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Shock-induced olivine-ringwoodite phase transition and natural dissociation of olivine in Bori L6 chondrite

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Olivine is one of the most important constituents of the Earth's mantle. We analyzed the shock melt vein (SMV) and melt-pockets (MP) of the strongly shocked Bori L6 chondrite. The minerals found in the host rock (HR) include olivine, maskleynite, chromite, apatite, Fe-Ni, and troilite. A majorite-pyrope solid solution was identified in the SMV matrix, along with high-pressure polymorphs such as ringwoodite, akimotoite, majorite, lingunite, jadeite, coesite, and tuite. Cellular like, pyroxene glass co-existing with bridgmanite at the core part and intergranular growth of akimotoite, asimowite, stishovite, and clinoenstatite are observed by TEM analysis. Furthermore, the olivine grains inside the SMV which exhibit fine dissociation texture have a composition similar to the HR olivine. Previous studies on olivine reported several dissociation assemblages: 1) magnesiowüstite and orthoenstatite; 2) ferroan-periclase and clinopyroxene; 3) magnesiowüstite and bridgmanite [1]. The segmentation textures, which indicate the sub-grain boundaries, are seen in the olivine grains inside the SMV. Shear-induced thermal stress causes several crystal defects to grow in the olivine and the subsequent diffusion of these crystal defects results in the sub-grain boundaries. Olivine grain segmentation results from defects that are thermally activated at high temperatures [2].

Inside the MP and SMV, polycrystalline ringwoodite grains show dendritic and acicular texture. The compositions of ringwoodite grains are similar to the HR olivine, suggesting ringwoodite may be formed by the solid-state transformation mechanism [3]. Polycrystalline to lamellar types of ringwoodite are observed in the HR olivine adjacent to the SMV and eventually dissipate with increasing distance from the SMV towards the host rock. This suggests a temperature gradient from the margin of SMV towards the host rock. The composition of the ringwoodite is similar to the HR olivine and possibly formed by an interface-controlled solid-state transformation mechanism. Based on the high-pressure phase diagrams and the presence of high-pressure polymorphs in Bori L6 chondrite suggest that it should have been exposed to pressure of at least 18 to 23 GPa.

References:

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