Cadernos Lab. Xeolóxico de Laxe
Coruña. 2000. Vol. 25, pp. 257-260

Sources of late-Hercynian biotite-rich granite plutons from northern Portugal: Inferences from zircon morphologies

Procedencia de los plutones graníticos ricos en biotita tardi-Hercínicos del Norte de Portugal: Deducciones a partir de la morfología de circones

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In the NW of Iberian Peninsula a great abundance and variety of granite magmatism were emplaced during the post-thickening collision stage of Hercynian orogeny. They are classified relatively to D3, the last ductile deformation phase, intra-Westphalian in age.

The granite plutons selected for this study, located in Central Iberian Zone, Northern Portugal, according to this classification are : (1) Late-tectonic biotite pluton of Vieira do Minho (VM) and (2) post-tectonic biotite pluton of Vila Pouca de Aguiar (VPA). The emplacement of these two granite plutons was controlled by tectonic regional structures, Vigo-Amarante-Régua ductile shear zone and Régua-Verin fault, respectively.

The late-tectonic composite VM pluton consists of two different units of biotite-rich porphyritic granite: coarse-grained monzogranite, the Vieira do Minho Granite (VMG) and the Moreira de Rei Granite (MRG), medium-grained monzogranite with abundant microgranular enclaves, which are rare in VMG. Both granites are later than D_3 regional structures (N60W). The gradational contacts between the VMG and MRG suggest a synchronous emplacement. The U-Pb isotopic analyses carried out on zircon and monazite fractions indicate an age of crystallisation of 311±2 Ma (Martins *et al.* 1999a).

The post-tectonic VPA pluton has a NNE-SSW (N20 to N30) elongated shape with the same orientation of the late Hercynian brittle structure, the Régua-Verin fault. It is also a composite massif with two main different biotite-rich porphyritic granite units; the Vila Pouca de Aguiar Granite (VPAG) medium-coarse grained with microgranular enclaves, the Pedras Salgadas Granite medium-fine grained (PSG) and a third granite type, Gouvães da Serra Granite (GSG) coarse-grained, very similar to PSG but with a minor extend in map view. The field relationships indicate a synchronous magmatic emplacement of all granites. The U-Pb isotopic analyses of zircon fraction give an emplacement age of 299± 3 Ma (Martins *et al.* 1999b).

With the present morphological zircon study it is aimed to characterize the sources reservoirs involved in the generation of these type of granites.

The morphology of zircon crystals is very resistant to mechanical and chemical attack and persists up to high-grade metamorphic conditions. Therefore, the zircon crystal shape has been used as an index for its magmatic genesis. Zircon is generally well distributed in granites and the zircon population of one sample is generally enough to characterize an homogeneous granitic body (Pupin 1985). Among several morphological parameters, the habit is the most variable and carry most petrogenetic information, as pointed out by Pupin and Turco (1972a) and Pupin (1976, 1980, 1988).

Zircon belongs to the ditetragonal-dipyramidal quadratic system class. The combination of the most common crystalline faces (pyramids {101}, {211} and prisms {100},{110}) is the basis of the zircon typology (Pupin and Turco 1972a). The extra {301} pyramid can exist but with a minor development. Main types and subtypes are reported in a square board with two variables (I.A -I.T diagram), depending up the relative development of prismatic and pyramidal crystal faces. The A index (I.A) is positively correlated with the K+Na/Al ratio. The T index (I.T) is directly and positively correlated with the temperature of zircon crystallization. The {211}, {101}and {301} pyramids are respectively well developed in aluminous, alkaline and hyperalcaline medium. A high T index ({100} prim) indicates a higher temperature than does a low T index ({110} prism), thus a geothermometric scale was proposed (Pupin and Turco 1972b).

A given zircon population will be characterized by a typological distribution (frequency of each type and subtype) a T.E.T. (Typological Evolutionary Trend) and a mean point (A, T) calculated as: $I.A = \Sigma\ I.A \times n_{I.A}$, $I.T = \Sigma\ I.T \times n_{I.T}$, where $n_{I.A}$ and $n_{I.T}$ are the respective frequencies for each value of I.A or I.T envisaged between 100 and 800, with $\Sigma\ n_{I.A} = \Sigma\ n_{I.T} = 1$. The T.E.T. represents the chronology of of the different types and subtypes during the magmatic stage and is defined by the mean points of I.A calculated for each value of I.T (Pupin 1988).

A morphological study using the zircon typology was carried out on two samples from VMG, one from MRG, VPAG and PSG.

