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Mação-Penhascoso laccolite granite: age and its implications (SW-Central-Iberia Zone)

O lacólito granítico de Mação-Penhascoso: idade e as suas implicações (SW da Zona Centro-Ibérica)

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ABSTRACT: The Mação-Penhascoso granite laccolith occurs in the SW border of the Centro-Iberian Zone near its boundary with Ossa Morena Zone. A U/Pb (ID-TIMS) age of "ca 483 Ma" was obtained from magmatic zircon of the main microgranite lithofacies. The Armorican Quartzite Formation (AQF) is bent by the intrusion and disconformably overlain by the Brejo Fundeiro Formation of Oretanian age. This suggests that the AQF, already compacted is of Tremadoc and Upper Cambrian age. We conclude that the AQF facies is diachronous between Upper Cambrian and Arenig from SW to NE across the Iberian Terranes; it was fed from a promontory of a stable and large Gondwana continent.

KEYWORDS: Iberia, laccolith, stratigraphic and radiometric ages, diachronous.

RESUMO: O lacólito granítico de Mação-Penhascoso ocorre no bordo SW da Zona Centro-Ibérica próximo da fronteira com a Zona de Ossa Morena. Uma idade U/Pb (ID-TIMS) de 483 Ma foi obtida em zircões magmáticos da sua litofácies microgranítica. A Formação do Quartzito Armoricano (FQA) é condicionada pela sua intrusão e discordantemente recoberta pela Formação do Brejo Fundeiro de idade Oretaniana. Isto sugere que a FQA, já compactada, é do Tremadociano ou do Câmbrico superior. Concluímos que as fácies da FQA são diacrónicas entre o Câmbrico superior e o Arenigiano de SW para NE no terreno Ibérico, tendo sido alimentadas a partir de um promontório do Continente Gondwana.

PALAVRAS-CHAVE: Iberia, lacólito, idades estratigráficas e cronológicas, diacronia.

1. INTRODUCTION

The Mação-Penhascoso granitic laccolith belongs to a group of granitoid rocks occurring in the SW border of the Central-Iberian Zone (CIZ) and these are confined to a sub-parallel alignment to the boundary between the CIZ and Ossa Morena Zone (OMZ) oriented NW-SE. It is a pre-orogenic tabular granitic body with subvolcanic textures, which is located south of the Amêndoa-Carvoeiro sinform D_3 (Romão, 2001). Its radiometric age has been intensively discussed since stratigraphic and structural observations seen in the field are not consistant with the previous Rb/Sr age determination which was 402±15 Ma (Abranches & Canilho, 1981/82).

We intend to solve the mentioned contradiction by presenting a new U-Pb zircon (ID-TIMS) age for the Mação-Penhascoso granitic laccolith followed by a discussion of its implications for the lithostratigraphic sequence of Iberian Terrane (Dias *et al*., 2006).

2. GEOLOGICAL SETTING

The Mação-Penhascoso granitic laccolith has a half-ring shape with two elongated edges in the NW-SE direction: the Penhascoso the SW side (1,5 - 2km wide) and the Mação village segment in the SE side (1 - 1,5 km wide).

This laccolith, whose thickness is above 80m, underlies with the synclinal section of the metasediments that compose the Palaeozoic sedimentary succession. An intrusion in the lithologies of the units that belong to Grupo das Beiras (GB) and Grupo de Vale do Grou (GVG)

can be seen throughout its lower limit. At the top, the granitic laccolith intrudes quartzite and conglomerate beds of the Quartzite Armorican Formation (QAF) and presents an erosive contact with the Brejo Fundeiro Formation (FBF). The granitic laccolith can be seen, at macroscopic or mesoscopic scale, invading the first beds of the base QAF (sub-horizontal dip and direction is N20º-30ºW), in the eastern margin of the Coadouro riverside, in Casal da Barba Pouca. Also in this region, an approximately circular granitic apophysis, 10-20 cm in diameter, defines a small intrusion into the first quartzite beds which are positioned immediately above the granite. At the border of the granitic apophysis the granularity slightly decreases which is a chilled margin, 1-2 mm thick forming a halo of iron oxides.

