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Hydrogenetic Fe-Mn crusts from European seas: source of potentially economic cobalt mining.

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The world increasing demand of electric vehicles (EVs) that use lithium-ion batteries (LIB), in which cobalt is one of the essential elements, focused the attention on its demand that is calculated will increase of 7-13% annually until 2030. The actual production of cobalt, usually extract as by-product of nickel and copper mine, is reduced to almost 20 countries between which the Democratic Republic of the Congo is the bigger producer with 55% of the world production. In Europe cobalt is produced only in Finland that actually provides 2.300 tonnes, the 2% of the world production. In this way several projects have been promoted by European Union, with the Raw Material Initiative, in order to find and evaluate the sustainable production of important materials in Europe.

MINDeSEA[1] project is part of the GeoERA and represent the collaboration of 12 national geological institution partners, to characterize marine deposits and their contents in Critical Raw Materials (CRM) and to generate a comprehensive cartography and metallogenic models of them. The first preliminary map produced in 2019 represents the localization and evaluation of cobalt rich deposits in the oceans within the EEZ and ECS of the European countries. Cobalt deposits are represented essentially by hydrogenetic Fe-Mn crusts located essentially in the Macaronesian area of the north east Atlantic Ocean (in the Portugal and Spain), submarine plateaus, as the Galicia Bank (in the north west Spanish) and in the Arctic Ocean ridges (Norway and Iceland). The report differentiates between occurrences (<0.05 wt. %) and deposits (>0.05 wt. %), with the possibility of more than 200 Mt resources per potential deposit.

Detailed mineralogical, geochemical and metallogenic studies are being developed in crusts from the Macaronesia. Fe-Mn crusts absorb dissolved elements in seawaters on the surface of the fresh precipitated oxy-hydroxides during their slow growth through millions of years. Several elements are concentrated in Fe-Mn crusts and between them cobalt is one of the most enriched trace metals (average 0.6 wt. %) accompanied by other strategic and critical metals such as nickel,

copper, tellurium, molybdenum and rare earth elements plus yttrium (REY) (respectively 3000, 500, 150, 500 and 3500 µg/g). Micro Raman and micro X-Ray diffraction can be used to differentiate the mineralogy in laminae of less than 20 microns. On the other hand, electron probe micro-analyzer (EPMA) and Laser Ablation Inductively Coupled Plasma Mass Spectrometry (LA-ICP-MS), are useful in order to quantify contents of CRM in the different mineral phases. These are innovative techniques in order to identify critical-elements bearing minerals and thus choose the metallurgic method for a more efficient and sustainable extraction of the interesting elements.

The evaluation of a seamount as a future mine site has to take into account all these mineralogical and chemical features as well as a proper knowledge of the seamount (morpho-structure, geology, oceanography, ecosystems) and the Fe-Mn crust thickness and extension

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