A TEM study of berthierine/chlorite in metapelites of Cameros basin (Northeastern Spain)

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A sequence from deep diagenesis to epizone can be defined for the rocks of the Cameros Basin on the basis of illite, chlorite crystallinity and mineralogical studies. Hydrothermal fluid circulation in favorable areas gave rise to a characteristic hydrothermal mineralogical alteration (Mata et al. 2001, 2004) and a pyrite mineralization (Alonso-Azcárate et al., 2001). The highest-grade mineral assemblage of the basin is represented by paragonite and chloritoid that disappear up sequence. Metamorphic conditions based on the mineralogical reactions calculated from coexisting chlorite/chloritoid yield a minimum temperature of 300 - 350 ºC over a pressure range of 1 - 6 kbar (Mata et al., 2001). In this study a textural and compositional characterization of coexisting chlorite-berthierine is made by optical study and scanning electron microscope (SEM) study using back-scattered electron (BSE) images and transmission electron microscope (TEM) fitted with EDS analysis.

Iron-rich chlorite, chamosite, is the main trioctahedral phyllosilicate in the low-grade metapelites of Cameros Basin. Optical and BSE images show chlorite as: I) fine grained crystals in the matrix; II) as coarse crystals in rounded diagenetic concretions or cavities with calcite, pyrite, quartz or albite and III) as grains or stacks interleaved with muscovite, pyrophillite, cookeite, kaolinite and probable relict biotite. TEM study revealed the presence of berthierine in many samples, not detected by conventional XRD analysis as small proportions of berthierine with chlorite may escape detection during routine mineralogical analysis. SAED patterns of chamosite display features varying from streaking parallel to **c*** in $k \neq 3n$ reflections, to sharply defined reflections having one-layer periodicities. Chlorite occur as well crystallized crystals with straight layers, few defects and rare 10 Å layers. Interstratification of Fe-rich berthierine and chlorite layers is frequent even in samples of the highest grade of the sequence. Berthierine occurs also as separate and well crystallized packets up to tens of nanometers. SAED patterns of interstratified chlorite-berthierine show streaking along c*, even order 001 reflections based on 14 Å periodicity being strong and sharp whereas odd-order reflections are weak and diffuse. Both chamosite and berthierine are common as inclusions in the poikiloblastic pyrite crystals. EDS analysis of chlorite and berthierine show significant differences in Fe and Al contents. Although berthierine has been inferred as a metastable phase in most occurrences, the occurrence of berthierine from the lowest up to the highest grade rocks in this sequence suggest that berthierine in Cameros metapelites is stable *vs* chlorite when increasing Fe proportion and does not evolve following Ostwald steep rule to chlorite as in other sequences. Although when chlorite is present, berthierine is rarely detected, it has been reported lately with increasing frequency when a carefully TEM study is made.

References

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