The actual geometry of the Mação-Penascoso granitic laccolith is a result of the phases of the Variscan orogeny. The D_1 Variscan folds affect the Palaeozoic lithostratigraphic units that occur in this region, including the laccolith, producing a syncline named Domingos da Vila-Casalinho. This structure presents a fracture cleavage subparalel to its axial plane with an orientation of N60º-70ºW that affects the Mação-Penascoso granitic laccolith. Also, in Monte de João Dias (W of Mação), folds with axes oriented N10ºW are associated with the D_2 Variscan refolded the laccolith. These folds have an axial planar cleavage marked by micaceous minerals and cut by a N-S dextral shear zone.

Distinct lithofacies have been mapped in the Mação-Penhascoso granitic laccolith: microgranite, rhyolite and eruptive breccias. The main lithofacies is composed of microgranite that lies in the central part and in the southern border of the laccolith. The remaining and smaller lithofacies are positioned along its northern margin.

The microgranites, which are thin to very thin, are mesocratic and porphyritic rocks, with inclusions of the presence of dark green phyllitic restites, usually connected to phyllitic minerals. They have a holocrystalline texture with rich in K feldspar crystals, macroscopic blue quartz, oligloclase and biotite over 5mm, in an essentially quartzo- feldspathic thin matrix. Other less important minerals include: garnet, zircon, apatite, sphene-leucoxene, chlorite, calcite, sericite, rutile and opaque minerals. The rhyolites are leucocratic rocks with textures ranging from holocrystalline to hypocrystalline, with aphanitic matrix micro-cryptocrystalline. They differ from the microgranites essentially due to the fine-grained matrix and the rarity of phenocrysts. The eruptives breccias, located in the base of the laccolith footwall, are composed of a matrix with rhyolitic nature in which are cemented and dispersed numerous elements from country rocks over 40-50 cm. The most common lithological elements are the pelite and the greywacke from GB. Less frequent fragments are granite (Belver) and microgranite, generally poorly calibrated and with granolumetric heterogeneity. The xenoliths lack a preferred orientation, but they occur with rounded shapes, and frequently flattened. On the other hand, greywacke and pelitic xenoliths, mostly laminated, occasionally present reaction edges where a slight recrystallization with a development of mica, quartz and eventually manganese (?) can be observed.

The absence of meaningful thermometamorphic effects in Paleozoic lithologies that outcrop around the Mação-Penhascoso granitic laccolith suggests that this body is the result of relatively shallow magmatic intrusions. This intrusion rose and cut the GB and GVG metasediments, extending laterally along the surface of discontinuity, located between the strata of the GVG and QAF units, invading the latter slightly. Moreover, when the Variscan deformation is removed the body of Mação-Penhascoso granitic corresponds to a mushroom-shape, injected between almost concordant layers on the laccolith margins.

The evolutionary model for the emplacement of the granite laccolith is described below. It begins with the deposition of the GB turbidite metasediments, which will overlap discordantly delta deposits of the GVG and the basal lithologies characteristic of the coastal environment of the QAF. Subsequently, there is the intrusion of laccolith, forcing its way between slightly

inclined strata of the GVG and sub-horizontal layers of FQA. This generates a mushroom-shaped a granitic body with the strata above the intrusion arch and rise, which may eventually emerge.

This uplift consists of poorly consolidated strata, composed by conglomerates and quartz-sandstone of the QAF, which are rapidly eroded by marine erosion. This erosion is evidenced by the differences in thickness in the QAF: near the laccolith the thickness is small (0-15 m) and in areas adjacent to the laccolith it reaches values of about 40-50m. Products resulting from erosion are resedimented, originating thin arkosic and conglomeratic horizons of low thickness between the eroded top of the QAF and pelitic unit (BFF) resulting from the subsequent resumption of sedimentation. In places where the QAF has been completely eroded, the BFF was deposited overlying directly on the granitic laccolith Mação-Penhascoso, for example in the Ribeira de Mação. This event would have occurred after the deposition of QAF and before the sedimentation of the pelitic BFF and it is conditioned by the structure of the pre-existing rocks.

3. RESULTS AND DISCUSSION

Abranches & Canilho (1981/82) determined the 402±15 Ma absolute age (using Rb/Sr method) for the Mação-Penhascoso granitic laccolith, from 6 whole rock samples. These define an isochrones with an initial ratio $^{87}Sr/^{86}Sr$ = 0.7140±0.0020(25) and MSWD=0.74. However, field data do not support this age since the laccolith intrudes during QAF deposition and before BFF deposition in Oretanian times.

