Alteration and deformation microstructures of biotite from plagioclase-rich dykes (Ronda Massif, S. Spain)

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Abstract: TEM analysis of microstructures and mechanisms related to alteration and deformation in igneous biotites was carried out on plagioclase-rich dykes from the ultrabasic Ronda massif (Betic Cordilleras, Spain). Compositional data for biotite and chlorite are used to establish the mass transfer of the alteration reaction, here considered as Al-conservative. Crystal defects -such as wavy layers and edge dislocations- commonly occur during the early stages of chloritization.

Deformation microstructures reveal that, at low-temperature and low-pressure, biotite and chlorite behave as multilayer packets, with the (001) planes acting as slip surfaces. Under these conditions, microscale kink-folds originate by flexural-slip folding. Most of the strain in fold limbs corresponds to intracrystalline gliding, but several other shear-strain structures are also observed: low-angle boundaries, voids, as well as ordered and disordered complex polytypes. Although ordered complex polytypes may originate by crystal growth, they probably arise in the studied samples by regular relaxation of low-magnitude shear stress around (001) slip planes. Hinge zones progressively evolve from kink-type through concentric-type with triangular voids, to serrated-type hinge zones. Intracrystalline permeability progressively increases during deformation and favours further alteration and recrystallization processes.

Keywords: alteration, deformation, complex polytypes, biotite, chlorite.

Introduction

The biotite-to-chlorite alteration reaction is generally due to retrogressive metamorphic processes. Details of microstructures and solid state mechanisms have been studied by Veblen & Ferry (1983), Olives Baños & Amouric (1984), Yau et al. (1984) and Eggleton & Banfield (1985). Alteration is produced by two different mechanisms: hydration of the mica interlamellar layer, potassium loss and a) removal of the tetrahedral sheets of one TOT mica layer, or b) brucitization at the interlayer level. Analytical studies on Al-conservative (Ferry, 1979) and Mg-conservative reactions (Eggleton & Banfield, 1985) conclude that volume loss is produced during the biotite-to-chlorite alteration, in agreement with the first reaction mechanism.

Deformation microstructures in mica have been previously studied to determine the deformation-crystallization relations, both at the optical as well as the TEM scale (Vernon, 1977; Knipe, 1981). Bell & Wilson (1981) compared TEM microstructures and intensity of deformation in biotite with respect to muscovite. In addition, Amouric (1987), using HRTEM, distinguished several specific deformation defects related to different degrees of deformation in phyllosilicates.

Phyllosilicate structures consist of bidimen-