Deformation-induced fluid influx and resultant dissolution-precipitation process in the mid-crustal rocks:

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In the mid-crustal rocks, the net-transfer reactions involve release or consumption of fluid phases. In general, prograde reactions are driven by the increase in temperature, whereas retrograde reactions are caused mainly by the influx of external fluids. Such the fluid influx would occur along grain boundaries (pervassive flow) or discrete fractures (channel flow). Because permeability of the intact rocks determined experimentally is very low (~10-20-10-23 m2), fluid influx causing the retrograde metamorphism could be associated with the channel flow. In this presentation, I provide a natural example that was deformed by means of cataclastic flow, followed by the influx of external fluids, and by resultant dissolution/precipitation creep under amphibolite-facies metamorphic condition.

In the mylonite zone of the Cretaceous Ryoke metamorphic belt in the Kishiwada district, SW Japan, strongly foliated amphibolites and weakly-foliated amphibolites are found. The former and the latter occur in the strongly and the weakly deformed parts, respectively. The weakly-foliated amphibolites in the low-strain zone exhibit cataclastic microstructures, whereas the strongly foliated amphibolites do not exhibit such features. In the highly deformed zone, strongly foliated amphibolites contain Ti-rich brown amphibole porphyroclasts rimmed by Ti-poor green amphibole, titanite and chlorite. These porphyroclasts are elongated, forming shear surfaces defined by preferential distribution of the chlorite and titanite. Porphyroclastic plagioclase in the strongly foliated amphibolites consists of two components: an anorthite-rich core and an anorthite-poor rim. These microstructural and chemical changes suggest that high-strain amphibolites were initially deformed by cataclasis, followed by deformation through hydration reactions. During the metamorphism/deformation, old phases were not stable and dissolved, and new phases crystallized at the old phase rim. Dissolution of old phase and precipitation of new phase occurred normal to and parallel to the foliation, respectively, reflecting anisotopic dissolution-precipitation due to differential stress and changes in P-T-H2O conditions. The development of dissolution/precipitation of minerals is attributed to increased fluid flux in the strongly foliated amphibolites, as evidenced by the greater abundance of hydration-reaction products in the strongly foliated amphibolites than in the weakly foliated ones.

Initial cataclastic deformation produced a rather weak shape-preferred orientation of brown amphibole grains with small aspect ratios as well as a poorly developed amphibole lattice-preferred orientation with a-axes scattered subnormal to the foliation and c-axes scattered around the lineation. During later deformation by dissolution-precipitation creep, preferential dissolution at grain boundaries subparallel to the foliation and simultaneous compaction normal to the foliation have likely produced a distinct alignment of elongate brown amphibole grains subparallel to the foliation as well as their fabrics such that their c-axes are scattered around the lineation, while a- and b-axes are spread along a girdle normal to the lineation. Also during this deformation green amphibole precipitated as isolated grains or in pressure shadow regions around brown amphibole grains. Nucleation and anisotropic growth of isolated green amphibole grains according to the orientations of the principal stress directions produced a fabric pattern of these grains such that their a-axes are oriented normal to foliation, b-axes within the foliation normal to the lineation and c-axes are parallel to the lineation. In addition, there is an associated shape-preferred orientation. Growth of green amphibole in pressure shadow regions around brown amphibole grains occurs either syntaxially or anisotropically according to the orientations of the principal stress directions.