U-PB GEOCHRONOLOGY FOR THE BARREIROS TECTONISED GRANITOIDS AND ARRONCHES MIGMATITIC GNEISSES: TOMAR CORDOBA SHEAR ZONE, EAST CENTRAL PORTUGAL

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Abstract: New single zircon U-Pb geochronological data for the Barreiros tectonised granitoids that outcrop on the southern border of the Tomar Cordoba Shear Zone (TCSZ) and the migmatitic gneisses that outcrop within the core of this same shear zone, near Arronches, are presented. The study indicates a Middle Cambrian to Lower Ordovician age for the Barreiros tectonised granitoids and a Palaeoproterozoic age for the Arronches migmatitic gneisses as well as a TCSZ-wide tectonothermal event in the Middle Ordovician.

Key words: Single zircon, Barreiros tectonised granitoids, Arronches migmatitic gneisses, Tomar Cordoba Shear Zone.

Resumen: Se presenta un estudio geocronológico U-Pb de los granitoides tectonizados de Barreiros y de los gneises migmatíticos de Arronches que afloran en la Zona de Cizalla Tomar Cordoba (ZCTC). Este estudio indica edades de Cámbrico Medio a Ordovícico Inferior para los granitoides tectonizados de Barreiros y una edad Proterozoico Inferior para los gneises migmatiticos de Arronches. Existe además evidencia de un evento tectonotérmico durante el Ordovícico Medio que afecta a todos los sectores de la ZCTC.

Palabras clave: Estudio geocronológico, granitoides tectonizados de Barreiros, gneisses migmatíticos de Arronches, Zona de Cizalla Tomar Cordoba.

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The Tomar Cordoba Shear Zone (TCSZ), also quoted in the literature as the Coimbra-Cordoba Shear Zone (Burg *et al.*, 1981; Abalos and Eguíluz, 1992; Azor *et al.*, 1994), and related areas are lacking in geochronological constraints with regards the temporal relationships that exist between the Neoproterozoic Série Negra metasedimentary succession (meta-arenites, metapelites, amphibolites, banded amphibolites, rhyolites and tuffs) and Palaeozoic granitoid rocks that intrude the metasedimentary sequence.

The purpose of this paper is two-fold: firstly, to present new single zircon U-Pb geochronological data for the Barreiros tectonised granitoids and the Arronches migmatitic gneisses that outcrop within the limits of the TCSZ and secondly, to highlight the many questions that remain unanswered in the TCSZ as a result of the lack of good geochronological data within the northern domains of the Ossa Morena Zone (OMZ).

Geological and structural setting

The boundary between two major tectonostratigraphic subdivisions of the Iberian Massif, the Central Iberian and Ossa Morena Zones, occurs at the northern limit of the TCSZ (Julivert *et al.*, 1972; Ribeiro *et al.*, 1979) in Portugal (Fig. 1) while in south-central Spain this boundary is located within the TCSZ (Sanderson *et al.*, 1991; Pereira and Silva, 2000). Notwithstanding this correlation disparity, the TCSZ represents a geologically complex and diverse zone of intense deformation and metamorphism contemporaneous with a large sinistral displacement, which may be due to a large intracontinental sinistral fault active during the Variscan Orogeny (Berthé *et al.*, 1979) with sinistral displacements of 100 (Burg *et al.*, 1981) to 300 km (Abalos and Eguíluz, 1992). This displacement caused mylonitisation and retrograde metamorphism (under greenschist

