Stress, fluids and metamorphism

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Centimetre-sized grains of Al-rich clinopyroxene within the anorthosites of the Bergen Arcs, W-Norway undergo deformation by micro-shear zones and faults along which fluid is introduced. The hydration is coupled to whitening of the dark primary feldspar reflecting fluid-induced reactions within the feldspar and growth of epidote as very fine inclusions. The Al-rich clinopyroxene (12 wt.% Al_2O_3) equilibrates to the deformation and hydration in two ways:

(i) replacement of the Al-rich pyroxene by chlorite and (ii) reaction to garnet ($Alm_{43}Prp_{28}Grs_{24}$) and a less aluminous pyroxene (3 wt. % Al_2O_3).

The two types of alteration develop in the same grain so that the garnet and the new pyroxene are formed along faults and kink bands while the chlorite is found in dilatational areas. As the lithostatic pressure and the temperature must be constant across the Al-rich pyroxene we are left with two possible explanations. 1. The water is accumulated in the dilatational areas allowing formation of chlorite while the imposed deformation enhances reaction kinetics and forms garnet where fluid is deficient. 2. The variation in stress across the grain stabilized the two assemblages, so that the garnet formed in the high pressure area and chlorite in the low pressure parts. Possibly the two mechanisms operated together.

This example illustrates the influence of fluid and deformation on metamorphism and it appears that the variation of the local stress within a single grain may determine the location of the new mineral assemblages.

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