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# Inclusions under pressure – useful for metamorphic processes?

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Coesite and diamond inclusions in robust minerals such as zircon and garnet are often used as indicators for ultrahigh-pressure (UHP) metamorphism. The key question is: Do these inclusions faithfully record the metamorphic conditions of the host rocks? To answer this question, case studies from the classical UHP localities of the Dora Maira and Kokchetav Massifs are presented, where the first occurrences of coesite and diamond as inclusions in garnet have been documented, respectively. Garnet grows during continuous prograde reactions and is able to capture mineral and fluid phases as inclusions. However, these inclusions can interact with the host garnet in several ways, during subsequent stages of metamorphism, complicating the interpretation of inclusions. An alternative approach is to investigate inclusions in zircon that is robust and chemically inert and that can be dated by in-situ age determination. However, in this case it is more difficult to determine at what P-T stage the inclusions were captured.

Zircon from whiteschists in the Dora Maira Massif display Variscan magmatic cores and multiple Alpine overgrowths. The zircons contain inclusions of prograde phlogopite, talc, phengite and a Na-Si-rich fluid. The inclusions occur at the core-rim interface or in the U-rich portions of the magmatic cores, suggesting that dissolution-precipitation reactions of metamict zircon led to the capture of inclusions. The comparison of mineral compositions from inclusions to experiments provides evidence for prograde metamorphism at UHP conditions.

The diamond-bearing gneisses of the Kokchetav massif experienced widespread retrograde equilibrations during exhumation, making the determination of peak conditions from main minerals extremely difficult. Garnet, clinopyroxene and phengite inclusions in zircon domains (with highest Ti contents that formed at peak temperatures) have significantly different compositions from matrix minerals. These inclusions constrain metamorphic conditions to 950-1000°C and ∼50 kbar, well within the diamond stability field.

Even more challenging than the interpretation of solid inclusions is to constrain the nature and composition of fluid inclusions in UHP minerals as the interaction of fluid with host minerals can be extensive. However, for elements that have very low concentrations in the host mineral the contamination is minimal. For example, LREE contents of homogenized multiphase solid inclusions in garnet from the Kokchetav Massif, interpreted to represent trapped melt, are in excellent agreement with partial melting at peak UHP conditions. These inclusions can be used to constrain the trace element characteristics of melts produced by crustal anatexis at diamond facies conditions. An underexplored field is the investigation of multiphase solid inclusions in zircon. Preliminary data will be presented that show the potential to use zircon as a host of trapped melt at high-pressure conditions.