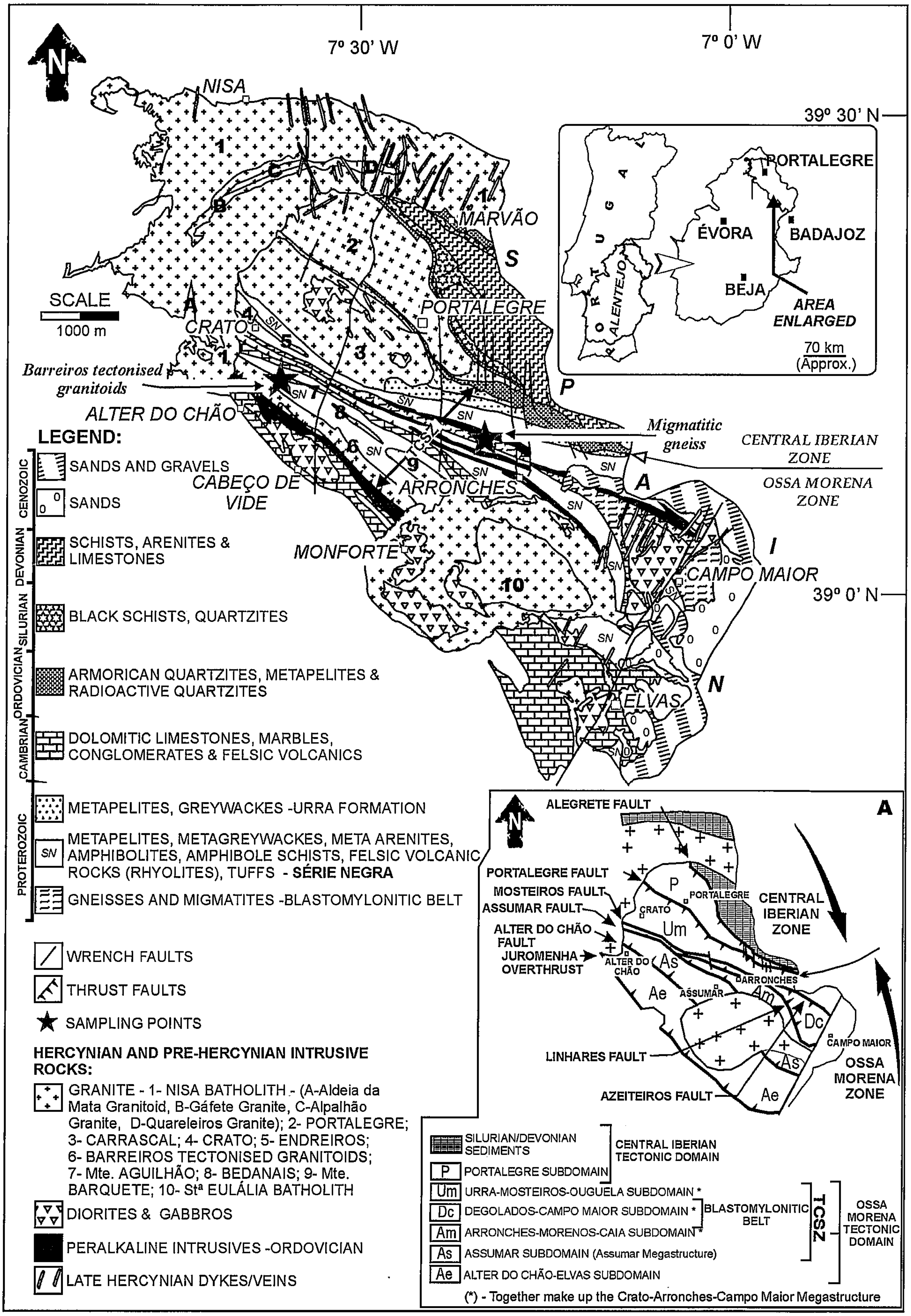

Figure. 1.- Excerpt from the 1:500000 geological map of Portugal (after Oliveira et al., 1992) showing the sample collection points and surrounding geology (simplified). The various granite names with their various facies types is reproduced within each granitoid type (where applicable). Nisa granite facies types are after Moreira, (1994) and Solá (1996-1999). Figure A adapted after Pereira (1995; 1999). (Figure adapted after de Oliveira, 2001).

to amphibolite facies) to all previous Cadomian structures and mineral assemblages (Quesada and Munhá, 1990). Pereira and Silva (2001) considered the Tomar Cordoba Shear Zone a major Eohercynian-Hercynian sinistral transcurrent fault overprinting a Cadomian arc localised at a convergent margin of Gondwana although this interpretation is still controversial (Azor *et al.*, 1993).

Within the TCSZ outcrop a thrust fault-bounded central corridor of high-grade metamorphic rocks comprising highly migmatised granitoid gneisses termed the Blastomylonitic Belt that is made up of the Campo Maior Formation (Gonçalves, 1978). Since these gneisses represent the core of the flower structure they were interpreted as the oldest rocks within the TCSZ (Gonçalves and Carvalhosa, 1994). However, recent structural data presented by Pereira (1999) refutes these claims.

