

Episodic melting and magmatic recycling along 50 Ma in the Variscan belt linked to the orogenic evolution in NW Iberia

G Gutiérrez-Alonso^{1,2}, A López-Carmona^{1,2}, G García Acera¹, J Martín Garro¹, J Fernández-Suárez³, A Gärtner⁴, M Hofmann⁴

¹Department of Geology, University of Salamanca, Plaza de los Caídos s/n, 37008, Salamanca, Spain

²Faculty of Geology and Geography, Tomsk State University, 36 Lenina Ave, Tomsk 634050, Russia

³Department of Petrology and Geochemistry, Complutense University of Madrid and IGEO-CSIC, 28040 Madrid, Spain

⁴Senckenberg Naturhistorische Sammlungen Dresden, Museum für Mineralogie und Geologie, Königsbruecker Landstr. 159, 01109 Dresden, Germany

E-mail: gabi@usal.es

Abstract. The advent of a large amount of more precise U-Pb age data on Variscan granitoids from NW Iberia in recent years has provided a more focused picture of the magmatic history of the Western European Variscan belt (WEVB). Based on these data, three main pulses of magmatic activity seem to be well established.

Variscan granitoid magmatism in NW Iberia is an example of the intimate linkage between granitoid magma production and plate convergence/collisional/post-collisional geodynamic scenarios. In the Western European Variscan belt (WEVB) realm, the major stages of convergent tectonics and its aftermath, are recorded by granitoid suites generated in a time span of about 50 million years (*ca.* 340-290 Ma). There is however some ongoing controversy regarding: i) whether there was a significant magmatic event in the early Carboniferous, for which there is hitherto scarce evidence, and ii) whether the Variscan magmatic activity was continuous or it rather occurred through discrete and relatively short-lived pulses. Unravelling these issues is one of the key elements to better constrain and interpret the different processes involved in the collisional scenarios that lead to the Variscan orogeny in Iberia during Late Paleozoic times [1-5] and the subsequent development of the Ibero-Armorican Arc (IAA) [6].

The advent of a large amount of more precise U-Pb age data on Variscan granitoids (and some volcanic rocks) from NW Iberia in recent years has provided a more focused picture of the magmatic history of the WEVB, providing solid ground for interpretations that link periods of more intense magmatic activity with large-scale crust-mantle processes involved in the collisional orogeny and the subsequent development of the Ibero-Armorican Arc.

Based on the observation of those more precise U-Pb ages and new data, three main pulses of magmatic activity seem to be well established. These pulses recycle (re-melt) the previously formed granitoid rocks (Figure 1 and 2):

1) Post-orogenic granitoid suite (POS henceforth) (*ca.* 305-290 Ma), that intrudes all the structural domains of the orogen, including the foreland fold and thrust belt, which makes the WEVB rather unique. The POS includes a large number of volumetrically minor intrusions of mafic and ultramafic rocks. This magmatic event has been extensively studied and dated. The POS has been interpreted as generated by lithospheric delamination triggered by the oroclinal bending of the mountain belt.



2) Syn-extensional collapse granitoids (*ca.* 325-315 Ma): mostly crustal (S-type) peraluminousleucogranites generated by decompression melting following the extensional collapse of the mountain belt.

3) A third suite of Variscangranitoids, not considered in most of the published models, has been found with ages clustering around 340 Ma. In addition, a significant amount of *ca.* 340 Ma zircon xenocrysts has been found in the *ca.* 320 Ma syntectonicleucogranitoids of the Tormes Dome and surrounding areas, in the *ca.* 305 Ma Toledo Anatectic Complex and the western part of the Gredos Massif, and also as detrital zircons in Variscansyn-orogenic sediments.

