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Stability and bulk modulus of Ni_3S, a new nickel sulfur compound, and the melting relations of the system Ni-NiS up to 10 GPa

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Abstract

We found a new nickel sulfide that is isostructural with Fe_3S. The synthesized nickel sulfide is a non-stoichiometric compound with a Ni deficiency and its composition is $Ni_{2.90\pm0.5}S$. In situ synchrotron X-ray observations indicate that $Ni_{3-x}S$ forms above 5.1 GPa and melts incongruently into Ni+liquid up to 10 GPa. The bulk modulus of $Ni_{3-x}S$ at 300 K was determined to be 140 ± 2 GPa with a fixed $K' = 4$ by static compression with a liquid pressure medium. The eutectic point of the Ni-NiS system lies between Ni_3S and Ni_3S_2 up to 10 GPa and its composition changes from $Ni_{66.6}S_{33.4}$ at 0.1 MPa to $Ni_{70.7}S_{29.3}$ at 10 GPa. The eutectic melting temperature of the Ni-NiS system decreases to 5.1 GPa and 720 K as the pressure increases where Ni and α-Ni_3S_2 are the eutectic solids. On the other hand, the eutectic melting temperature increases with a positive slope above 5.1 GPa where Ni_3S+α-Ni_3S_2 is stable under subsolidus conditions. Intermediate compounds appear at a lower pressure in the Ni-NiS system than that for the Fe-FeS system. Ni_3S_2 is stable at atmospheric pressure and Ni_3S forms at 5.1 GPa, whereas Fe_3S_2 and Fe_3S form at 14 and 20 GPa, respectively. The addition of Ni complicates the melting relationship in the Fe-FeS system at high pressure because of the wider stability field of Ni_3S. The low-melting temperature of the Fe-Ni-S system plays an important role in the percolative core-formation of planetesimals during planetary accretion.

Keywords: Nickel, sulfur, light element, melting, high pressure, core