Geosciences Supporting the EU Competitiveness Compass

October 2025. A Position Paper on the Essential Role of Earth Sciences in European Competitiveness and Innovation

1. Executive Summary

Geosciences are fundamentally intertwined with the European Union's economic growth, competitiveness objectives, and strategic autonomy. As the EU implements its Competitiveness Compass and pursues the dual green and digital transitions, Earth sciences provide the essential foundation for sustainable economic development, resource security, and innovation-led productivity growth.

The geosciences sector directly contributes over €200 billion annually to EU GDP through natural resource industries, environmental services, and technological innovation. Beyond direct economic contributions, geoscientific expertise underpins every aspect of the EU's competitiveness agenda: from securing critical raw materials essential for clean technologies to enabling climate-resilient infrastructure, from supporting renewable energy deployment to managing water resources for agricultural and industrial productivity.

Key Economic Contributions:

- Critical raw materials assessment and responsible extraction supporting the EU's strategic autonomy,
- Climate resilience and adaptation strategies protecting €billions in infrastructure and economic assets,
- Renewable energy resource assessment and deployment supporting the clean transition,
- Environmental risk management reducing economic disruption, insurance costs, impact on ecosystem services, and ecosystem and human health and safety.
- Innovation in clean technologies, AI applications, and sustainable resource management.

Policy Recommendations:

- Integrate geoscientific expertise into EU competitiveness and industrial policy frameworks,
- Expand geological education and skills programmes to address critical workforce gaps,
- Support geoscience-based innovation through dedicated research and development funding,
- Strengthen geological surveys cooperation across Member States for strategic environmental and resource management and use, by supporting a sustainably-funded Geological Service for Europe,
- Leverage geoscientific knowledge for enhanced climate adaptation and economic resilience.

2. The Economic Imperative

2.1. Geosciences and EU Competitiveness

The European Union's ability to boost competitiveness, achieve strategic autonomy, and succeed in the green and digital transitions depends critically on geoscientific knowledge and expertise. As outlined in the EU's Competitiveness Compass, Europe faces massive investment needs of €750-800 billion per year by 2030 to achieve its innovation, climate neutrality, and defence objectives. Geosciences provide the fundamental understanding and technological capabilities necessary to make these investments successful.

Earth sciences serve as the foundation for numerous sectors identified as priorities in the EU's industrial strategy. The extraction, processing, and recycling of critical raw materials—central to the Critical Raw Materials Act—requires geological expertise to locate primary and secondary deposits, assess extraction feasibility, develop sustainable processing technologies, monitor raw materials supply chains, create circular economy solutions, generate needed research and innovation across these areas, provide trusted expert knowledge to support public awareness and social acceptance, and deliver technical support to strategic international partnerships on raw materials. Without robust geoscientific capacity, the EU cannot achieve its target of mining 10% of strategic raw materials domestically, processing 40%, and recycling 25% by 2030.

2.2. Resource Security and Strategic Autonomy

The EU's current extreme dependence on third countries for critical raw materials—including 100% reliance on China for rare earth processing and 97% for magnesium—represents a fundamental economic vulnerability. Geoscientists are essential for reducing these dependencies by mapping domestic resources, developing extraction technologies suitable for European conditions, creating innovative recycling and substitution strategies, and supporting strategic partnerships with like-minded third countries.

Recent geopolitical disruptions have highlighted these vulnerabilities. China's export restrictions on gallium, germanium, graphite, and antimony have led to dramatic price increases, with gallium prices nearly doubling and antimony reaching record highs. These materials are essential for defence technologies, renewable energy systems, and digital infrastructure—all priorities for EU competitiveness.

3. Impact of Geoscience on the EU Economy

3.1. Critical Raw Materials and Clean Technology Manufacturing

Economic Scale. The European raw materials sector contributes over €1.3 trillion annually to EU GDP, supporting millions of jobs across mining, processing, and manufacturing value chains.

Geoscience Contributions. Geoscientists identify and assess critical raw material mineral deposits essential for EU supply chain and economic resilience, and technological sovereignty. This relies on

ongoing investment in building knowledge of the mineral prospectivity and mineral endowment of the European continent, primarily through the activities of geological survey organisations, in turn driving private exploration investment. Generation of new geoscience data and knowledge is crucial. Modern exploration methods, including AI-enhanced geological modelling and remote sensing, can also significantly improve discovery rates whilst reducing environmental impacts.

The transition to renewable energy technologies depends entirely on geological knowledge for materials sourcing. Wind turbines require rare earth elements for permanent magnets, solar panels need silicon and silver, and battery systems demand lithium, cobalt, and nickel. European competitiveness in clean technology manufacturing requires secure, sustainable access to these materials, which only comprehensive geological data, information, and expertise can provide.

