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Details of the gabbro-to-eclogite transition determined from microtextures and calculated chemical potential relationships

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Permian-aged metagabbros from the eclogite type-locality in the eastern European Alps were partially to completely transformed to eclogite during Eoalpine subduction [1,2]. Microtextures developed along a preserved fluid infiltration front in the gabbros record the incipient gabbro-to-eclogite transition [3], allowing the details of the eclogitisation process to be investigated.

Original, anorthite-rich igneous plagioclase is pervasively replaced by intergrowths of fine-grained clinozoiste, kyanite and albitic plagioclase. Where plagioclase was in contact with igneous orthopyroxene (bronzite), 100–200 m thick bimineralic coronas of symplectic kyanite and diopsidic clinopyroxene form along the edges of the grains. The rims of igneous orthopyroxene develop a bimineralic corona of diopsidic clinopyroxene and garnet. Igneous clinopyroxene (augite) does not show any replacement textures; however, jadeite content gradually increases towards the rims.

The development of such spatially-associated textures is a consequence of the inability of one or more elements to diffuse freely between local compositional domains [4]. Given that the igneous plagioclase is pervasively replaced by clinozoisite, kyanite and albite, whereas kyanite–diopside symplectites are confined to narrow rim zones, it suggests that the development of these textures was controlled by the (im)mobility of different elements on different length scales. The presence of hydrous minerals in the core of formerly anhydrous plagioclase indicates that H_2O diffusivity occurred on a mm-scale. By contrast, the size of the anhydrous diopside–kyanite and diopside–garnet symplectites indicate that Fe–Mg–Ca–Na diffusivity was limited to a 10s of µm scale.

Chemical potential relations calculated in the idealized NCASH chemical system show that the clinozoisite–kyanite–albite symplectites formed due to an increase of H_2O to plagioclase, whereas all other elements remained immobile on the scale of this texture. Fluid conditions indicated by this texture span from virtually dry conditions (a_{H2O} = 0.2) to H_2O-saturation, and, therefore, do not imply that the rocks were ever fluid-saturated. Modelling of the anhydrous symplectic corona textures in the CMAS and NCF–MAS systems assumed that Al and Si were immobile, and that the textural developement was controlled by diffusion of Ca (+ Na) and Mg (+ Fe). Calculations show that the gabbro-to-eclogite transition is characterised by the break down of orthopyroxene to metamorphic garnet and diopsidic clinopyroxene due to an increase in CaO. Simultaneously, plagioclase is shown to first undergo an intermediate reaction where it breaks down to garnet and kyanite as a consequence of higher MgO. The intermediate garnet subsequently breaks down to diopsidic clinopyroxene and kyanite at higher pressure, at which point the remaining plagioclase decomposes directly to diopside and kyanite. The anhydrous nature of the textures indicate that the gabbro-to-eclogite transition is not driven by hydration; however, increased H_2O acts as a catalyst, similar to deformation–recrystallization that allows the metamorphic reactions to occur. Our results show that eclogite formation requires low water activity, confirming that true eclogites are dry rocks [5].

References:
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