Tobelite in Low-Grade Metamorphic Organic-Rich Shales from Douro-Beira, Portugal

EUGXI.O11.2608

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Organic-rich Carboniferous shales associated with coal seams from the Bacia Carbonifera do Douro-Beira (N Portugal), have been studied by TEM, as well as by a variety of other methods. Micas rich in NH4 (tobelite) and K, together with berthierine, form small subparallel nanometer scale packets separated by low-angle boundaries. One- and two-layer ordered polytypes, with some spot streaking characteristic of minor disorder, coexist in the NH4 micas. All the common characteristics described for subgreenschist facies were observed, including a lack of textural and chemical equilibrium. The compositions of both K and NH4 micas vary considerably, and except for Ti, exhibit similar compositional ranges. The most significant trends of variations are explained by phengitic substitutions (Si from 3 to 3.25, Fe+Mg from 0.1 to 0.3), while no evidence of large changes in interlayer site vacancies has been found. NH4 in tobelite was determined by analysis of NH3 using Nessler's reagent, basal spacing and 1-(K+Na).

The resulting values suggested that NH4 contents could range from 38 to 59% of the interlayer site occupation. The presence of N in the white micas was confirmed by electron energy loss spectroscopy (EELS) of crushed grains dispersed on holey-carbon grids. EELS analyses showed that the composition of the interlayer site varied between grains, and that a significant margarite component was present in some of the crystals. In other previously studied localities, the intergrowth of NH4 and K in micas is on the nm-scale at very low temperatures (e.g., North Sea, Drits et al, 1997). At higher temperatures, NH4 and K are found in separate micas (e.g., Pennsylvania, Juster et al., 1987). The Douro-Beira samples represent an example of the highertemperature case. NH4 and K coexist in the same layer, but one cation is dominant. NH4- and K-dominated micas have segregated into well-separated packets with scarce intergrowth and almost no mixed-layers. Thus, the evolution of tobelite during low-grade metamorphism follows a path of metastable mixed compositions that increase in segregation as grade increases. This is similar to the evolution of paragonite and margarite.

Drits VA, Lindgreen H & Salyn AL, *Am.Min.*, **83**, 79-87, (1997).

Juster TC, Brown PE & Bailey SW, *Am.Min*, **72**, 555-565, (1987).