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Creeping gabbro: dissolution-precipitation creep facilitating deformation in mafic rocks

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Mafic rocks consist of strong minerals (e.g. clinopyroxene, plagioclase) that can only be deformed by crystal plastic mechanisms at high temperatures (>800°C). Yet, mafic rocks do show extensive deformation by non-brittle mechanisms when they have only reached lower temperatures (~650°C). In many of such cases, the deformation is accommodated by an interaction of deformation with simultaneous mineral reactions. Here we show that dissolution-precipitation creep plays a major role in deformation of gabbro lenses at mid and upper amphibolite facies conditions.

The Kågen gabbro in the North Norwegian Caledonides intruded the Vaddas Nappe at 439 Ma at pressures of 7-9 kbar, temperatures of 650-900°C, and depths of 26-34 km. The Kågen gabbro on south Arnøya is comprised of undeformed gabbro lenses with sheared margins wrapping around them. This contribution analyses the evolution of the microstructures and metamorphism from the low strain gabbro lenses to high strain mylonites at margins of the lenses. Microstructural and textural data indicate that dissolution-precipitation creep is the dominant deformation mechanism, where dissolution of the gabbro took place in reacting phases of clinopyroxene and plagioclase, and precipitation took place in the form of new minerals: new plagioclase and clinopyroxene, amphibole, and garnet. Amphibole shows a strong CPO that is primarily controlled by its preferential growth in the extension direction. Synchronous deformation and mineral reactions of clinopyroxene suggests mafic rocks can become mechanically weak during the general transformation weakening process, i.e. the interaction of mineral reaction and deformation by diffusion creep. The weakening is directly connected to a fluid-assisted transformation process that facilitates diffusion creep deformation of strong minerals at far lower stresses and temperatures than dislocation creep. Initially strong lithologies can become weak, provided that reactions can proceed during deformation, the transformation process itself is an important weakening mechanism in mafic (and other) rocks, facilitating deformation at low differential stresses.