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High-pressure polymorphs of silica in shocked meteorites and their implications

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A high-pressure polymorph of silica is one of most unambiguous evidences for an impact event. Natural coesite and stishovite were discovered from impact craters on the Earth for the first time. Some meteorites are heavily shocked. Recent our studies reveal that high-pressure polymorphs of silica occur in many kinds of meteorites. Stishovite and coesite were identified from a lunar meteorite, Asuka 881757 for the first time (Ohtani et al., 2011). Subsequently, α-PbO_2 type silica, seifertite along coesite and stishovite were found from a lunar meteorite, NWA 4734 (Miyahara et al., 2013). In addition to lunar meteorites, we also identified stishovite from a lunar return sample, Apollo 15299 breccia (Kaneko et al., 2014). Considering radio-isotope chronology, the high-pressure polymorphs of silica are closely related with the late heavy bombardment and subsequent meteoroid impacts on the Moon. Miyahara et al. (2014) identified coesite and stishovite from eucrite which was expected to originate from 4 Vesta, which raised an objection about howardite-eucrite-diogenite delivery model to the Earth. Coesite and stishovite are also found from enstatite and carbonaceous chondrites (Weisberg et al. 2010; Kimura et al., 2014) although their parent-bodies are expected to be less shocked. Now the existences of coesite and stishovite in shocked meteorites appear to be ubiquitous. Therefore, high-pressure polymorphs of silica, which were overlooked, will become a new clue for clarifying a dynamic event in the solar system. On the other hand, the pervasive existence of coesite in shocked meteorites is enigmatic. The phase transition from quartz to coesite is not easily achieved in a transient high-pressure condition due to a high kinetic barrier (e.g., Mosenfelder and Bohlen, 1997). Coesite occurs in a silica grain entrained in a shock-melt vein or melt-pocket. Most coesite are un-oriented fine-grained assemblages accompanying silica glass. Coesite in shocked meteorites may crystallize from silica-glass or melt subsequent to amorphization or melting. Coesite probably has a high nucleation rate in silica-glass or melt.

Reference

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