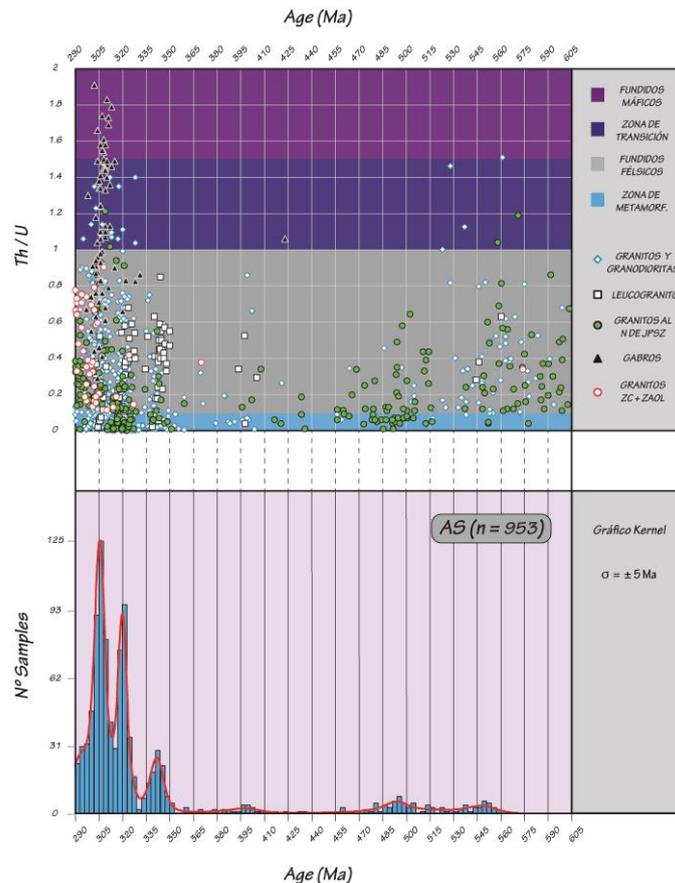


Figure 1.A) Graph [Th/U] vs. Age (Ma).and B) Histogram and Kernel distribution (KDE) of single zircon U-Pb ages of Variscangranitoids in NW Iberia [7]. Data from[8-17].

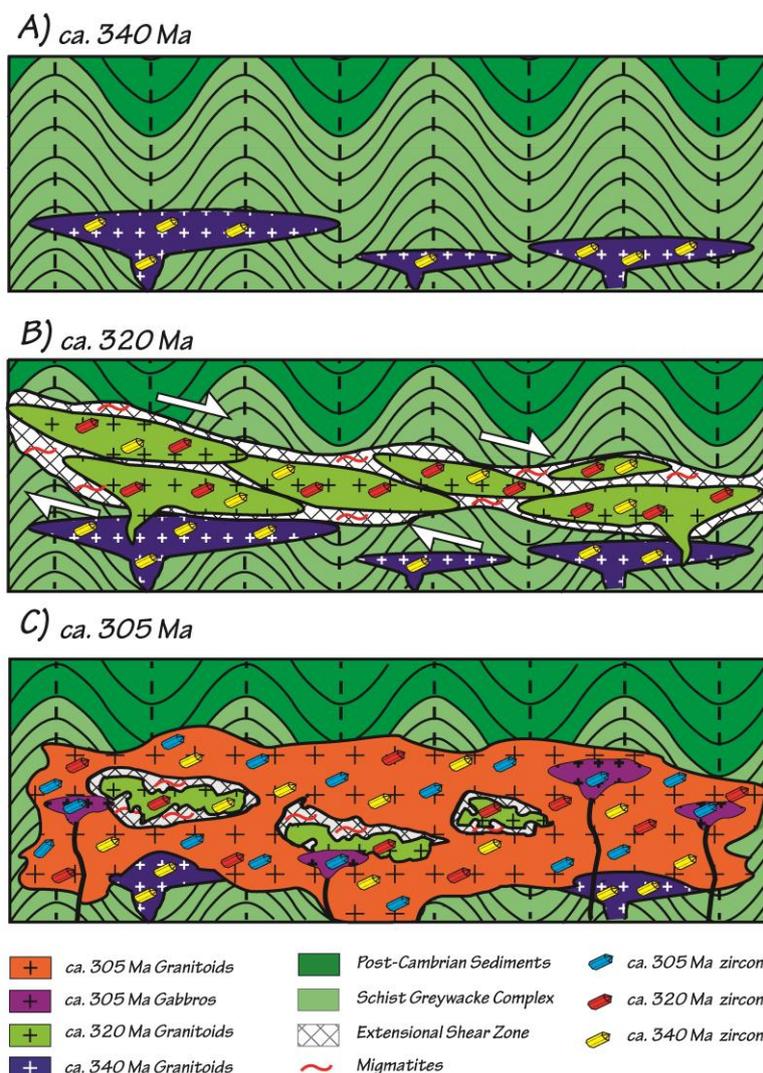


Figure 2. Proposed conceptual model for the recycling and re-melting of the three magmatic events found in NW Iberia according to the ages of the zircon grains found in them. A: Felsic magmatism of uncertain origin at *ca. 340 Ma*. B: Felsic magmatism at *ca. 320 Ma* associated with the orogenic collapse, extensional shear zones and extensive migmatization recycling previous 340 Ma granite bodies. C: Felsic and mafic magmatism of *ca. 310-295 Ma* that produced new zircons and recycled zircons from the two previous magmatic Variscan events. The latter event is interpreted to have occurred due to orocline triggered lithospheric delamination.

This work has been funded by the Spanish Ministry of Economy and Competitiveness under the project ODRE III-Oroclines & Delamination: Relations & Effects (CGL2013-46061-P) and the Russian Ministry of Education and Science under the project «Origin, metallogeny, climatic effects and cyclicity of Large Igneous Provinces» (14.Y26.31.0012).

