Goldschmidt 2021 Abstract
https://doi.org/10.7185/gold2021.6819

The reduced phase(s) in the deep Earth mantle (≥ 6 GPa): Phase relations and chemical composition of a Fe-Ni-S-C(-P) melt coexisting with mantle silicates

MICHAEL FUX[1], MAX W. SCHMIDT[2] AND CHRISTIAN LIEBSKE[1]

[1]Institute of Geochemistry and Petrology
[2]ETH Zürich
Presenting Author: michael.fux@erdw.ethz.ch

An increasingly majoritic garnet with increasing pressure leads to ferrous iron disproportionation starting between 6-9 GPa according to 3 FeO (silicates) = Fe_2O_3 (garnet) + Fe^0 (reduced component). The oxygen fugacity at the depth of ferrous iron disproportionation is close to the iron-wüstite (IW) oxygen buffer and further decreases with increasing pressure. Hence, at pressures > 6-9 GPa the mantle is reducing enough to stabilize a Fe-Ni dominated metal phase with a mode of approximately 0.1-0.2 wt.% at the base of the upper mantle (670 km). Light elements such as S, C, N and potentially P and other silicate-incompatible or siderophile elements alloy into the reduced phase. Depending on bulk composition and pressure, Fe-Ni-rich alloy, sulfide liquid, Fe-rich carbides and diamond could occur with mantle silicates. In mantle upwellings, the reduced phase oxidizes and yields CO_2, which triggers initial silicate melting in the mantle.

We target the reduced Fe-Ni-S-C(-P) component and equilibrate it with natural olivine, opx, cpx and garnet in single-crystal San Carlos olivine capsules at ≥ 6 GPa using a multi anvil press. The Fe-Ni-S-C(-P) starting composition was calculated from theoretical and pressure-dependent modes of Fe-Ni metal and Bulk Silicate Earth values for S, C and P, yet the phase proportion of this calculated metallic phase composition was increased to approximately 20 vol.% to ensure reliable chemical analysis of the reduced phase(s).

The results show that at adiabatic temperatures (1400-1450 °C) the metallic phase in the Fe-Ni-S-C system consists of a sulfide liquid close to monosulfide proportion, graphite and probably a Fe-rich carbide, coexisting with the silicates. In the P-bearing system, silicates coexist at 1100 °C with a sulfide liquid and graphite along with unidentified phosphate and phosphide phases. At 900 °C a solid Fe-rich sulfide is present in addition to the afore-mentioned phases. At adiabatic temperatures, the reduced component is, except for diamond, completely molten and represents a sulfide liquid containing 2.5-3.5 wt.% P. Furthermore, P_2O_5-rich olivine (up to 7 wt.%) and opx (up to 20 wt.%) are produced and coexist with cpx and garnet and a yet unidentified and not fully equilibrated P_2O_5-CaO-rich silicate phase.