High-temperature ammonium white mica from the Betic Cordillera (Spain)

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ABSTRACT

High-temperature, ammonium-rich white mica has been identified for the first time in deep Paleozoic (and probably older) polymetamorphic schists from the Internal Zone of the Betic Cordillera (Spain). Ammonium-rich white mica has been characterized by optical microscopy, X-ray diffraction, infrared spectroscopy, elemental analysis, electron microprobe, and scanning and transmission electron microscopy. High-temperature, ammonium-rich white mica shows some significant chemical differences with tobelite formed in hydrothermal and low-temperature metamorphic rocks. Although the average formula, $\text{Ca}_{0.00} \text{Na}_{0.00} \text{K}_{0.15} (\text{NH}_3)_{0.75} (\text{Al}_{1.01} \text{Ti}_{0.05})\text{Fe}_{0.26} \text{Mg}_{0.30} \text{Si}_{2.99} \text{Al}_{1.01} \text{O}_{10} (\text{OH})_2$, is typical of a dioctahedral mica, the chemical plots reveal a clear deviation toward the trioctahedral field. Thus, the increase in Fe + Mg contents is not accompanied by the parallel increase of Si contents, characteristic of the phengitic substitution, which is characteristic of low-pressure conditions of formation. Chemical differences are also accompanied by notable differences in the optical properties, both features suggesting that the term tobelite is not appropriate for this mica. Ammonium-rich white mica relics only persist in some graphite-rich microdomains, defining the first schistosity. Textural relations indicate that this mica formed during an older pre-Alpine metamorphic episode.

Keywords: Ammonium-rich white mica, Betic Cordillera, muscovite, SEM, TEM-AEM, tobelite

INTRODUCTION

Ammonium dioctahedral mica was discovered in hydrothermal deposits of Japan and termed tobelite by Higashi (1982). From that time, the number of reports of tobelite and ammonium-bearing illite has progressively increased. Ammonium-rich dioctahedral mica appears in two main geologic environments: (1) hydrothermal deposits and (2) very low-grade metapelites. In the second case, tobelite can have a wider distribution, especially in sedimentary terrains rich in organic components, such as many Carboniferous formations (Juster et al. 1987; Daniels and Altaner 1990; Sucha et al. 1994; Liu et al. 1996; Nieto 2002).

Lack of tobelite in higher-grade rocks has been attributed to devolatilization processes occurring between 300 and 500 °C (Juster et al. 1987). Nevertheless, the available DTA curves (e.g., Higashi 1982) indicate that loss of NH$_3$ begins at approximately 550 °C, and tobelite must be, theoretically, stable in metamorphic rocks below this temperature. Indeed, tobelite and its analogous trioctahedral mica have been synthesized at relatively high temperatures (up to 550 °C) (Eugster and Munoz 1966; Boss et al. 1988; Sucha et al. 1998; Harlov et al. 2001a, 2001b). Surprisingly, high-temperature, ammonium-rich white mica had not been previously described, in this case in spite of the fact that high NH$_3$ contents (up to 3000 ppm) have been measured in micas of various metamorphic grades (Honma and Itihara 1981; Itihara and Suwa 1985; Duit et al. 1986; Visser 1992; Boyd and Philippot 1998; Mingram and Braüer 2001).

We present the first finding of high-temperature ammonium dioctahedral mica, which has been identified in polymetamorphic schists from the Internal Zone of the Betic Cordillera (Alpujárride Complex). Nevertheless, ammonium-rich white mica is very scarce in these rocks, which is a possible explanation of why it has not been previously reported.

GEOLOGIC SETTING

The Betic Cordillera, the westernmost European Alpine chain, has been traditionally divided into a northern external domain including the Prebetic and the Subbetic zones; an intermediate domain, the Flysch units from the Gulf of Cádiz area; and a southern domain, the Internal Zone. The Alpine orogeny (Upper Cretaceous to Miocene) involved collision of the Internal and External Zones. The collision was accompanied by intense structural deformation and metamorphism, which mainly affected the Internal Zone. Structurally, the Internal Zone is formed of four tectonically superimposed complexes (Egeler and Simons 1969; Puga et al. 2002), from bottom upward, the Veleta and the Mulhacén (both generally included in the Nevado-Filabride), the Alpujárride and the Maláguide (Fig. 1). The geotectonic relationships between the Maláguide, the Alpujárride, and the Nevado-Filabride are essentially constant in the Betic Cordillera. The Maláguide Complex tectonically overlies the Alpujárride Complex, and this later overlies the Nevado-Filabride Complex.

The Alpujárride Complex shows sequences comprising poorly dated Palaeozoic (and probably older) terrains (Egeler...