Resource Potential of Hydrothermal Manganese Deposits from the Global Ocean

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Marine manganese-oxide deposits (MnD) are cemented and replaced volcaniclastic and biogenic sediments that were mineralized by distal, low-temperature, hydrothermal fluids, and are predominantly sediment-hosted deposits. These MnD are considered to not have an economic potential in contrast to their non-hydrothermal counterparts, ferromanganese crusts and nodules. This is true despite the fact that MnD have the highest manganese contents (up to 55% Mn, so-called battery-grade Mn) of all deep-ocean mineral deposits, and the growing demand for manganese and upward trend in price on the global market. Also, the economnic potential of other elements have not been considered, especially lithium (to 0.17%) and molybdenum (to 0.24%), but also vanadium (to 820 ppm), chromium (to 346 ppm), and nickel (to 0.45%), among others. Which minor element(s) are enriched and their concentrations depend on the types of rocks leached at depth by the hydrothermal fluids, the composition of hydrothermal minerals precipitated in the higher temperature parts of the system, and the types of sediments mineralized by the manganese oxides. For example, mineralization of carbonate sediments results in the highest lithium contents, whereas leaching of ultramafic rocks at depth results in the highest chromium and nickel contents in the hydrothermal MnD. Even though hydrothermal manganese deposits are known to be widespread, especially in volcanic arcs, their lateral and vertical extents are not known; consequently size, tonnage, and grade of deposits have not been determined. Most samples of hydrothermal deposits have been collected by dredging and therefore the in situ relationships are also not known. However, one sample from the Mariana volcanic arc, W Pacific, was collected by ROV from an outcrop meters thick that may be a bedded sequence of pervasively mineralized volcaniclastic rocks; this offers the first clue as to the vertical extent that these deposits may attain. Although large manganese deposits occur on the continents, they consist of manganese carbonates, silicates, or complex mixtures of manganese minerals. In contrast, marine hydrothermal MnD exhibit relatively simple mineralogy that can make processing of this potential ore much simpler.