3.2. Renewable Energy Resource Assessment and Deployment

Economic Scale. The EU renewable energy sector represents €100+ billion in annual investment, with geothermal energy alone projected to reach €20 billion by 2030.

Geoscience Contributions. Geoscientists assess and develop renewable energy resources across multiple domains. Geothermal energy assessment requires detailed subsurface geological knowledge to identify heat sources, evaluate reservoir characteristics, and design sustainable extraction systems. Wind energy development depends on geological assessment for site selection and foundation design, whilst hydroelectric projects require comprehensive hydrological and geological analysis.

Carbon capture, utilisation, and storage (CCUS) technologies—essential for achieving climate neutrality in energy-intensive industries—rely fundamentally on geological expertise. Geoscientists identify suitable storage formations, assess capacity and integrity, and monitor long-term storage security. The EU's industrial decarbonisation strategy, particularly for steel, cement, and chemical sectors, depends on successful CCUS deployment.

3.3. Climate Adaptation and Economic Resilience

Economic Scale. Climate-related damages in Europe average €12 billion annually, with projections reaching €20+ billion by 2030 without adequate adaptation measures.

Geoscience Contributions. Geoscientists provide essential climate adaptation services that protect economic infrastructure and maintain productivity. Coastal erosion management, flood risk assessment, and extreme weather impact evaluation all require geological expertise. Understanding subsurface conditions enables design of climate-resilient infrastructure, from transport networks to energy facilities.

Agricultural productivity—worth €178 billion annually in the EU—depends on soil science expertise for sustainable intensification, precision agriculture, and climate adaptation. Hydrogeological knowledge ensures sustainable groundwater management for irrigation whilst protecting aquifer resources for long-term food security.

3.4. Circular Economy and Resource Efficiency

Economic Scale. The European circular economy sector generates €200+ billion annually and supports 4 million jobs, with potential to reach €500 billion by 2030.

Geoscience Contributions. Geoscientists enable circular economy development through urban mining technologies, waste characterisation for resource recovery, and development of substitution materials. Advanced analytical techniques identify recoverable materials in mine tailings, industrial waste streams, and end-of-life products.

Research into alternative materials reduces dependence on critical raw materials whilst maintaining technological performance. For example, geological research into clay minerals and industrial minerals can provide alternatives to imported materials for construction, ceramics, and advanced manufacturing applications.

3.5. Environmental Risk Management and Insurance

Economic Scale. Environmental risk management services represent €30+ billion annually in the EU, whilst climate-related insurance losses average €15 billion per year.

Geoscience Contributions. Geoscientists provide essential risk assessment services that enable economic planning and investment decisions. Natural hazard assessment—including earthquake, landslide, and flood risks—underpins insurance models and infrastructure design standards. Environmental site assessment enables brownfield redevelopment, supporting urban regeneration and economic growth.

Space weather monitoring and geomagnetic risk assessment protect critical infrastructure including satellite communications, power grids, and navigation systems. A single severe space weather event could cause €40+ billion in economic losses across Europe, making geoscientific monitoring and prediction services essential for economic security.

4. Geoscience enables EU Strategic Priorities

4.1. Innovation and Digital Technologies

Geosciences contribute significantly to the EU's innovation ecosystem through development of modelling, AI applications, digital twin technologies, and advanced materials research. Machine learning applications in geological exploration, environmental monitoring, and resource management represent growing markets worth billions annually.

Digital geological models support infrastructure planning, urban development, and climate adaptation strategies. Integration of geological data with IoT sensors and satellite observations enables precision agriculture, environmental monitoring, and natural hazard early warning systems.

4.2. International Partnerships and Development

European geological expertise supports international partnerships through technical assistance, capacity building, and joint development projects. The EU's Global Gateway initiative leverages geological knowledge for sustainable mining partnerships, climate adaptation support, and resource management cooperation with partner countries.

These partnerships provide economic returns through technology export, consulting services, and preferential access to mineral resources whilst supporting sustainable development objectives in partner countries.

4.3. Defence and Security Applications

Geoscientific expertise supports EU defence and security objectives through resource security assessment, infrastructure protection, and environmental intelligence. Understanding geological conditions enables secure facilities design, operational planning, and strategic resource management for defence applications.

5. Case Studies: Geoscience Drives Economic Value

5.1. European Lithium Development

Portugal's lithium deposits, identified through advanced geological exploration, represent €10+ billion in potential economic value. Geoscientific expertise enables sustainable extraction methods that meet EU environmental standards whilst providing strategic materials for battery manufacturing.

