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Lower mantle ferropericlase as a major reservoir for sodium

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Sodium is the most abundant alkali metal on Earth. The storage and mobility of sodium in the mantle can be related to processes such as subduction and mixing of basalt and cycling of carbon and water. Constraints on sodium chemistry are important for modeling thermodynamic stability and seismic properties of the mantle phase assemblage. In a pyrolytic lower mantle, experiments have shown that major phase ferropericlase (Mg,Fe)O may be the major host phase for sodium with up to ~1% observed. However, the quantity and incorporation mechanisms for sodium in ferropericlase at lower mantle conditions are not well understood. In this study, we reacted synthetic ($Mg_{0.75-0.25}$, $Fe_{0.25-0.75}$)O ferropericlase with NaCl in the laser-heated diamond anvil cell at HPCAT and GSECARS facilities at Argonne National Laboratory at lower mantle pressure and temperature conditions of 35-90 GPa and 1800-2300 K for 15-120 minutes. After heating, the phase assemblage and structure of ferropericlase inside and outside of the heated spot were observed by synchrotron X-ray diffraction at beamlines 16-ID-D, Advanced Photon Source, and 12.2.2, Advanced Light Source. Compositions of recovered samples were measured ex situ by energy-dispersive X-ray spectroscopy at Michigan State University. Heated regions of recovered ($Mg_{0.75}$, $Fe_{0.25}$)O, a composition similar to that inferred for mantle ferropericlase, contain as much as 6% Na/(Na+Mg+Fe). The measured concentration of sodium in ferropericlase increases with pressure and iron content. Ferropericlase in Earth's lower mantle has capacity to store Earth's entire sodium budget