FORMATION AND POST-SHOCK EVOLUTION OF COESITE IN SUEVITE FROM THE RIES IMPACT STRUCTURE (GERMANY)

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Introduction: Coesite is one of the most common and abundant high-pressure phases occurring in impactites. Although coesite textures were studied for more than 40 years in numerous impactites from many impact structures (e.g., [1-3]), recent studies are often lacking detailed microstructural observations at the nanometer scale (e.g., Ries, [4]; Xiuyan, [5]), which are of primary importance to constrain its mechanism(s) of formation.

In this work, we revisited the mechanism of formation of coesite and its post-shock evolution on the basis of new observations on coesite aggregates within diaplectic glass of suevite from the Ries impact structure [6].

Samples and Methods: A moderately strongly shocked clast from the Seelbronn outer suevite was selected due to its high abundance of coesite-bearing diaplectic glass grains and to its similarities with impactites from other impact structures (e.g., [7, 8]). The identification of silica phases and their textures was initially carried out through Raman microspectroscopy and SEM, respectively. Two areas were selected for TEM investigations. Electron-transparent samples (thickness <300 nm) were prepared by focused-ion beam milling.

Results: Elongated grains of diaplectic silica glass (up to 5 x 1 mm) and biotite-rich layers are characteristic for the studied suevite clast. Due to the presence of vesicular feldspar glass next to the coesite-bearing diaplectic silica glass it can be assigned to shock stage III [9]. Its protolith was a felsic metamorphic rock.

Coesite within diaplectic glass generally occurs as veins (up to 15 µm thick), alignments of small spherical to sub-spherical (up to ~10 x 30 µm) aggregates, or as large elongated aggregates (up to ~180 x 50 µm) of tiny crystals. Most of them show an increase of the grain size and interstitial silica glass amount going toward the inner part. All coesite crystals show rotation twinning around the *b* axis with the composition plane (010). The twins are polysynthetic (< 70 nm) and not decorated by dislocations.

Despite the ubiquity of coesite, quartz is the most common phase within diaplectic silica glass grains. It occurs at the rim and in form of polycrystalline veins. Quartz veins and coesite aggregates are parallel and in some cases related. Quartz aggregates are easily recognizable due to numerous fractures, partially filled with clay minerals. The central part of the veins consists exclusively of quartz; the outer rim has a finer grain size and the Raman spectra show additional peaks related to the cristobalite and hydroxylated microcrystalline quartz. The quartz is unshocked.

Discussion: Our TEM investigation reveal a uniform defect microstructure of coesite with nanocrystalline aggregates containing abundant polysynthetic growth twins. These observations and the further occurrence of intergranular glass in which coesite is embedded indicate its rapid crystallization under high pressure. Grain sizes suggest that cooling rate at the rim was faster than in the core. Coesite apparently crystallized in local hot spots within the diaplectic glass. Due to textural similarities to unshocked gneiss clasts in Ries suevite, we interpret these hot spots as previous fluid inclusions in quartz.

The features of quartz rims and veins support the hypothesis that they are secondary products of the annealing of coesite aggregates and diaplectic glass surrounding them. The early post shock evolution of suevites is characterized by the circulation of hot fluids, which may have assisted the back-transformation of coesite into quartz and diaplectic glass into β-cristobalite, which transforms into α-cristobalite and then into microcrystalline quartz during subsequent stages of the post-shock evolution. Altogether, these post-shock modifications result in a significant volume loss and extensional fracturing. During a late post-shock stage, they may be filled with clay minerals.

Conclusions: In this study, we relate the formation of coesite aggregates to the occurrence of fluid inclusions in precursor quartz. Upon the impact, fluid inclusions formed hot melt spots, from which coesite crystallized during the unloading, while the surrounding quartz was transformed in diaplectic glass. The occurrence of secondary phases demonstrates that post-shock annealing started to reset the primary shock signature and resulted in the conversion of coesite to quartz and the recrystallization of diaplectic glass to cristobalite.

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