STRESS-INDUCED ALTERATION OF SUDOITE: STRUCTURAL AND CHEMICAL MODIFICATIONS

MARÍA DOLORES RUIZ CRUZ1,*, MARÍA DOLORES RODRÍGUEZ RUIZ1, AND CARLOS SANZ DE GALDEANO2

1 Facultad de Ciencias, Campus de Teatinos, 29071 Málaga, Spain
2 Instituto Andaluz de Ciencias de la Tierra, CSIC-Universidad de Granada, Facultad de Ciencias, 18071 Granada, Spain

Abstract—The purpose of this study was to investigate the structural and chemical modifications of phyllosilicates that occur under natural conditions, using the progressive deformation of chloride (sudoiite) present in quartz-rich veins from the Internal Zone of the Rif range (Morocco) as the model system. Signs of chloride deformation include kinks, chevron-like folds, and fractures. The samples also contain later, undeformed grains, which sealed the fractures or grew with (001) perpendicular to the compressive stress. Deformation-induced structural changes consist mainly of basal cleavages associated with ordered replacement of brucite sheets by hydrated layers, thus leading to irregular microdomains of mixed-layer chlorite-vermiculite and sudoite. Such structural modifications represent a mechanism for accommodating the compressive stress. Structural changes were accompanied by minor chemical ones, which lead from di,tri-chlorite (sudoiite) to phases with a more trioctahedral character (mixed-layer chlorite-vermiculite). The hydration reaction occurred throughout a topotactic replacement of the pre-existing sudoite grains. Later, undeformed grains consist of mixed-layer chlorite-vermiculite intergrown with retrogressive kaolinite and minor Fe oxide, and are interpreted as having formed through a dissolution-precipitation process, during deformation. Retrogression of sudoite probably occurred during the latest stage of exhumation, in low-temperature conditions.

Key Words—Chlorite-vermiculite, Clinohlore, Deformation, Mixed-layer, SEM, Sudoite, TEM-AEM.

INTRODUCTION

Quartz-, carbonate-, or plagioclase-bearing veins found in metamorphic terranes are generally interpreted to have formed during metamorphism through a process of metamorphic differentiation or segregation, as defined by Kretz (1994). Generally, the minerals found in a given vein are also constituents of the enclosing metamorphic rocks. The composition of the vein phases and of the enclosing rocks are, in most cases, similar (Kretz, 1994). Based on these observations, the general assumption is that the vein-forming elements in this case were derived from the immediately surrounding rocks.

Strongly deformed quartz veins are common in Permo-Triassic metapelites from the Internal Zone Complexes of the Betic-Rif range. In the northernmost part of the Beni Mezala window (Figure 1), some veins contain very small amounts of other metamorphic phases, including Ca-silicate (pumpellyite + actinolite + epidote) and kyanite + chloritoid assemblages. Carpholite-bearing veins have not been found at this zone but carpholite pseudomorphs have been described in other areas of the window. Veins generally contain minor amounts of trioctahedral chlorite but sudoite had only been described in veins from the tectonically overlying Boquete de Anyera unit. Veins are interpreted as having formed during prograde metamorphism, and preservation of some metamorphic phases has permitted the accurate determination of the metamorphic conditions affecting these formations, especially of those characterizing the high-pressure/low-temperature (HP-LT) alpine event (e.g. Goffé et al., 1989; Azañón et al., 1992; Bouybaouène, 1993; Azañón and Goffé, 1997; Ruiz Cruz et al., 2010).

Deformation affecting veins from the Betic-Rif range is generally observed at both the field and thin-section scales. Plastic deformation in metals and in some rock-forming minerals, such as quartz, carbonates, or feldspars, has been studied extensively (see Kretz, 1994, and references therein). Generally, plastic deformation occurs due to gliding, and is favored in most structures by the presence of dislocations. Plastic deformation generally leads in a first step to migration of the dislocations and formation of clusters of dislocations or polygonization. As the process advances, new dislocation-free crystals grow at the expense of the strained crystals. Stress-induced deformation in phyllosilicates is mainly due to basal slip, is favored by the presence of planar and linear defects, and leads to several types of folds and cleavages, with or without chemical perturbations (Baronnet and Olives, 1983; Bell and Wilson, 1981, 1986; Bell et al., 1986; Amouric, 1987).

Strongly deformed phyllosilicates (mainly micas and chlorite) are common in metamorphic terranes and numerous examples of the compositional changes...