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Tectono-Metamorphic Evolution of the Eastern Rif of Morocco (External Zone of Rif Chain, Morocco) during Mesozoic and Tertiary Times

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In this work we have determine the characteristic of low grade metamorphism in metapelites from Temsamane and Ketama Units from the eastern Rif and the mineralogical assemblages of serpentinites of peridotites from Beni-Malek.

The Tánger-Ketama unit has an estratigraphic sequence from the Lower Jurassic to the Cenozoic and it is composed by metapelitic and quartzitic rocks, and marbles. The mineralogical composition determined by XRD of the samples is quartz, calcite, chlorite and muscovite. The Crystallinity Index (IC) of mica was determined in the ethilenglycol and natural samples. In some samples, the IC was different between the ethilenglycol and natural samples, which indicate the presence of the R3 illite/smectite. For these samples we have used the 5 Å peak of mica in order to determine the metamorphism grade. The Lower Cretaceous rocks have an anquizone grade (0.331-0.496 Δ^{o} 2 ?). The Jurassic samples present diagenetic conditions (0.567 Δ^{o} 2 ?). Azdimousa et al. (1998) determine the age of two events metamorphic with fission track analysis that occurred during the Cretaceous period. The first age is Barriasian to Hauterivian (126.6 $\pm$ 2.1 to 131.9 $\pm$ 3.2 Ma) and it is related with an important extension period related with the exhumation of the peridotites from Beni-Malek and the second one was Santonian to Campanian (78.0 $\pm$ 1.2 to 81.6 $\pm$ 4.0 Ma).

The Temsamane Unit forms a mountains chain of ENE-OSO directions and is composed by marbles, quartzites, and phyllites from Palaeozoic to Aptian-Albian times. The mineralogical composition of the samples studied is quartz, calcite, plagioclase, chlorite, muscovite, and paragonite. The kaolinite is present in some samples. The IC of mica indicates a late anquizone to epizone grade (0.300- 0.159 Δ^{o} 2 ?). In according to Guidotti and Sassi (1986), the b parameter of mica indicates intermediate pressure (at less 3 Kbar). The presence of paragonite indicates a metamorphism temperature higher of 200º C. However, the kaolinite is a typical sedimentary mineral suggesting a latter event in diagenetic conditions. Monié et al (1984) and Negró (2005) determined the age of the metamorphism at Oligocene times.

The main Cenozoic structure is the Nekor fault zone that dips around 15º degrees towards the northwest and separates the Ketama metamorphic unit (hanging wall) from the Temsamane Units (Footwall). The Beni-Malek Peridotites outcrops within the main thrust surface that overlay 5 to 10 meters of mylonitic marbles with an ENE-WSW-trending stretching lineation and a top-to-.the-WSW sense of movement. The peridotites of BeniMalek include websterite layers with spinel that contain the metamorphic association tremolite + chlorite produced by the reaction of plagioclase and olivine. The serpentinites of the massif shows the presence of two main phases through HRTEM technique. The first is a typical deformed mesh texture with lizardite, chrysotile and polygonal serpentinite. This texture is common in peridotites altered in an oceanic floor setting. The HRTEM images also show a fine grained aggregate of antigorite, the high temperature polymorph of serpentine, located within shear zones suggesting that the transformation to antigorite was induced by deformation of the mesh around the 300º C.

Discussion and Conclusions

The Early Cretaceous rocks of the Ketama massif (syn-rift sequences) are located over a Jurassic sequence (prerif sequence) in the south and over the Beni Malek Peridotites in the east, which are thinned peridotite altered in a sea floor setting. This disposition is strongly similar to the Galicia margin of the north-western Iberian Peninsula. During the Early Cetaceous, crustal extension affected both the prerift and the synrift sequences. The extension in the prerif sequence (Jurassic materials) was achieved by normal faults. In the synrif sequence, extension was achieved both by normal synsedimentary faulting linked to growth strata. In the Ketama Unit, the localization of the anquizone metamorphic rocks agreed with one half-graben basin geometry, with diagenetic conditions in the borders (Jurassic materials) of the basin and higher grade metamorphic (anquizone) in the Lower Cretaceous materials in the deepest part of the basin. The present day geometry of the Ketama Massif is mainly due to the Tertiary contraction, which inverted the basin and superposed it over the metamorphic Temsamane units.

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