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Metamorphic differentiation via enhanced dissolution along high strain pathways

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Metamorphic differentiation, resulting in the segregation of minerals into compositional bands, is a common feature of metamorphic rocks. Considering the ubiquitous nature of compositionally layered metamorphic rocks, the processes that are responsible for metamorphic differentiation have received very little attention. The studied outcrop, located within the Bergen arcs of southwestern Norway, preserves the hydration of an anorthositic granulite at amphibolite-facies conditions. The amphibolite-facies hydration is expressed as both a statically hydrated amphibolite and a shear zone rock, defined by the interlayering of amphibolite with leucocratic domains. Detailed petrography, quantitative mineral chemistry and bulk rock analyses are applied to investigate compositional variation with assemblage microstructure. Within the outcrop, quartz-filled fractures and their associated amphibolite alteration haloes, are observed crosscutting the granulite. These fractures are demonstrated to be relict of the initial fluid infiltration event. The fracture assemblage (quartz + plagioclase + zoisite + kyanite ± muscovite ± biotite) is equivalent to that occurring locally within leucocratic domains of the shear zone. Due to the textural and compositional similarities between quartz-filled fractures and leucocratic domains, the compositional layering of the shear zone rock may be directly linked to fracturing during initial fluid infiltration.

Mass-balance and thermodynamic calculations indicate quartz-filled fractures and compositional differentiation of the shear zone form by internal fractionation rather than partial melting or precipitation of minerals from an eternally derived fluid. The process of internal fractionation within the shear zone is attributed to enhanced dissolution along fracture pathways, resulting in the loss of MgO, Fe_2O_3 and K_2O within leucocratic domains. These elements, being more mobile in the fluid, are then transported and ultimately either precipitated in amphibolite lithologies or escape with the fluid, resulting in an overall volume loss in the shear zone. This inferred fluid connectivity combined with the enhanced local dissolution indicates the presence of a continuously replenished fluid along fracture pathways, leading to the overall conclusion that the mass transfer processes that result in metamorphic differentiation of the shear zone lithologies

are dependent on both continuous fluid flux and heterogeneous strain distribution.