According to their morphology four different populations of zircon have been recognised in late and post-tectonic granites: prismatic zircons (short, long and acicular), lamellar zircons and subspherical zircons, this last type only occurs in late-tectonic granites. The internal structure (BSME images) of the zircons show a typical magmatic structure, with a inner zone with nebulitic textures surrounded by regular fine magmatic zoning. In zircons from post-tectonic granites the zoning is much more complex and sometimes they have a core that corresponds an earlier magmatic crystallization. These structures are common in long prismatic zircons. The prismatic acicular and the lamellar zircons are very homogeneous crystals devoid of cores and showing generally a faint zoning dominantly nebulitic internal structures. The BSME imaging of the subspherical type reveal the presence of inherited cores.

According to their typological distribution, the zircons of the late-tectonic granites are dominantly of subtypes S2, S3, S7, S12 and S17 for the Vieira do Minho Granite, while in the Moreira de Rei Granite we can distinguished two different typological distributions, one is dominantly of subtypes S12, S13 and S17, typical of calc-alkaline granites (Pupin 1988) and the other belong to the L3 type with a I.A=349 and I.T=452. The zircon population from VMG show low A and T indexes (I.A=328, I.T=395) which put the mean point in the field of aluminous monzogranites-granodiorites, but overlapping several typological domains. On the other hand morphological characteristics of zircons from GMR seems to indicate a typological characteristics closer to the zircons from calc-alkaline granites. The T.E.T. indicates a crustal or dominantly crustal origin for VMG and an origin from hybrid calc-alkaline magma for MRG. The occurrence of microgranular enclaves associated with this granite supports the model of mantle-crustal source.

The zircon population from the post-tectonic granites VPAG and PSG show a great variety of subtypes and are more concentrated in the right side of the zircon typological diagram, specially PSG zircons. In VPAG they going from subtypes S17, S18, S24 to S19, S22, S23, S25 and to G1, P1 and P2. Thus the mean point (I.A=487, I.T=550) locate this formation in the calc-alkaline domain. The PSG zircons are dominantly G1, P1 followed by subtypes S19, S24 and S25, with a lower T index (I.T=472) but higher A index (I.A= 589) than VPAG, indicating that PSG belong to the sub-alkaline granites. Both granites define a typological evolutionary trend between calc-alkaline and subalkaline granites.

In VPAG the presence of microgranular enclaves can not exclude the hypothesis of an hybridisation process between basic and felsic magma. In contrast the zircon morphological characteristics from GPS (more subalkaline) suggest a under crustal or mantle source.

The petrogenetic indications given by zircon typological study in both plutons is in accordance with geochemical and isotopic data (Martins et al. 1999b). According to their characteristics the different magmas are probably derived from partial melting of a continental crust at different levels, possibly related to the progressive rise of the isograds and, at least partially, to the crustal emplacement of mantle-derived magmas.

Acknowledgements

This work is integrated in the "Centro de Geologia da Universidade do Porto" activities, with the financial support of the "Programa de Financiamento Plurianual de I & D (FCT)". The authors thank to the CEMUP for the BSM analyses.

REFERENCES

MARTINS H.C.B., ALMEIDA, A, NORONHA, F. & LETERRIER, J. 1999a. U-Pb zircon and monazite geochronology of Hercynian composite granite plutons (Northern Portugal). In: B.Barbarin (Ed.), The origin of granites and related rocks, fourth Hutton Symposium, Abstracts, Clermont-Ferrant, França, p.215. BRGM.Orléans. (Documents du BRGM 290)

MARTINS H.C.B., NORONHA, F. & LETERRIER, J. 1999b. Post-thickening collision-related granites from Northern Portugal. In: B.Barbarin (Ed.), The origin of granites and related rocks, fourth Hutton Symposium, Abstracts, Clermont-Ferrant, França, p.163. BRGM. Orléans. (Documents du BRGM 290)

PUPIN, J.P., 1976. Signification des caractères morphologiques du zircon commun des roches en pétrologie. Base de la méthode typologique. Applications.394pp. Univ. Nice. Thèse de doctoract es Sciences.

PUPIN, J.P., 1980. Zircon and granite petrology. *Contr. Mineral. Petrol.*, 110: 463-472.

PUPIN, J.P., 1985. Magmatic zoning of Hercynian Granitoïds in France based on zircon typology. *Schweiz. Mineral. Petrog. Mitt.*, 65: 29-56.

PUPIN, J.P., 1988. Granites as indicators in paleogeodynamics. *Rend. Soc. Ital. Mineral. Petrol.*, 43,2: 237-262.

PUPIN, J.P. & TURCO, G., 1972a. Une typologie originale du zircon accessoire. *Bull. Soc. Fr. Mineral. Cristallogr.*, 95: 348-359

PUPIN, J.P. & TURCO, G., 1972b. Le zircon accessoire en géothermométrie. *C.R. Acad. Sci.* Paris, Sér.D, 274: 2121-2124.