Mineral zircon as a marker for high shock pressures and temperatures in geological materials

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Extremely high pressures (> 100 GPa) and temperatures (> 2.9 kK) affect terrestrial and extra-terrestrial rocks during the hypervelocity impact events or, in other words, catastrophic collisions with meteorites and asteroids. Often, the impactor and the target rocks at the contact point completely vaporize, while the surrounding rocks of the target undergo melting and severe deformation during impact cratering. Such rocks–products of the impact event–are called impactites. Cited melting and deformation in impactites occur extremely rapidly, and under non-equilibrium conditions. Thus, the traditional phase diagrams for minerals and mineral solid solutions cannot be relied on when observing mineral microstructures and textures with the purpose of reconstructing shock pressures and temperatures. Therefore, alternative, impact-specific phase diagrams are required. We show that the micro- and nano-textures in accessory minerals, particularly in zircon ($ZrSiO_4$), can serve as robust indicators of pressure, temperature and ages of the impact events. Shocked zircon preserves a wide variety of micro- and nano-structures that are characteristic of impactites: granular aggregates, amorphous domains, nano-inclusions of cubic and tetragonal ZrO_2 and silicate glass, micro-grains of high-pressure polymorph reidite, rims of baddeleyite, etc. Each of these features is indicative of the particular extreme conditions.

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