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Shock-induced *P-T* conditions and formation mechanism of akimotoite-pyroxene glass assemblages in the Grove Mountains (GRV) 052082 (L6) meteorite

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Abstract

Akimotoite [(Mg,Fe)SiO_3-ilmenite] was encountered in shock-induced melt veins of Grove Mountains (GRV) 052082, a highly equilibrated low iron ordinary chondritic meteorite (L6). Coexistence of ringwoodite, majorite, and majorite-pyrope solid solution indicates the shock pressure at 18–23 GPa and temperature of 2000–2300 °C during the natural dynamic event. Most low-Ca pyroxene clasts entrained in the melt veins have been partially or entirely transformed into akimotoite-pyroxene glass assemblages, which contain micrometer-sized areas with various brightness in the backscattered electron images, different from the chemically homogeneous grains in the host-rock ($Fs_{20.5–21.3}$). The transmission electron microscopy study of a focused ion beam (FIB) slice from the heterogeneous areas shows that the assemblages are composed of FeO-depleted and heterogeneous akimotoite ($Fs_{6–19}$) crystals (100 nm up to 400 nm in size) scattered in FeO-enriched and relatively homogeneous pyroxene glass ($Fs_{31–39}$). All analyses of the akimotoite-pyroxene glass assemblages plot on a fractionation line in FeO-MgO diagram, with the host-rock pyroxene at the middle between the compositions of FeO-depleted akimotoite and the FeO-enriched pyroxene glass. These observations are different from previous reports of almost identical compositions of akimotoite, bridgmanite [(Mg,Fe)SiO_3-perovskite], or pyroxene glass to the host rock pyroxene (Chen et al. 2004; Ferroir et al. 2008; Ohtani et al. 2004; Tomioka and Fujino 1997), which is consistent with solid-state transformation from pyroxene to akimotoite and preexisting bridgmanite that could be vitrified. The observed fractionation trend and the granular shapes of akimotoite suggest crystallization from liquid produced by shock melting of the host-rock pyroxene, and the pyroxene glass matrix was probably quenched from the residual melt. However, this interpretation is inconsistent with the static experiments that expect crystallization of majorite [(Mg,Fe)SiO_3-garnet], instead of akimotoite, from pyroxene liquid (Sawamoto 1987). Our discovery raises the issue on formation mechanisms of the high-pressure polymorphs of pyroxene and places additional constraints on the post-shock high-pressure and high-temperature conditions of asteroids.

Keywords: Akimotoite, pyroxene glass, high-pressure polymorphs, meteorite, shock, impact