As an attempt to resolve this incongruence, a sample of the microgranitic lithofacies collected from the left margin of the river Coadouro (geographical coordinates N39º 32´ 38´´; W29º 01` 21``), was selected for geochronological studies. The zircons were separated from fresh rock samples using standard techniques of heavy minerals separation. The final selection of the zircon grains was performed first using binocular microscope and then by cathodoluminescence.

The result of the U-Pb (ID-TIMS) analysis of prismatic zircon from the microgranite of the Mação-Penhascoso laccolith, was an age of "ca 483 Ma" (base of Tremadoc in accordance with the new chronostratigraphic classification of the Ordovician System, Bergstrom *et al*., 2009). Since the laccolith intruded the QAF, this unit would already have some thickness and be compacted, which means that the deposition is prior to "ca 483 Ma" (Tremadoc and Upper Cambrian).

In the base of the first beds of the QAF the ichnofossils species *Cruziana* cf. *ománica* and *Cruziana*? *barbatarugosa* were identified. These *Cruzianas* have been described from Upper Cambrian (Seilacher, 2007).

As the QAF is slightly discordant on the GVG transgressive deltaic succession (Romão *et al*., 2005), it is expected that the deposition of this group has happened in the Upper Cambrian. There is a high angle unconformity between the BG metasediments and the GVG and QAF successions, embodied by a major sedimentary hiatus, erosion and/or deposition over a considerable period of time, a consequence of the "Sardic s.l." phase with minor upper stage disconformities (QAF/GVG) and a major lower (GVG/GB).

The present data should be considered in the context of age correlations, stratigraphical and geochronological, of the SW Europe Variscides (Iberia and Armorica). In Spain, the GB equivalent units have been dated as Lower Cambrian to terminal Ediacaran from in trilobites, *Cloudine* and icnofossils (Jensen *et al*., 2007; Cortijo *et al*., 2010). So, we infer that to consider that the "Sardic s.l." phase is intra-Cambrian (base of the Upper Cambrian to Middle Cambrian?) in the SW border of the CIZ.

Zircons from an altered ash-fall tuff bed within the upper Barrios Formation (Ordovician Armorican Quartzite facies), in the Cantabrian Zone of the Iberian Variscan belt were dated. U-Pb analyses of six highly abraded single grains yielded concordant and overlapping error ellipses with a pooled concordia age of 477.47 ± 0.93 Ma (Gutiérrez-Alonso *et al*., 2009). The GVG lithologies can be correlated with the Cap de la Chévre Formation, Crozon Peninsula, and "*Inicial Red Be*ds", in central Brittany, including the French Armorican Massif. The first unit has

volcaniclastic strata, which have been dated to 465±1Ma (Darriwilian) by method U/Pb zircon (Bonjour *et al*., 1988), and the second unit contains, interstratified, trachytic and andesitic lavas have been dated by 472 ± 5Ma (Floian) by the Rb/Sr whole rock method. These data suggest that these units were deposited during the Ordovician.

We conclude that the Armorican quartzite lithofacies are possibly diachronous. In the Iberian traverse the QAF is younger from SW to NE. In the OMZ, the quartzite lithofacies is possibly Upper Cambrian, below the Floian Barrancos Formation represented by pelites of deeper lithofacies than the quartzite lithofacies and above an unconformity on Middle Cambrian sequences (Araújo *et al*., 2006). In the SW segment of CIZ, where the Mação studied area is situated, the QAF is Upper Cambrian to Tremadoc according to the new isotopic data presented in this paper. In the NE segment of the CIZ the AQF is considered Floian because of the conglomeratic and impure quartzite unit (Bojas Formation) below were found inarticulate brachiopods whose first record is located in the Tremadoc and occur in large numbers in the Floian (Coke & Gutiérrez-Marco, 1995). The AQF lithofacies in the WALZ have been dated in most of the Arenig (Vera *et al*., 2004).

The diachronic age of QAF is consistent with a foreland to the NE, in the basement of the Cantabrian Zone. This corresponds to a promontory of Gondwana that can feed mature sands to the Cambro-Ordovician siliciclastic platform from a passive margin of a large continent such as Gondwana. This paleogeography could be extended to adjacent areas of Armorica fed from southern Gondwana continent before the opening of Paleotethys Ocean. The synchronous deposition of shallow water would require a very rapid sedimentation rate which is not compatible with a stable and quiet sedimentary environment; alternatively a stable large continent such as Gondwana could feed with mature sands its shallow water passive margin for a long period of time.

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