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Critical minerals in the European seas: The project GeoERA-MINDeSEA

Javier Gonzalez[1], Teresa Medialdea[1], Henrik Schiellerup[2], Irene Zananiri[3], Pedro Ferreira[4], Luis Somoza[1], Xavier Monteys[5], Thomas Kuhn[6], Johan Nyberg[7], Igor Melnyk[8], Vitor Magalhaes[9], Rosario Lunar[10], Egidio Marino[10], James R. Hein[11], Georgy Cherkashov[12], and MINDeSEA team[1]

[1]Geological Survey of Spain (IGME), Marine Geology Division, Madrid, Spain (fj.gonzalez@igme.es)
[2]Geological Survey of Norway (NGU)
[3]Hellenic Survey of Geology and Mineral Exploration (HSGME). Greece
[4]National Laboratory of Energy and Geology (LNEG). Portugal
[5]Geological Survey Ireland (GSI)
[6]Federal Institute for Geosciences and Natural Resources (BGR). Germany
[7]Geological Survey of Sweden (SGU)
[8]SRDE "GeoInform of Ukraine" (GIU)
[9]Portuguese Institute for Sea and Atmosphere (IPMA)
[10]Geosciences Institute (IGEO). Spain
[11]U.S. Geological Survey (USGS). USA
[12]Institute for Geology and Mineral Resources of the Ocean (VNIIOkeangeologia). Russia

The oceans and seas cover more than 70% of the planet, representing a promising new frontier for mineral resources exploration, and an enormous challenge for science and technology. Communities are demanding actions to address global climate change, and the necessary high- and green-technologies required for a transition from a carbon-based to green-energy-based world. The global ocean is at the core of these issues. The seabed mineral resources host the largest reserves on Earth for some critical metals like cobalt, tellurium, manganese, and the rare earth elements, critical for Industry. But seabed geology and ecosystems are widely unexplored, and new geological and environmental studies are required to address the impacts of potential mining activities. In addition, a regulatory framework for minerals extraction and marine spatial planning are necessary for seabed mining sector development.

The pan-European seas cover about 15 millions square kilometres in the Arctic and Atlantic oceans and the Mediterranean, Baltic, and Black seas, from shallow waters up to 6000 m water depth. Spanning a large diversity of environments and resource settings, including high and low temperature hydrothermal deposits, phosphorites, cobalt-rich ferromanganese crusts, and manganese nodules, deep-sea deposits are particularly attractive for their polymetallic nature with high contents of rare and critical metals. Moreover, shallow-water resources, like marine placer deposits, represent another source for many critical metals and gems. The GeoERA-MINDeSEA[1] project is compiling data and genetic models for all these deposit types based on extensive studies, carried out previously, which include geophysical surveys, dredging stations, underwater

photography and ROV surveys, and mineralogical, geochemical, and isotopic studies.

The preliminary MINDeSEA results show the potential of the pan-European seas for critical metals, and the enormous gaps of information covering vast marine sectors. More than 600 mineral occurrences are reported in the MINDeSEA database. Seamounts and banks in the Macaronesia sector (Portugal and Spain) and the Arctic ridges (Norway, Denmark, Iceland) show a high potential for Fe-Mn crusts, rich in energy-critical elements like Co but also Te, REEs, and Mn. Fe-Mn crusts are accompanied by phosphorites on the seafloor of continental shelves and slopes along the western continental margins. Seafloor polymetallic sulphides and metalliferous sediments precipitating from hot hydrothermal solutions and plumes are forming today in the Azores Islands (Portugal), the Arctic (Norway, Denmark) and, the Mediterranean volcanic arcs (Italy and Greece). They are among the most important marine resources for Cu, Zn, Ag, and Au. In addition, hydrothermal deposits may contain economic grades of Co, Sn, Ba, In, Bi, Te, Ga, and Ge. Placer deposits of chemically resistant and durable minerals have been discovered on shallow-water settings (<50 m water depth on estuaries, deltas, beaches) linked to the weathering of onshore rocks and ore deposits from the Variscan Belt (UK, France, Portugal, Spain). Finally, shallow-water concretions and nodules from the Arctic, Baltic, and Black Sea represent potential targets for metals exploration and environmental studies.

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