To the north of the Blastomylonitic Belt, but still within the Ossa Morena domain outcrop thrust fault-bounded packages of greenschist facies-grade Neoproterozoic Série Negra metasedimentary and Urra Formation rocks (see Fig. 1). South of the Blastomylonitic Belt occur packages of amphibolite facies-grade metasedimentary Série Negra rocks, Cambrian age lithologies and hyperalkaline intrusive rocks. The distribution of several of these thrust fault-bounded lithological packages creates a (asymmetric) flower structure-like morphology (Gonçalves, 1971). The compartmentalisation of these packages has led Pereira (1995; 1999) to define a series of polymetamorphic tectonic subdomains (or megastructures) within the TCSZ (Fig. 1A).

The Série Negra within these subdomains is intruded by granitoid magmas both during and after the Hercynian deformation, e.g. the syntectonic Mte. Aguilhão, Bedanais and Mte. Barquete granites (Fig. 1) as well as the Nisa and Stª Eulália granites respectively. There is also evidence of extrusive volcanism SE of the São Martinho area, 5.5 km east of Alter do Chão, that is expressed as prominent rhyolite lavas (de Oliveira, 2001, Figs. 2.10, 2.11 and 2.13). There are four tectonostratigraphic subdomains defined by Pereira (1999) that make up the TCSZ (Fig. 1A) and these are from south to north, the Assumar Subdomain or Megastructure, the Arronches-Morenos-Caia Subdomain, the Degolados-Campo Maior Subdomain and finally the Urra-Mosteiros-Ouguela Subdomain, last latter three making up the Crato-Arronches-Campo Maior Megastructure.

The Crato-Arronches-Campo Maior (CAC) Megastructure

The CAC Megastructure in Portugal represents a belt some 60 km in length with varying widths between 16 km near Campo Maior and approximately 4 km near Crato. Its northern and southern limits are marked by the Mosteiros and Assumar faults respectively (Pereira, 1999, Fig. 52).The CAC Megastructure contains four formations of known Proterozoic age (Oliveira *et al.*, 1991); from oldest to youngest these are, the Campo Maior, Morenos, Mosteiros and the Urra Formations.

The Campo Maior Formation is essentially composed of ortho- and paragneisses and migmatites. However, biotite gneisses with sillimanite, amphibole or pyroxene gneisses (with or without evidence of hydrothermal alteration, e.g. epidote) are frequent. Furthermore, the centre of this structure has been found to contain mafic granulites that are partially or totally replaced by amphiboles, and pyroxene-rich rocks with hypersthene as the dominant mineral (Gonçalves and Carvalhosa, 1994). The Campo Maior Formation is also intruded by hyperalkaline syenitic-type rocks with well-developed riebeckite crystals.

The (older) Morenos and (younger) Mosteiros Formations are essentially metapsammitic and meta-arenitic in character and represented today by the occurrence of quartz mica schists, tuffaceous units with intense, locally developed ferroan dolomite alteration north of the Blastomylonitic Belt, and both intruded by amphibolites and amphibole schists south of the Blastomylonitic Belt. The contact of the Mosteiros Formation with the overlying Urra Formation is sharp which led Oliveira *et al.* (1991) to introduce a possible unconformity between these two formations. This formation comprises a lower porphyry unit, approximately 200 m thick and an upper greywacke-siltstone unit approximately 500 m thick (Oliveira *et al.*, 1991) and is considered to be of detritic origin (Gonçalves and Fernandes, 1973). Pereira (1999) has divided the CAC Megastructure into three units, namely the Campo Maior (CM), Contenda-Barragem do Caia (CBC) and Arronches (ARR) Units (Pereira, 1999, Fig. 52). Essentially, apart from the CM Unit, this subdivides the Morenos Formation. The CM Unit refers to the migmatitic gneisses, amphibole gneisses, quartz diorites, mafic granulites and retrograded eclogites that form the core of the flower structure proposed by Gonçalves (1971). Northwards of this unit, the Mosteiros Formation marks a substantial decrease in metamorphic grade from eclogitic to greenschist facies.The CBC Unit, southwards of the CM Unit, was previously considered as two separate units by Pereira (1995) and Pereira and Silva (1997). This unit comprises fine-grained quartz-feldspathic (felsic volcanic) rocks, quartzites, micaceous schists with amphibolites that have been affected by high greenschist facies to lower amphibolite facies metamorphism.The ARR Unit outcrops between the Assumar Megastructure and the CBC Unit (Pereira, 1999, Fig. 52, units 3 and 11) and consists of metapelites, metapsammites, black quartzites, carbonates, amphibolites and felsic volcanic rocks and micaceous garnet schists typical of the Mosteiros formation (Pereira, 1999).

