Seismogenic microstructures in eclogites and granitoid HP gneisses, Norwegian Caledonides: A response to densification?

Simon Cuthbert[1]

[1] AGH University of Science & Technology, 30-059 Krakow, Poland

Microstructures indicative of brittle fracture under metamorphic conditions are an important indicator of deep crustal or mantle seismicity. This may have been triggered by the physical response to metamorphic transformations, including hydro-fracturing due to dehydration reactions (particularly at the blueschist-eclogite transition; Bukała *et al.*, 2020) or by shear stresses set up by domains undergoing metamorphic densification (Yamato *et al.*, 2022). Feedbacks between fracture, fluid ingress and catalysis of eclogite genesis in previously dry rocks are also important.

Evidence for brittle fracture in garnet and omphacite has been found in the Western Gneiss Region continental eclogite terrain at Kroken, Nordfjord, sited at the coesite isograd, and near Flekke in Sunnfjord in the southern HP domain. Charge-contrast imaging of prograde-zoned garnet in an eclogite at Kroken revealed a pervasive network of connected filament-like features with major and trace-element compositions identical to the rim zone; some have inclusions of quartz and omphacite aligned along them. These microstructures have been interpreted as healed microfractures and indicate that early, amphibolite-facies garnet has been catastrophically disaggregated prior to new garnet growth under HP or UHP conditions. No protolith compositions have been preserved at this locality. The Sunnfjord locality has eclogites associated with granitoid HP orthogneisses that have developed from dry Proterozoic charnockites and anorthositic gabbros passing over short distances into domains of eclogite-facies felsic rocks of up to a few km^2. Similar features to those seen at Kroken have been imaged in garnet in both eclogite and granitoid HP gneiss, but here omphacite also shows similar “channel”-like networks. These healed fracture networks are superimposed upon a gross concentric zoning of composition and (in eclogites) solid inclusion assemblages indicating evolution from amphibolite to eclogite. At least two sets of healed micro-fractures here suggest multiple seismic events. No evidence for lawsonite breakdown that might favour reaction-induced hydrofracturing is known although omphacite-filled hydrofractures are common. Estimates of density changes across the eclogite transition in these examples based upon P-T pseudosections suggest rapid density increases in the amphibole- and plagioclase-out interval during continental subduction.

These observations are consistent with recent numerical modelling (Yamato *et al.*, 2022) of brittle deformation due to densification where seismicity is favoured by a large P overstep for eclogite formation and the formation of small eclogitic (densified) domains. Large changes in shear stress at the tips of densifying regions could have favoured seismic pumping of fluids that aided eclogitisation. A likely source of the fluids was a large, continental shield brine aquifer (Hughes *et al.*, 2021).

Bukała M. *et al.*, 2020. Brittle deformation during eclogitization of early Paleozoic blueschist. *Front. Earth Sci*. 8, 594453.

Hughes, L. *et al.*, 2021. Halogens in Eclogite Facies Minerals from the Western Gneiss Region, Norway. *Minerals* 11, 760.

Yamato, P. *et al.*, 2022. Reaction-induced volume change triggers brittle failure at eclogite facies conditions. *Earth and Planetary Science Letters* 584, 117520.