030: at least 10% of annual demand extracted within European territory, 40% processed within the EU, and 25% sourced from recycling[20]. These targets point in the right direction, but stand in contrast to the current industrial reality: Europe's refining capacity is virtually non-existent, the time required to develop it is considerable, and the funds committed are insufficient relative to the scale of the challenge.

[18]GOODENOUGH, K. M. et al. (2016). Europe's rare earth element resource potential: An overview of REE metallogenetic provinces and their geodynamic setting. Ore Geology Reviews, 72, 838-856.
[19]GOODENOUGH, K. M. et al. (2016), op. cit.
[20]European Commission. (n.d.), op. cit.

The friend-shoring strategy—diversifying supply towards allied countries such as Australia, Canada, Namibia, and Kazakhstan—is a necessary complement but not a substitute for domestic capabilities. Agreements concluded within this framework reduce exposure to a single supplier, but partly reproduce the same pattern of external dependency if they are not accompanied by investment in processing capacity within the bloc. The EU risks replacing dependence on China with managed dependence on other suppliers, without addressing the structural bottleneck represented by the absence of domestic refining capacity[21].

Spain: between structural dependence and latent potential

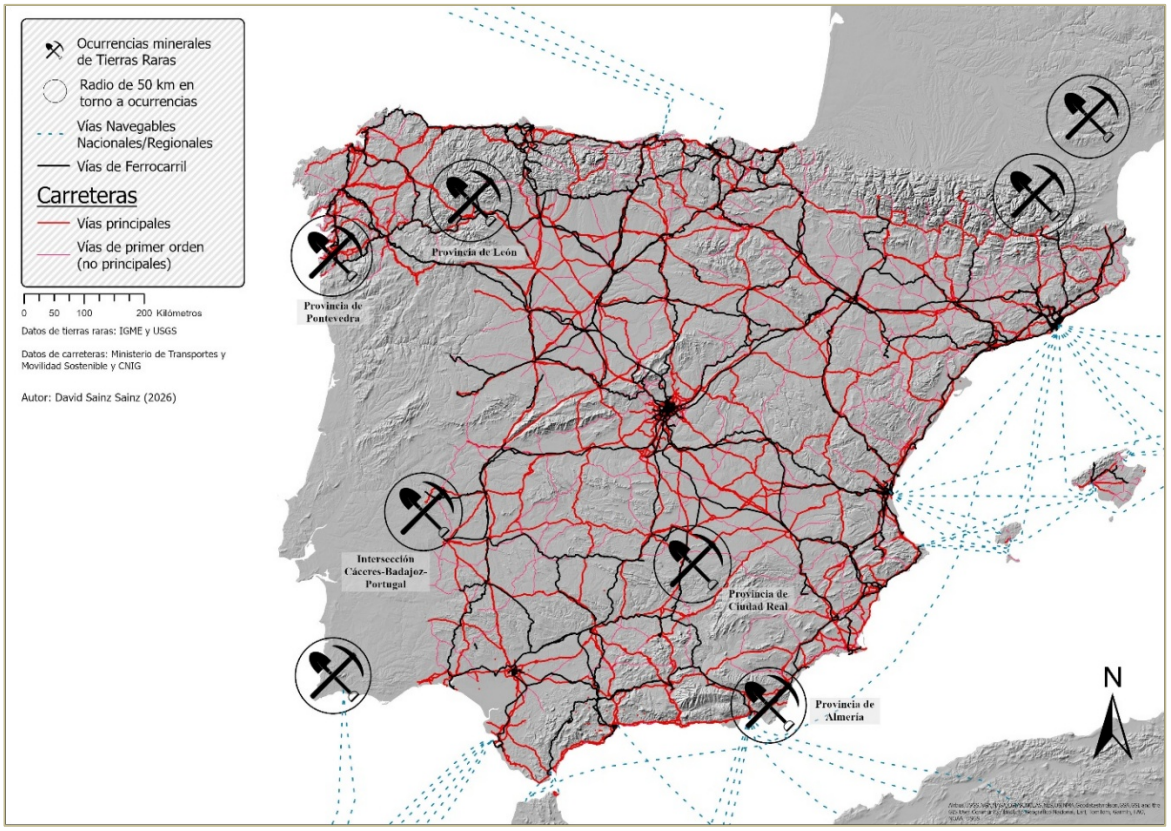


Figure 5: Rare earth occurrences in Spain and transport infrastructure network (main and first-order roads, railways, and navigable waterways). 50 km radii around each occurrence. Own elaboration. Sources: IGME; USGS; Ministerio de Transportes y Movilidad Sostenible; CNIG.

[21]PECK, D. (2023), op. cit.

At present, Spain neither produces nor refines rare earth elements. Its position in the global supply chain is that of a pure importer, capturing value exclusively at the final stages—assembly, consumption, and incipient recycling—without participating in any of the stages that generate technological power or bargaining leverage[22]. This situation is structural: there is no active mining production, no industrial facilities for chemical separation, and the geological occurrences identified within Spanish territory generally lack the economic assessment required to determine whether they constitute resources with development potential or merely occurrences without demonstrated commercial viability.

For methodological purposes, it is important to distinguish between the different stages of the supply chain: an occurrence or indication is simply the detection of mineral presence without characterisation of volume or concentration; a resource implies a degree of geological characterisation but does not guarantee economic viability; a reserve is a proven resource that is economically exploitable under current market conditions; and active production additionally requires industrial infrastructure, processing capacity, and access to markets. The cartographic analysis presented here works with occurrences and indications recorded in official sources. The inferences regarding logistical accessibility are descriptive and indicative in nature, but cannot in themselves establish the economic viability of any mining operation, which would require specific pre-feasibility studies that are currently unavailable in most cases.

