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Metasomatized calc-silicate resisters in migmatites (Variscan Orogen, NW Portugal)

M. Areias, M. A. Ribeiro, and A. Dória
1Centro Geologia Universidade Porto, DGAOT-FCUP, R. Campo Alegre, 4169-007 Porto, Portugal (maria.areias@gmail.com)

The Central Iberian Zone (CIZ) is the axial zone of the Iberian Massif and one of the most complete exposures of the European Variscan Belt. It is composed by Late-Proterozoic to Lower-Paleozoic metasedimentary rocks and syn- to late-tectonic variscan granitoids. A large area of CIZ corresponds to the outcrop of interlayered pelites and psammites (with thin subordinate calc-silicate rocks) named "Complexo Xisto-Grauvaquico" (CXG). These metasedimentary rocks were intruded by syntectonic granites, coeval with the orogenic variscan metamorphism, with a metamorphic zoning from greenschist facies (chlorite zone) away from igneous contacts, to upper amphibolite or granulite facies (silimanite zone), close to syn-tectonic granites.
In the coastal area of NW Portugal, metatexitic and diatexitic gneiss-migmatitic rocks occur in the border of the syn-tectonic variscan granite, associated with metapelitic and calc-silicate rocks. Decimetric (10 to 60cm) calc-silicate resister (CSR) are abundant mostly in the metatexitic zones, with ovoid or ellipsoidal geometry resulting from stretching and boudinage, associetd with migmatitic foliation. The calc-silicate bodies are sub-parallel to the foliation, whose direction varies from N150° to N200°. The published geological mapping assigns these migmatitic and cal-silicate rocks to CXG.
The CSR boudins are well individualized from the surrounding migmatitic rocks, by the concentric zonal structure and by the granoblastic microtexture, with fine quartz and plagioclase and larger poikilitic diopside, garnet and hornblende, with inclusions of quartz and plagioclase. The zonal structure of the CSR includes three concentric zones of variable thickness and shape: core zone (CZ) with anorthite + diopside + quartz + titanite + garnet (hight Ca) $\pm$ epidote $\pm$ calcite $\pm$ monazite $\pm$ sulfides; intermediate zone (IZ) without clinopyroxene that was replaced by hornblende, and the external zone (EZ) with biotite + quartz + oligoclase + garnet (low Ca) + ilmenite. The adjacent migmatitic rocks show silimanite and magmatic feldspar.
The whole rock geochemistry, the geometrty and internal structure of the CSR resisters suggest a siliciclastic protolith with some carbonate concretions as cement for the lenticular shaped CZ and IZ, and a quartz-feldspathic sandstone or greywacke protolith for the surrounded EZ. The geochemistry and mineralogical composition indicate that the IZ may be the result of metasomatic processes between the two different protoliths, during the metamorphism and migmatization. Compared with the CZ, the IZ is enriched in Na, K, Mg, P, LILE, Sc and metal transition elements. The geometry (diffuse boundaries), size (centimetric thickness) and textural features of CZ and IZ suggest a diffusion metasomatism model, promoted by high T, geochemical gradient and fluids, during the peak of metamorphic conditions, coeval with the adjacent migmatization.
The REE patterns of the CSR show similarity with upper crustal sedimentary rocks: elevated fraccionation, negative Eu anomaly, higher content of REE in CZ and IZ, related to the monazite and allanite content, and lower content in EZ. All these zones show low fractionation of HREE probably related to garnet content.

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