

Phase structure of metallothermally reduced deep-sea concretion

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Metallothermally reduced deep-sea nodules from Clarion-Clipperton Zone (Pacific Ocean) are investigated in this study. The aim is to prepare “natural alloy”, to construct as simply as possible way to reduce nodules into the usable alloy without wasting the energy, mainly to avoid the purification of individual metals. Here used nodules contain manganese as the dominant element, whereas iron, nickel and copper are other major constituents besides aluminium and silicon. The deepest investigated is the aluminothermic process [1], nevertheless the other reducing metals - titanium and silicon - are investigated too.

The nodules were reduced and annealed alloys at 700 °C with various excess of aluminium (0 %, 10 %, and 20 %). Using XRD there were found three, five and eight phases, some of them not listed in databases. Some other minor phases as sulphide MnS were found using SEM with EBSD/EDS coupled detectors.

There is a couple of interesting points. The formation of main manganese rich phase, which develops from β -Mn₆₆Ni₂₀Si₁₄ phase (*P2₁3* space group) at 0 % of excess to β -Mn phase (*P4₁32* space group) at 10 % of excess and to α -Mn phase (*I-43m* space group) at 20 % of excess. The separation of Mn₂FeSi and Mn₂FeAl phases. Those phases were just recently confirmed experimentally to exist.

[1] Novák P., Nguyen H. V., Šulcová L., Kopeček J., Laufek F., Tsepeleva A., Dvořák P. & Michalcová A. (2021) *Materials* **14**, 561.

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