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The development of a gneiss dome in the Variscides of Northern Central Portugal: age constraints on metamorphism

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The Porto-Viseu Belt, located in the innermost zone of the Iberian Variscan Fold Belt – the Central Iberian Zone (CIZ), corresponds to an antiformal structure developed during the D3 Variscan deformation event. It is a classical example of a gneiss dome with medium- to high grade metasediments, HT-LP migmatites and anatectic syn-D3 granites, in the core, and low- to very low-grade metamorphic rocks, in the limbs.

The Variscan regional metamorphism is recorded in the metapelites of the Porto-Viseu Belt by a prograde Barrovian metamorphic succession from the chlorite and biotite zones to the staurolite, kyanite, sillimanite and sillimanite+K-feldspar zones. Microstructural criteria indicate that the growth of the Barrovian index minerals is syn-kinematic with D1 structures and, in the deeper levels, early to syn-D2.

The metapelites also preserve petrographic information about their retrograde metamorphic evolution as it is documented by the following observations: a) occurrence of relict staurolite porphyroblasts rimmed by coronas of andalusite + biotite, b) presence of kyanite and sillimanite grains overgrown by large syn-D3 crystals of andalusite and c) growth of muscovite as a late, retrograde phase in the sillimanite+K-feldspar zone.

The retrograde metamorphic history is controlled by decompression, associated with the tectonic exhumation during the D2 deformation event, and by D3 nearly isobaric cooling. One of the major effects of the tectonic exhumation was to trigger vapour-absent melting. As a result, melts of leucogranitic composition were produced by crossing the muscovite-breakdown reaction. Field evidence show that part of the

granitic melts produced in the migmatite zone was collected in veins and irregular masses of leucocratic granites.

Moreover, the P-T conditions reached in the migmatite zone had to be sufficiently high to allow the vapour-absent melting of biotite and reach the critical melt percentage ($\sim$20%–35%), required for such a remobilization (Clemens and Vielzeuf, 1987). The presence of stable biotite in these metapelites, as well as the absence of orthopyroxene, indicate that the maximum temperature did not exceed T » 830 ˚C.

The migmatite leucosomes are intensely deformed and folded. This folding is correlated to D3 dextral and sinistral transcurrent shear zones and clearly indicates that anatexis should have started before the D3 deformation episode.

Structural relationships show that the emplacement of the large, syn-D3 Junqueira – Serra da Freita batholith, along the axial zone of the Porto-Viseu Belt, post-dates the metamorphic climax. In fact, these granites crosscut the high-grade metamorphic isograds and show evidence of heterogeneous deformation. U-Pb monazite geochronology places the leucogranite intrusion at 307.8 ± 0.7 Ma (Valle Aguado et al., in press).

Assuming that the production of leucogranite melts is the direct consequence of tectonic exhumation and given the close spatial and chronological relations between extension, anatexis and leucogranite intrusion, the 308 Ma U-Pb age of the Junqueira – Serra da Freita granites provides a time constraint for the age of the metamorphic peak. It is unlikely that decompression occurred much prior to the extraction and crystallization of these melts because the crust would tend to cool rapidly during the decompression stage. The metamorphic climax cannot therefore be much older than 308 Ma.

References

Clemens, J. D., & Vielzeuf, D. (1987). Constraints on melting and magma production in the crust: Earth and Planetary. *Science Letters*, v. 86, p. 287–306.

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