Effect of polymetallic nodules on the corrosion rate of S235 steel as a model to study hull immersion.

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Polymetallic nodules are currently being considered a widely appreciated source of minerals and metals (such as manganese, iron, nickel, copper, titanium and cobalt), and are heavily sought-after commodities prompting a race to the deep sea, where a great number of maritime companies are readying themselves for deep-sea mining of these nodules. These nodules are redox active and appear to play a direct role in the production of oxygen for the deepsea ecosystems [1]. Currently, four oceanic regions are being investigated for future mining: the Clarion-Clipperton Zone, the Peruvian Basin, the Penrhyn Basin and the Indian Ocean. After mining, these nodules are being transported and safeguarded in steel compartments on board of the ships which are used to mine them. These compartments often consist of standard steel walls, which are not coated or otherwise protected. Contact with the polymetallic nodules therefore may lead to corrosion, e.g. galvanic corrosion. The direct aim of this research is therefore to assess the impact of the contact between the nodules and these steel walls.

Several polymetallic nodules were acquired from AllSeas Goup SA. Steel plates (S235 carbon steel) were exposed to various experimental conditions to determine the impact of polymetallic nodules and nodule powder over two months of exposure. Mass loss experiments, XRF analysis, and Open Circuit Potential (OCP) tests were conducted to assess the chemical composition and electrochemical properties of the S235 steel.

OCP measurements suggested that nodules have a higher potential (-0.234 V) than the steel (-0.674 V), implying that steel would corrode faster in their presence. Corrosion exposure tests showed mixed outcomes: the mass loss experiment did not reveal a significant difference in corrosion rate (ranging between 0.03-0.05 mm/year) between steel with and without nodules, or when the nodules were powdered. However, it is anticipated that extending the duration of the experiments would likely demonstrate a long-term negative impact on hull corrosion rates.

[1] Sweetman, A. K. *et al.* (2024). Evidence of dark oxygen production at the abyssal seafloor. *Nature Geoscience*, *17*(8), 737-739.

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