The formation of coesite in impact rocks

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Coesite, a high-pressure silica polymorph, is a diagnostic indicator of impact cratering in quartz-bearing target rocks. The mechanism formation of coesite is still debate since its discovery in 1960s therefore it remains the subject of numerous studies aiming to better understand how silica polymorphs react under sudden and extreme P-T increases. Here, I show evidence documenting the coesite formation through direct quartz-to-coesite transformation in subsolidus conditions studying two different impact events: Kamil crater (Egypt), a small-scale simple crater of 45 m in diameter, and the large-scale Australasian tektite/microtektite strewn field.

In Kamil crater, coesite occurs as individual and spheroidal single-crystal grains (Campanale et al., 2021) that represent the first crystallization seeds of coesite. In the Australasian samples, coesite occurs as individual grains or aggregate, either with subrounded or subhedral shape. In both Kamil crater and Australasian tektite strewn field, quartz and coesite, when in direct contact, show a recurrent reciprocal orientation, with the {10-11} or {-1011} plane families of quartz almost parallel with the plane (010) of coesite. This suggests a genetic relation between the recurrent {10-11} orientation for planar features in shocked quartz, including planar deformation features (PDFs) and the twinning of impact coesite along (010) composition planes. A possible way to transform quartz into coesite would be through a topotactic transformation. The presence of pre- and post-shock discontinuities in the target rock may facilitate the quartz-to-coesite transformation, in which the shock-wave reverberation provides the P-T-t conditions for coesite formation.

This work is also a good test-case for showing the potential of the TEM-based techniques, i.e., three dimensional electron diffraction (3D ED) and precession-assisted crystal orientation mapping (PACOM), in integrating well-established analytical methods like SEM, conventional TEM, and Raman micro-spectroscopy. Such combination can push forward the structure characterization of nanoscale materials, shock metamorphic features and their defective nature in the impact rocks. TEM and ED allow to address outstanding open questions in shock metamorphism and impact cratering studies, such as the high-pressure polymorph transformation mechanisms induced by the passage of shock waves in impact scenarios.

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