Chloritization of biotite in slates from the Santa Elena shear zone (Southern Iberian Massif, SE Spain) promoted by deformation and fluid circulation

J. Jiménez-Millán [1], N.Velilla [2] and M. Vázquez [3]

[1] Departamento de Geología. Universidad de Jaén. 23071 Jaén. Spain.
[2] Departamento de Mineralogía y Petrología. Universidad de Granada. Facultad de Ciencias. Fuentenueva s/n. 18002 Granada. Spain.
[3] Departamento de Geodinámica. Universidad de Granada. Facultad de Ciencias. Fuentenueva s/n. 18002 Granada. Spain.

Relatively small shear stresses are required for the onset of plastic deformation in biotite, which is ultimately produced by dislocation glide in the (001) basal planes of crystals, regardless of the orientation of compressional axes. Naturally deformed biotite in contact metamorphosed slates affected by a shear zone of the Southern Iberian Massif near Jaén (SE Spain) were studied by X-ray diffraction, optical microscopy, scanning electron microscopy, electron probe microanalysis and transmission and analytical electron microscopy.

Biotite is found in the contact metamorphism aureole produced by the intrusion of the Santa Elena granodioritic stock. The shear band developed on the contact metamorphism aureole produced the rotation and elongation of the biotite crystals defining the stretching lineation of the sheared slates. The southern part of the shear band is strongly deformed, containing thick clay gouge zones. The northern part is less deformed and develops weaker planar-linear fabrics. An initial synkinematic retrograde metamorphic stage produced during the shearing event caused the crystallization of chlorite, muscovite and pyrophyllite. The shearing process evolved towards progressively cooler conditions producing a retrograde event characterized by the kaolinite crystallization.

Deformation and fluid-rock interaction processes produced structural and chemical modifications of the biotite crystals. X-ray diffraction data reveal the predominance of the $2M_1$ biotite in the undeformed samples whereas the 1M polytype is predominant in the sheared samples. Chemical data and electron images of the biotite from unsheared slates do not show the presence of intercalated phases. This biotite is almost defect-free and electron diffraction patterns have sharp reflections indicating a two-layer polytype (probably $2M_1$). Back-scattered electron images from the deformed biotite in the moderate deformation part of the shear zone do not reveal intergrown minerals, but the electron microprobe analyses show some Fe and Mg enriched compositions. Transmission electron microscopy indicates that disordered polytype packets are predominant (probably $1M_d$). Their electron diffraction patterns have diffuse streaking along c*. These packets have high dislocation densities, microcavities with ≈ 5 Å lattice fringe regions (probably brucite-like layers) and interlayering of chlorite-berthierine. Kaolinized biotite can be observed in the clay gouges from the strongly deformed south part of the shear zone. The degree of streaking, as an indication of the intensity of deformation, revealed that the disordered polytype packets are more deformed than the two-layer polytype packets. The microcavities of the disordered polytype packets could act as potential channels for transport of fluids during the shearing stage and serve as sites for chloritization of biotite, producing chlorite-berthierine domains within biotite. Berthierine is an intermediate metastable phase replaced by chlorite with along-layer transitions.