American Mineralogist, Volume 87, pages 433–444, 2002

Andalusite-sillimanite replacement (Mazarrón, SE Spain): A microstructural and TEM study

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ABSTRACT

At Mazarrón, SE Spain, dacitic lavas of the Neogene Volcanic Province contain numerous xenocrysts and xenoliths with abundant andalusite that displays variable degrees of transformation to both fibrolite and coarse sillimanite. At the onset of replacement, andalusite dissolves along grain boundaries and (110) cleavage planes, probably assisted by fluids or melts. At the same time, fibrolite crystallizes together with plagioclase, cordierite, and graphite in newly formed embayments or in the adjacent matrix. With increasing reaction progress, fibrolite needles coalesce into coarser sillimanite prisms, and direct topotactic replacement of andalusite is observed.

The mutual crystallographic orientation of andalusite and sillimanite obtained from TEM investigation deviates slightly from the topotactic relationship proposed in the literature ($c_{\mathrm{And}} \| c_{\mathrm{Sil}}$, $a_{\mathrm{And}} \| b_{\mathrm{Sil}}$, $b_{\mathrm{And}} \| a_{\mathrm{Sil}}$). The two lattices are rotated by ~2.5° around a_{And} (= b_{Sil}). With this misorientation, the structurally equivalent $\{032\}_{\mathrm{And}}$ and $\{302\}_{\mathrm{Sil}}$ planes, which exhibit the smallest misfit between the two lattices, become parallel. Macroscopic interfaces with such orientations are rare. Microscopically, however, decomposition of faces into $\{032\}_{\mathrm{And}} \| \{302\}_{\mathrm{Sil}}$ and {110} facets are common. The mutual crystallographic orientation of the reactant and the product phases is, therefore, controlled by lattice misfit minimization. The prismatic shape of the final coarse sillimanite crystals, however, is controlled by kinetic factors. The reaction seems to proceed fastest parallel to the octahedral Al chains resulting in the development of crystals elongated along the *c* axis. The high activation energy and the large overstepping of the equilibrium temperature required for the transformation are probably responsible for the large differences in reaction progress observed in the samples from Mazarrón.