Do eclogite garnet textures record intermediate-depth seismicity?

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Mineral assemblages, compositions, and textures in UHP eclogites record metamorphic processes occurring in rocks subducted to mantle depths, but the potential record of earthquakes in these rocks is incompletely explored (Austrheim *et al.*, 2017). In several eclogites from the North Qaidam UHP terrane, China, compositional maps of garnet porphyroblasts reveal non-concentric zoning that suggests fracturing of early-grown garnet, which was then healed by later-grown garnet. These garnets typically contain high-Ca, low-Mg cores that represent prograde growth, surrounded by lower Ca, higher Mg garnet that records peak pressure conditions. A variably-preserved outer zone that is slightly higher in Ca and lower in Mg is interpreted to record the final stage of garnet growth during early exhumation; further exhumation resulted in partial resorption of the outer zones of garnet. We infer that fracturing of the Ca-rich garnet core zone is responsible for the observed compositional modification along inferred fractures and in inclusion-richer areas. This modification is more pronounced in Mg than in Ca, suggesting that faster-diffusing Mg underwent more extensive modification compared to slower-diffusing Ca. We suggest that earthquakes are responsible for the fracturing, which must have occurred after garnet cores formed, but before the higher Mg zones formed. Based on P-T paths from two nearby samples, P-T conditions of fracturing are estimated to be between 22-26 kbar, 530-570°C, corresponding to depths of 75-85 km (Hernandez-Uribe *et al.*, 2018; Meyer *et al.*, 2015). These conditions are close to the predicted limit of amphibole stability in these eclogites, where fluid release rates along the P-T path are predicted to spike (Meyer *et al.*, 2015), consistent with the hypothesis that metamorphic dehydration reactions should trigger earthquakes. Other implications of garnet fracturing are that prograde inclusions likely break down when fractures connect them to the reactive rock matrix, so early prograde inclusions are unlikely to be preserved; the P-T implications of such inclusions should therefore be interpreted with caution. In addition, fractures create fast diffusion pathways which in higher-temperature samples result in unzoned garnets that lack prograde path information. Low- and medium-temperature eclogites may therefore be the most promising potential recorders of intermediate-depth seismicity.

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