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Brittle deformation during eclogitization: a perspective from a cold, early Paleozoic subduction zone

Michał Bukała[1], Christopher Barnes[2], Iwona Klonowska[1], Károly Hidas[3], Kathrin Fassmer[4,5], and Jarosław Majka[1,6]

[1]AGH - University of Science and Technology, Department of Mineralogy, Petrography and Geochemistry, Kraków, Poland (michal.bukala91@gmail.com)

[2]Institute of Geological Sciences, Polish Academy of Sciences, Kraków, Poland

[3]Instituto Geológico y Minero de España, Tres Cantos, Spain

[4]Institute of Geosciences, University of Bonn, Bonn, Germany

[5]Department of Geology, University of Innsbruck, Innsbruck, Austria

[6]Department of Earth Sciences, Uppsala University, Uppsala, Sweden

The Tsäkkok Lens (northern Scandinavian Caledonides) represents the outermost part of the rifted passive Baltica margin and consists of sediments and pillow basalts of MORB affinity that were metamorphosed under eclogite facies conditions. Fieldwork and further multidisciplinary analytical approach (including e.g. X-ray and EBSD mapping, and μ-CT imaging) revealed that eclogites record brittle deformation on the μm-to-m scale. This deformation is expressed as a set of microfractures (single-grain rupture) and mesofractures (sealed by garnet- and omphacite-veins). Phase equilibrium thermodynamic modeling of phengite-bearing and phengite-free eclogites performed in NCKFMMnASHT and NCFMMnASHT systems predict profuse dehydration related to lawsonite and amphibole breakdown at ~2.35 GPa and ~600°C, close to the peak conditions of ~2.55 GPa and ~640°C. These estimates are in line with conventional thermobarometry and Zr-in-rutile thermometry results. The evidence for dehydration is also provided by the occurrence of relic glaucophane in matrix and polyphase inclusions in garnet consisting of clinozoisite + quartz ± kyanite ± paragonite that are interpreted as pseudomorphs after lawsonite. Dehydration reactions were responsible for producing fluid, which facilitated brittle fracturing of the eclogites at HP conditions due to increased pore-fluid pressure (also promoted by the volume changes during eclogitization) on the microscale. Altogether, micro- and mesofracturing acted as migration pathways for released fluid, whereas the microfractures are likely precursors of the mesoscale fractures. Garnet-WR Lu-Hf geochronology provided ages of 487.7 ± 4.6, 486.2 ± 3.2, and 484.6 ± 4.5 Ma. LA-ICP-MS trace element profiles of garnet revealed a well-pronounced peak of Lu content in the garnet cores that decreased towards the rims, indicating these dates represent the age of prograde metamorphism. Therefore, the early Paleozoic Tsäkkok Lens eclogites constitute the oldest documented natural example of HP brittle deformation during eclogitization of blueschist.

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