

Scandium enrichment in Arctic Ocean Fe-Mn Crusts: Where does the Sc come from?

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Fe-Mn crusts dredged from the Chukchi Boarderland, a continental fragment located north of Alaska in the Arctic Ocean, show high concentrations of the rare metal scandium (Sc) [1]; bulk sample concentrations range from 38-60 ppm Sc. Such high enrichments of Sc have not been found in deep-ocean mineral deposits recovered elsewhere in the global ocean. Sc concentration averages about 15 ppm in the Earth's crust and is rarely found in high enough concentrations to form an ore deposit. Scanning Electron Microscopy-Energy Dispersive X-ray spectroscopy data for the Arctic samples show that Sc is disseminated throughout the matrix of the Fe-Mn crusts (up to 400 ppm) and is also concentrated in a large variety of detrital and biogenic grains that were incorporated into the Fe-Mn crusts via settling during crust hydrogenetic growth: Example concentrations are: ferromagnesian minerals (0.11-0.14 wt.% Sc), apatite (0.17-0.41% Sc), zircon (0.08-0.28% Sc), titanite (0.13-0.16% Sc), dolomite and calcite (0.44-0.66% Sc), and foraminifera (0.54-0.78% Sc). Mass-balance calculations indicate that these detrital minerals cannot account for the Sc concentrations in the bulk Fe-Mn crusts, which is supported by correlation coefficients. Sc in bulk samples and crust layers has positive correlations (>95% confidence level) with Al, P, LOI, H₂O, As, Be, Ga, and Hf and negative correlations with Mn, Si, Mg, Ca, Ag, Co, Cu, Nb, Ni, Pb, Ta, Te, Th, Tl, and Hg. Sc does not correlate with Fe, K, or the rare earth elements. The correlation coefficients indicate that Sc is likely associated with a hydrated phase within the Fe-Mn oxide matrix, possibly a phosphate, an idea that is being further tested. Multiple working hypotheses are being developed to determine the ultimate source of the Sc, but data needed to constrain some of these ideas are not commonly available for the Arctic Ocean. Similar Sc-rich deposits have been found to the NW of the Chukchi Boarderland, on the Mendeleev Ridge [2], which attests to the widespread occurrence of these characteristic deposits in the western Arctic Ocean.

[1] Hein, J.R., *et al.* (2013), AGU Annual Fall Meeting, Abstract OS12B-O6. [2] Konstantinova, N. *et al.* (2015), Goldschmidt 2015, Prague, Abstracts, p. 1655.