References

- [1] Matte P 2001 The Variscan collage and orogeny (480-290 Ma) and the tectonic definition of the Armorica microplate: a review *Terra Nova* **13** p 122–128
- [2] Ballèvre M Bosse V Ducassou C Pitra P 2009 Palaeozoic history of the Armorican Massif: models for the tectonic evolution of the suture zones *Comptes Rendus Geoscience*. **341** p. 174–20

- [3] Martínez Catalán J R Arenas R Abati J Martínez S S García F. D Suárez J F Clavijo E G 2009 A rootless suture and the loss of the roots of a mountain chain: the Variscan belt of NW Iberia *Comptes Rendus Geoscience* **341(2)** p114-126
- [4] Arenas R Sánchez Martínez S Díez Fernández R Gerdes A Abati J Fernández-Suárez J Andonaegui P González Cuadra P López-Carmona A Albert R Fuenlabrada J.M Rubio Pascual F J 2016 Allochthonous terranes involved in the Variscan suture of NW Iberia: A review of their origin and tectonothermal evolution *Earth-Science Reviews* **161** p 140–178
- [5] Díez Fernández R Arenas R Pereira M F Sánchez-Martínez S Albert R Martín Parra L M Rubio Pascual F.J and Matas J 2016 Tectonic evolution of Variscan Iberia: Gondwana-Laurussia collision revisited *Earth-Science Reviews* **162** p 269–292
- [6] Weil A.B Gutiérrez-Alonso G Johnston S.T Pastor-Galán D 2013 Kinematic constraints on buckling a lithospheric-scale orocline along the northern margin of Gondwana: A geologic synthesis *Tectonophysics* **582** p 25–49
- [7] García Acera G 2017 Geología y geocronología U-Pb (LA-ICP-MS) de las facies graníticas del Valle del Jerte (Cáceres) BSc Thesis University of Salamanca 32 pp
- [8] Gutiérrez-Alonso G Fernández-Suárez J Jeffries T E Johnston S T Pastor-Galán D Murphy J B Franco M P Gonzalo J C 2011 Diachronous post-orogenic magmatism within a developing orocline in Iberia, European Variscides *Tectonics* **30**
- [9] Zeck H P Wingate M T Pooley G 2006 Ion microprobe U-Pb zircon geochronology of a late tectonic granitic-gabbroic rock complex within the Hercynian Iberian belt *Geological Magazine* **144** p 157-177
- [10] Díaz-Alvarado J Castro A Fernández C Moreno I 2011 Assessing Bulk Assimilation in Cordierite-bearing Granitoids from the Central System Batholith, Spain; Experimental, Geochemical and Geochronological Constraints *Journal of Petrology* **52** p 223-256
- [11] Díaz-Alvarado J Fernández C Castro A Moreno I 2013 SHRIMP U-Pb zircon geochronology and thermal modeling of multilayer granitoid intrusions. Implications for the building and thermal evolution of the Central System batholith, Iberian Massif, Spain *Lithos* **175-176** (2013) 104-123
- [12] Martín Garro J 2015 Geocronología de U/Pb mediante LA-ICP-MS en circones del Complejo anatéctico de Toledo y el batolito de los Montes de Toledo MSc Thesis Salamanca University 50 pp
- [13] Pereira M F Díez-Fernández R Gama C Hofmann M Gärtner A Linnemann U 2017 S-type granite generation and emplacement during a regional switch from extensional to contractional deformation (Central Iberian Zone, Iberian autochthonous domain, Variscan Orogeny) *International Journal of Earth Sciences*
- [14] Díez-Fernández R Pereira M F 2017 Extensional orogenic collapse captured by strike-slip tectonics: Constraints from structural geology and U-Pb geochronology of the Pinhel shear zone (Variscan orogen, Iberian Massif) *Tectonophysics* **691** p 290-310
- [15] Villaseca C Orejana D Belousova E Armstrong R A Perez-Soba C E Jeffries T 2011 U-Pb isotopic ages and Hf isotope composition of zircons in Variscan gabbros from central Spain: evidence of variable crystal contamination *Mineralogy and Petrology* **101** p 151-167
- [16] Bea F Montero P Molina J F 1999 Mafic precursors, peraluminous granitoids, and late lamprophyres in the Avila batholith: a model for the generation of Variscan batholiths in Iberia *The Journal of Geology* **107(4)** p399-419
- [17] Montero P Bea F Zinger T 2004 Edad $^{207}\text{Pb}/^{206}\text{Pb}$ en cristal único de circones de las rocas máficas y ultramáficas del sector de Gredos, Batolito de Ávila (Sistema Central Español) *Revista de la Sociedad Geológica de España* **17(3-4)** p157-167