
Incomplete hydration during ‘retrograde’ metamorphism: ‘Barrovian’ kyanite-, staurolite-, chloritoid-bearing pseudomorphs after andalusite (Cap de Creus, E Pyrenees, Spain)

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Résumé

Metapelitic rocks from Cap de Creus (Eastern Pyrenees, Spain) have developed andalusite ± cordierite-bearing assemblages during the Variscan low-pressure high-temperature metamorphism. Andalusite crystals are commonly transformed to very fine-grained assemblages containing white micas with various combinations of staurolite, kyanite, chloritoid, and/or biotite, chlorite, corundum. The hydrous character of the replacement minerals (pseudomorphing anhydrous andalusite) and the fact that transformation locally occurs along fractures, suggests that it was enhanced by fluid circulation. Using calculated equilibrium-assemblage phase diagrams (pseudosections) for the analysed whole-rock compositions, the equilibration of the primary andalusite-bearing assemblage is constrained at $\approx 3 \pm 1$ kbar and $\approx 550 \pm 30$ °C. The presence in the pseudomorphs of kyanite and staurolite, typical of Barrovian-type metamorphism, could suggest a pressure increase. However, P - T - M (H₂O) modelling of phase equilibria for local bulk compositions of the pseudomorphed andalusite porphyroblasts points to the crystallisation of the observed pseudomorphs at low pressures (≈ 2.5 kbar) and variable, but relatively low temperatures (≈ 370 – 500 °C), in an H₂O-undersaturated environment due to the incomplete character of the hydration. In other words, the fluid incursion triggered the crystallisation of the hydrous pseudomorphing assemblages, but the fluid was consumed during this process, leading finally to fluid-absent, H₂O-undersaturated conditions. This highlights the critical importance of considering the effects of H₂O undersaturation during metamorphism. The partial hydration can be tentatively attributed to a prograde hydrothermal overprint associated with the development of shear zones during Jurassic stretching of a cooled Variscan crust, rather than ‘simple’ late-Variscan retrogression.

Mots-Clés: pseudomorphs after andalusite, phase diagrams, incomplete hydration, H₂O undersaturation, Pyrenees

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