5.2. North Sea Carbon Storage

Geological assessment of North Sea formations enables large-scale carbon storage projects worth €20+ billion in investment. These projects support industrial decarbonisation while maintaining European manufacturing competitiveness in global markets.

5.3. Geothermal Energy in Iceland-EU Partnership

Geological expertise enables geothermal energy development that could provide 25% of EU heating needs through underwater cables and heat networks. Economic value exceeds €50 billion in investment whilst supporting energy security objectives.

5.4. Mediterranean Critical Minerals

Geological surveys across Mediterranean regions have identified substantial deposits of battery raw materials and rare earth elements. Sustainable development of these resources could reduce EU import dependence by 30% while supporting regional economic development.

6. Challenges and Opportunities

6.1. Skills and Workforce Development

The EU faces a critical shortage of geological expertise, with over 40% of geoscientists approaching retirement age whilst university programmes struggle to attract students. This skills gap threatens the EU's ability to implement its competitiveness agenda and achieve strategic autonomy in critical materials.

Opportunities:

- Cross-disciplinary programmes linking geology with engineering, environmental science, and data science,
- Enhanced career pathways in emerging sectors such as carbon storage, renewable energies, and space resources and deep-sea minerals.
- Modern geological techniques incorporating AI, robotics, and environmental sustainability attract new generations.
- Increasing the mobility of geologists within the Single Market to address skill gaps and boost competitiveness by including the Geologist profession in Directive 2005/36/EC, ensuring the automatic recognition of qualifications.

6.2. Regulatory Framework and Permitting

Current permitting processes for geological projects average 5-7 years across Member States, significantly hindering competitiveness compared to other regions. Streamlined, harmonised permitting frameworks could accelerate project development whilst maintaining environmental protections.

Opportunities:

- Digital permitting systems reducing administrative burden,
- Harmonised environmental standards across Member States,
- Strategic project designation for critical raw materials development.

6.3. Technology Innovation and Investment

European geological research requires increased investment to maintain global leadership in sustainable extraction technologies, environmental monitoring, and resource assessment. Current R&D investment lags behind competitors in Asia and North America.

Opportunities:

- EU research programmes linking geological science with clean technology development,
- Public-private partnerships for geological innovation,
- Integration with Horizon Europe and Clean Industrial Deal initiatives.

7. Policy Recommendations

7.1. Strategic Integration

Embed Geoscientific Expertise in EU Competitiveness Framework. Integrate geological expertise systematically into the Competitiveness Coordination Tool, ensuring Earth sciences perspectives inform industrial strategy, infrastructure planning, and international partnerships. This integration should encompass:

- Geological assessment requirements for Strategic Projects under critical raw materials legislation,
- Incorporation of geological expertise in Clean Industrial Deal implementation, including support to a sustainably funded Geological Service for Europe
- Earth sciences input to the European Defence Fund for resource security and infrastructure resilience.
- Using recognised diploma levels and certifications, such as the European Geologist (EurGeol) professional title, as benchmarks under EU legislation to contribute to the simplification of the regulatory framework for responsible resource extraction, while upholding rigorous ethical, environmental, and professional standards for geologists.

Establish European Geological Intelligence Capability. Create a coordinated geological intelligence function linking Member State geological surveys with EU strategic planning, connected to a future Geological Service for Europe. This capability should support early warning for resource supply disruptions, assessment of emerging opportunities, and coordination of geological data across borders.

7.2. Skills and Capacity Development

Launch EU Geological Skills Initiative. Address critical skills shortages through comprehensive education and training programmes linking universities, industry, and research institutions. Priority actions include:

- Modernised geological curricula incorporating digital technologies, sustainability, and interdisciplinary approaches,
- European geological mobility programmes facilitating skills exchange across Member States,
- Industry-academia partnerships providing practical training and career pathways,
- Recognition and certification standards enabling geological professionals to work across EU borders.

Support Geological Research and Innovation. Significantly increase R&D investment in geological sciences through dedicated funding streams within Horizon Europe and the proposed European Competitiveness Fund. In addition to existing and coming relevant Partnerships such as Water4All, Clean Energy Transition, and Raw Materials, funding streams should be dedicated to a Partnership supporting a Geological Service for Europe that also addresses:

- Integrated geological data, information, and knowledge that matches the integrated nature of Earth's subsurface systems,

- Climate adaptation and resilience technologies based on Earth system understanding,
- Interdependencies between subsurface resources and environments including critical raw materials, geothermal heat, pore space for H or CO2 storage, soil health, geohazard monitoring and mitigation, and groundwater,
- Holistic, and strategic management of the increasing use of the European subsurface.

