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Yttrium geothermometry: an approach to determine the oldest garnet growth recrystallization conditions from micaschists (Yunquera Unit, Betic Cordilleras, southern Spain

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The garnet-xenotime geothermometry is nowadays been using as a tool to identify low-grade relic garnets and even to calculate garnet growth temperatures in metapelites that have undergone a polymetamorphic evolution (Pyle and Spear, 2000; Borghi et al., 2006). A prograde metamorphic evolution, under continuously increasing temperature, can induce garnet and accompanying phase's composition homogenization by intra-crystalline diffusion, leading to flat zoning profiles. Consequently, the application of conventional geothermobarometers on those mineral assemblages does establish minimum P-T conditions. Therefore, the less susceptible elements to diffusion processes, like trace elements, should be taken into account in order to reconstruct their metamorphic evolution.

We studied a polymetamorphic micaschist recovered from the Yunquera Unit, one of the tectonic slices of the Internal Zone of the Betic Cordilleras (southern Spain) (Dürr, 1963). The Yunquera unit evidences three stages of recrystallization at different P-T conditions. According to conventional geothermobarometry (Esteban et al., 2005) the metamorphic peak, M2, is estimated at 1200-1300 MPa and 560-695 ºC and the decompression path, M3, at 600 MPa and 700 ºC. The lack of mineral paragenesis in apparent chemical equilibrium during M1, does not allow determining accurately its recrystallization conditions.

Xenotime, identified by scanning electron microprobe, appears as matrix mineral and therefore the entire garnets are assumed to be in chemical equilibrium with it. Yttrium profiles of two garnets show a mean bell-shape compositional variation that differs significatively from the discontinuous profiles shown by Ca, Mg and Fe. This difference accounts for different diffusion rates for those elements and agree with the original Y-zoning preservation. A third Y-profile shows an oscillatory compositional variation. The internal part of garnets, bounded by sharp inclusion trails, are characterized by sawed bell-shape zoning in the range of ca. 500-2000 ppm of Y, that abruptly decreases to less than 500 ppm to the borders. Temperature distribution calculated from the garnet-xenotime geothermometer of Pyle and Spear (2000) is outlined by flat patterns, matching up with the cores of the garnets, and by a slightly increase to the rim. The metamorphic temperature calculated using the Y-concentration of the central portions of garnet cores is ca. 520 ºC, whereas towards the rim the temperature does increase up to ca. 575-625 ºC. The estimation of garnet recrystallization pressure is still a matter of discussion, furthermore when the hypothetical equilibrium paragenesis is absent.

According to the presented data, we suggest that the oldest garnet growth generation did occur at ca. 520 ºC and therefore, the preservation of original Y-zonings can be used for thermal history reconstructions, as Y-content in garnet is T-dependent.

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