

The Fe-Fe₂P and Ni-Ni₂P phase diagrams at 6 GPa

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Fe-P and Ni-P are among the basic phase diagrams for understanding the core formation in asteroids and planets. Recent finding of high-pressure minerals in iron meteorites (Holtstam et al., 2003; Litasov and Podgornykh, 2017) and abundance of complex Fe-Ni-P-S quench textures with unusual bulk compositions indicate great importance of the study of related systems at elevated pressures. Although high-pressure modifications of meteorite appear under shock impact conditions for the short time, static high-pressure experiments are more relevant for interpretation of these processes relative to shock wave experiments, where duration of shock is too short to model meteorite impact. We have determined the Fe-Fe₂P and Ni-Ni₂P phase diagrams at 6 GPa and 900-1600 °C. Experiments have been conducted in ceramic (3 MgO + 4 SiO₂) capsules using multianvil technique.

The Fe-Fe₂P system has two stable phosphide compounds: Fe₃P and Fe₂P. The Fe-Fe₃P eutectic is established at 1075 °C and 16 mol% P. The Fe₃P compound melts incongruently at 1250 °C to produce Fe₂P and liquid containing 23 mol% P. The Fe₂P compound melts congruently at 1575 °C. In whole studied temperature range, metallic iron dissolved measurable amounts of P suggesting an existence of limited solid solutions of P in Fe. The maximum P content in Fe, 4.2-5.2 mol%, is established at 1100-1200 °C. X-ray diffraction study indicates that Fe₂P corresponds to barringerite structure, whereas Fe₃P corresponds to schreibersite. Thus, quenched phases at 6 GPa do not correspond to high-pressure polymorphs, such as (Fe,Ni)₂P allabogdanite (Britvin et al., 2002), which was synthesized previously at 8 GPa (Dera et al., 2008).

The Ni-Ni₂P system has three stable phosphide compounds: Ni₃P, Ni_{3-x}P, where x = 0.4-0.7 and Ni₂P. The Ni-Ni₃P eutectic locates at 975 °C and 20 mol% P. The Ni_{3-x}P solid solution field narrows to the Ni_{2.3}P composition as temperature increases to 1175 °C, where Ni_{2.3}P melts incongruently to Ni₂P and liquid containing 29 mol% P. The Ni₂P compound melts congruently at 1250 °C. Ni also forms limited solid solutions with P. Similarly to Fe-P system, Ni₂P and Ni₃P compounds correspond to barringerite and nickelposphide crystal structures at 6 GPa. The intermediate compound Ni_{3-x}P has variable composition, which may correspond to Ni₅P₂ or Ni₁₂P₅ observed at 1 atm.

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References

- Britvin, S.N., Rudashevsky, N.S., Krivovichev, S.V. et al. (2002) *Amer. Mineral.*, 87: 1245-1249.
 Dera, P., Lavina, B., Borkowski, L.A., et al. (2008) *Geophys. Res. Lett.*, 35: doi: 10.1029/2008GL033867.
 Holtstam, D., Broman, C., Soderhielm, J., Zetterqvist, A. (2003) *Meteorit. Planet. Sci.*, 38: 1579-1583.
 Litasov, K.D., Podgornykh, N.M. (2017) *J. Raman Spect.*, 48: 1518-1527.

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