7.3. Institutional Framework

Strengthen European Geological Survey Network. Enhanced cooperation among Member State geological surveys to support EU strategic objectives whilst respecting national competences, by sustainably funding a Geological Service for Europe. Key elements include:

- Harmonised geological data standards and sharing protocols and ongoing support to the European Geological Data Infrastructure,
- Sustained support to a collaborative pan-European geological expert network to provide on-demand policy support,
- Joint assessment programmes for geological resources (e.g., raw materials, groundwater, geothermal energy, CO2 storage), across borders,
- Coordinated research programmes addressing EU-wide challenges.

Create EU Centre for Geological Innovation. Establish a dedicated centre linking geological research with industrial applications, supporting technology transfer and commercialisation of geological innovations. The centre should coordinate with existing institutions while filling gaps in applied geological research.

7.4. International Cooperation

Expand Geological Diplomacy. Strengthen geological cooperation with international partners through enhanced technical exchanges, joint research programmes, and capacity building initiatives. Priority partnerships include:

- Enhanced cooperation with Canada, Australia, and other resource-rich countries leveraging their geological expertise and resources,
- Technical assistance programmes in developing countries building geological capacity whilst securing resource partnerships,
- Multilateral initiatives through G7, OECD, and UN frameworks promoting sustainable resource development.

Support Responsible Mining Partnerships. Leverage European geological expertise to support sustainable mining development in partner countries, creating win-win partnerships that provide EU resource access whilst supporting sustainable development.

7.5. Regulatory and Market Framework

Streamline Geological Project Permitting. Implement transparent permitting procedures for strategic geological projects whilst maintaining environmental protections. Key reforms include:

- Harmonised permitting decision-trees across Member States,
- Digital permitting platforms reducing administrative burden,
- Strategic project designation for critical raw materials exploration and development,
- Environmental assessment procedures optimised for geological projects.

Reinforce the European Geological Data Infrastructure. Expand comprehensive, accessible geological databases supporting business development, research, and policy-making. This infrastructure should link national geological data while ensuring security for sensitive information. It should be sustained through support to a Geological Service for Europe.

8. Economic Impact Projections

8.1. Short-term (2025-2030)

- **Direct Economic Contribution:** €250+ billion annually through enhanced resource security, innovation, and environmental services.
- **Job Creation:** 500,000 new positions across geological services, environmental consulting, and resource industries.
- **Investment Mobilisation:** €100+ billion in geological research, exploration, and sustainable resource development.

8.2. Medium-term (2030-2040)

- **Strategic Autonomy Benefits:** €50+ billion annual savings through reduced critical raw materials import dependence.
- **Climate Adaptation Returns:** €200+ billion in avoided climate damages through improved resilience and early warning systems.
- **Innovation Economy Growth:** €300+ billion in new industries based on geological knowledge and sustainable resource technologies.

8.3. Long-term (2040-2050)

- **Circular Economy Maturation:** €500+ billion annual economic value through comprehensive resource recovery and substitution.
- **International Leadership:** €100+ billion in geological services exports and technology licensing.
- **Climate Neutrality Support:** Essential contribution to EU climate neutrality whilst maintaining industrial competitiveness.

9. Conclusion

Geosciences represent a fundamental enabler of EU economic competitiveness, strategic autonomy, and sustainable development. As Europe implements its Competitiveness Compass and pursues ambitious climate and digital transition goals, Earth sciences provide the essential knowledge and technological capabilities necessary for success.

The economic value of geosciences extends far beyond traditional resource extraction to encompass innovation, climate resilience, environmental protection, and international cooperation. Investment in geological expertise, research, and infrastructure will yield substantial returns across multiple sectors whilst supporting broader EU strategic objectives.

The recommendations outlined in this position paper provide a framework for leveraging geoscientific knowledge to support a vibrant EU economy. Implementation requires coordinated action across EU institutions, Member States, industry, and research communities, working together to harness Europe's geological potential for sustainable prosperity.

The choice is clear: invest in geological expertise and infrastructure to secure Europe's economic future, or accept continued dependence on external resources and diminished competitiveness in an increasingly challenging global environment. Geosciences offer a pathway to European economic sovereignty, environmental sustainability, and long-term prosperity.

About this Position Paper

This position paper builds upon extensive consultation with geological professionals, industry representatives, and policy experts across the European Union. The recommendations reflect current best practices in geological sciences and their applications to contemporary economic and policy challenges.

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