

Na-bearing phases in the deep transition zone and lower mantle: composition, structural features and Na transport to the deep Earth

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Ringwoodite (Mg_2SiO_4 with spinel-type structure) and bridgmanite (MgSiO_3 with perovskite-type structure) are the major phases in the deep transition zone and lower mantle of the Earth, respectively. For better understanding of the crystal-chemical behavior of sodium in the deep Earth, we performed experiments on a simplified chemical system involving a Na-rich carbonated melt and mantle silicate at 23-24 GPa and 1300–1700°C, thus representing the conditions at the border between the transition zone and lower mantle.

In all samples, partial melting was registered: crystals of Na-bearing Al, Fe^{3+} -bridgmanite occurred in microcrystalline carbonate-silicate quenched matrix. With decreasing temperature melt composition evolved from silicate-carbonate to alkaline-carbonate. Bridgmanite contained up to 1.6 wt % Na_2O (at 1700°C). Ringwoodite with high amounts of Na was found at 24 GPa and 1700°C. Ringwoodite incorporated up to 4.4 wt% Na_2O by the mechanism: $\text{Mg}^{2+} \square \square \text{Na}^+ + \square \text{Si}^{4+}$. The unit-cell volumes of Na-bearing bridgmanite and ringwoodite increased along with the Na content.

Our results have implications for transport of alkalis into the lower mantle of the Earth. Carbonatitic melt metasomatism in the deep transition zone may lead to local Na-enrichment, and ringwoodite may be an important host for Na in the deep transition zone. Subsequent convection or subduction of metasomatised mantle may lead to enrichment of alkaline elements in the upper and lower mantle.

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