Map 5 depicts the location of known occurrences and indications in relation to the existing transport network, with 50-kilometre radii drawn around each occurrence to facilitate the visualisation of its potential logistical accessibility. According to official IGME cartography, indications have been recorded in several regions: southwestern Galicia, the area around Ciudad Real, parts of eastern Andalusia—with an indication in the province of Jaén awaiting more detailed characterisation—and other smaller sites scattered across the central plateau and northern Spain[23].

[22]CHOMÓN PÉREZ, J. M. (2025). Las tierras raras y la seguridad nacional y humana en España [Tesis doctoral, Universidad de Salamanca]. GREDOS; ALGORA WEBER, M. D. (2021). El impacto geopolítico de las tierras raras en el orden internacional. Economía Industrial, 420, 47-58.

[23]Instituto Geológico y Minero de España (IGME). Base de datos de recursos minerales de España; Ministerio para la Transición Ecológica y el Reto Demográfico. (2021). Plan Nacional de Materias Primas Minerales 2021-2030. Gobierno de España. Las ocurrencias mencionadas corresponden a indicios registrados en la cartografía oficial; su

The cartographic analysis shows that high-capacity roads, certain railway lines, and even regional maritime connectivity networks are present within these 50-kilometre radii. This would reduce the hypothetical logistical costs of any potential exploitation compared with more isolated locations, but it does not replace an assessment of mineral concentration, volume, extraction and processing costs, or competitiveness against the major deposits currently in production worldwide. The occurrences in Almería and southwestern Galicia present somewhat more favourable logistical conditions, particularly the former due to its proximity to Mediterranean maritime routes.

The absence of systematic and up-to-date geological exploration makes it impossible to determine whether these indications reach the concentration and scale thresholds required to make them economically competitive. Without such a preliminary assessment, any industrial development plan would be premature, and establishing this knowledge base would require a clear political and budgetary commitment. It should therefore first acquire a priority position on the national agenda[24].

The recent business landscape adds a dimension that deserves attention. The exploration of strategic mineral resources in Spain is being undertaken in part by foreign capital, which could reproduce the pattern identified by resource curse theory as the most unfavourable for host countries: expatriated profits, limited technology transfer, and control of strategic assets in foreign hands[25]. This issue must be managed in a way that promotes the active participation of the Spanish state in the strategic autonomy of the European bloc.

The most realistic strategy for Spain in the short to medium term is not to become a major primary producer, but rather to develop a three-pillar approach: systematic exploration and economic assessment of identified indications; development of recycling and secondary recovery capacity, where the country's industrial base—particularly in automotive manufacturing, wind power generation, and electronics—provides a concrete

viabilidad económica requeriría prospección sistemática y estudios de prefactibilidad que en la mayoría de los casos no se han completado.

[24]CHOMÓN PÉREZ, J. M. (2025), op. cit.

[25]Xunta de Galicia. (2026). Plan de reactivación minera de Galicia. Para el Plan Nacional de Minerales Críticos: Ministerio para la Transición Ecológica y el Reto Demográfico. (2024). Plan Nacional de Minerales Críticos. Gobierno de España. Sobre presencia de capital extranjero en exploración minera española: Atalaya Mining plc. (2025). Annual Report and Accounts 2024; Denarius Metals Corp. (2025). Corporate Presentation.

starting point; and active positioning within the international secure-supply networks being developed under the Critical Raw Materials Act, enabling Spain to capture value in processing and assembly even if it cannot compete in primary extraction.

Conclusions

The multiscalar analysis developed in this study allows five conclusions of strategic interest for Spain and the European Union to be drawn.

First: the geological and technological asymmetry in China's favour is not an immutable fact of nature, but the cumulative result of political decisions—both Chinese and Western—that can and should be partially reversed. China has built its advantage through sustained state investment and by assuming environmental costs that no democracy can replicate on the same terms. The West can and must therefore compete in the stages with the highest added value—processing, component manufacturing, and recycling—without requiring parity in primary extraction.

Second: the Arctic and the reconfiguration of global trade routes are opening a window for diversification that Western allies cannot leave exclusively in Washington's hands. The exploration and development of deposits in Greenland, Norway, and Canada, within the framework of alliances among democracies, is the most viable medium-term alternative to dependence on the Chinese hub. The EU must commit its own resources, not merely establish regulations.

Third: economic interdependence with China has a stabilising value, but it cannot be the sole guarantee of security of supply for critical materials. Managing this interdependence requires the simultaneous development of domestic capabilities that increase the political cost of any potential restriction: without credible alternatives, economic coercion will always follow the path of least resistance.

Fourth: the Critical Raw Materials Act sets appropriate objectives, but bridging the gap between regulation and industrial capacity requires a degree of political will that has not yet been demonstrated with sufficient clarity in Spain. The exploration of occurrences, the conditions governing foreign capital's access to strategic resources, and the development of recycling infrastructure are decisions that cannot be postponed without incurring a real geopolitical cost.

Fifth**:** Spain possesses basic logistical infrastructure that, in certain cases, could be favourable to the potential exploitation of its geological occurrences. However, logistical accessibility is a necessary but not sufficient condition: economic pre-feasibility assessments, which are currently lacking, are required, as are access conditions that ensure value is retained within Spain and the European Union.

David Sainz Sainz *
Geographer. Master's student in *Tecnologías de la Información Geográfica*, Complutense University of Madrid

Rosa Mecha López *
PhD in Geography. Research and teaching faculty member at Complutense University of Madrid.