Omphacite gneisses and mafic eclogites in the southern Norwegian Caledonides: Links between densification and palaeoseismicity?

Simon J Cuthbert[a] and Adam Włodek[b]

[a,b]Faculty of Geology, Geophysics & Environmental Protection, AGH University of Krakow, Krakow, Poland, simon.cuthbert@agh.edu.pl; wlodek@agh.edu.pl

Microstructures indicative of brittle fracture under metamorphic conditions are an important indicator of deep crustal or mantle seismicity. It has been proposed that his 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). Feedback between fracture, fluid ingress and catalysis of eclogite genesis in previously dry rocks are, arguably, also important.

In the southern part of the Western Gneiss Region (WGR) felsic gneisses and mafic eclogites have often escaped the pervasive anatexis that characterises its more northerly region, so high-pressure parageneses have frequently survived even in felsic orthogneisses, in which omphacite and high-silica phengite are sometimes preserved. In such rocks there is also microstructural evidence for syn-metamorphic brittle fracture in garnet and omphacite. Such microstructures, in garnet, have been observed in eclogite in the Nordfjord area in close proximity to coesite-bearing pelitic schists. Charge-contrast imaging of prograde-zoned garnet in the latter revealed a pervasive network of connected filament-like features that are also exhibited by an identical pattern of major and trace-element compositions. These microstructures are interpreted as healed microfractures and indicate that early garnet has been catastrophically disaggregated prior to new garnet growth under HP or UHP conditions. No protolith relics have been preserved at this locality. However, further south in Sunnfjord, eclogites are associated with granitoid HP orthogneisses that have developed from dry Proterozoic charnockites and anorthositic gabbros that pass over short distances into domains of eclogite-facies felsic rocks of up to a few km^2 in extent. Similar features to those seen at Nordfjord have been imaged in garnet in both eclogite and granitoid HP gneiss, but here omphacite also shows similar "channel"-like networks. At least two sets of healed micro-fractures here suggest multiple seismic events. No evidence for lawsonite breakdown that might favour reaction-induced hydrofracturing (Bukała et al., 2020) is known although omphacite-filled hydrofractures are common so some role for fluids is required. Estimates of density change across the eclogite transition in these examples, based upon P-T pseudosections, demonstrate abrupt increases in the amphibole- and plagioclase-out interval during continental subduction.

The observations from Sunnfjord 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 eclogitisization. A likely autochthonous source of the fluids in the WGR was a large continental shield brine aquifer (Hughes et al., 2021).

The evidence exhibited in the southern WGR suggests that seismicity as a result of metamorphic transitions is likely in the vast masses of transiently-subducted granitoid crust that characterize continental collision zones.

References

Bukała M., Barnes, C.J., Jeanneret, P. and seven others, 2020. Brittle deformation during eclogitization of early Paleozoic blueschist. *Front. Earth Sci. 8*, 594453.

Hughes, L., Cuthbert, S.J., Quas-Cohen, A., and six others, 2021. Halogens in Eclogite Facies Minerals from the Western Gneiss Region, Norway. *Minerals 11*, 760.

Yamato, P., Duretz, T., Baïsset, M., Luisier, C., 2022. Reaction-induced volume change triggers brittle failure at eclogite facies conditions. *Earth and Planetary Science Letters 584*, 117520.