The Assumar (ASS) Megastructure

The ASS Megastructure comprises an area some 60 km in length by 5 to 8 km in width that is bounded in the north by the CAC Megastructure, in the south by the Alter do Chão-Elvas Subdomain (- the Alter do Chão fault, Fig. 1A), in the NW by the Nisa batholith and in the SE by the St^a Eulália batholith (Pereira, 1999, Fig. 80). Stratigraphically, the Neoproterozoic Série Negra is represented by the Besteiros amphibolites in the south (Pereira, 1999), a sequence of metasediments (metapelites, metapsammites and meta-arenites) and locally interbedded black quartzites. Discordantly overlying these Proterozoic age lithologies is the Freixo-Segóvia Volcano Sedimentary Complex (FSVSC) (Pereira, 1999). The FSVSC consists of fine-grained tuffs and felsic/rhyolitic rocks and conglomerates with clasts of igneous rocks and black quartzites of the Série Negra.The top of the stratigraphic sequence is marked by the display of a Cambrian sequence of platform carbonates with crystalline and marly limestones intruded by basic dykes. This grades into a fine-grained detritic facies with mudstones as well as coarse-grained, thickly bedded, impure sandstones and arkoses. These units were previously attributed the name *Câmbrico de Assumar* (Gonçalves, 1971) which is stratigraphically the equivalent of the Torreáboles and Pedroches Formations in Spain (Liñan, 1978).The Barreiros tectonised granitoids, also referred to as the Barreiros orthogneisses in the literature, form the southern boundary of the Assumar Megastructure and hence, the southernmost edge of the TCSZ. Field evidence shows that these are intruded into the Série Negra sequence (de Oliveira, 2001).

Petrography of the studied rock types

Barreiros tectonised granitoids – Although this is a granitoid complex consisting of granite, granodiorite, pegmatites and amphibolites (written com. M.F. Pereira, 2002), at the sample site this is a porphyritic, medium- to coarse-grained alkali granite with penetrative tectonic banding that shows mylonitisation and recrystalisation textures in thin section (Gonçalves and Fernandes, 1973; Pereira, 1999). It is made up of abundant recrystallised quartz, feldspar (albite, albite-oligoclase, microcline-perthite and microcline) that are intensely sericitised and ubiquitous biotite that shows exolution of titanite and Fe(-oxide) minerals. Muscovite is rare.

Arronches migmatitic gneisses – The migmatites are highly foliated rocks composed chiefly of quartz, plagioclase, muscovite, biotite, rare hornblende, sphene and epidote. These rocks include amphibolite boudins and are commonly intruded by granites and felsic pegmatitic veins.

Sampling

Sampling of the Barreiros tectonised granitoid was carried out adjacent Mte. da Cascalheira, approximately 5.5 km E of Alter do Chão (Fig. 1) in the São Martinho area (6-21-500E;43-40-250N) whereas the sample of the migmatitic gneisses was collected on the road Portalegre – Arronches at km 46.125 SSE of Mte. das Algueireirinhas, N of Arronches (Fig. 1) (6-45-200E;43-36-170N).

Sampling consisted of obtaining fresh handspecimen size blocks totalling in excess of 50 kg per sample. Field collected blocks were cleaned in water and in ultrasound baths to prevent possible contamination of soil derived zircons and crushed to < 2mm. The < 2mm fraction was sieved to trap a < 720 μm fraction. This was ground further to between 100-150 μm and a heavy mineral concentrate was obtained from this after treatment on a Wilfley table. Zircons were examined with a binocular microscope in order to assess grain quality, degree of fracturing and the possible existence of inherited cores. Handpicked zircons were abraded using the techniques of Krogh (1982) and washed in ultra-pure acetone, diluted nitric acid and hydrochloric acid. Single grains or small populations of zircons were then placed into 0.35 ml Teflon vials together with 30 μl HF and a mixed ^{205}Pb-^{235}U spike. Eight of these Teflon vials were then placed in a Parr Container for 2 days at 220°C. The samples were chemically processed without separating U and Pb (Lancelot *et al.*, 1976) and loaded on a rhenium filament together with a 0.25N phosphoric acid - silica-gel mixture. The analyses were performed on an automated VG54E mass spectrometer using a Daly collector and corrected by 0.002 (± 0.05%) for mass fractionation in the Hugh Allsopp Laboratory at the University of the Witwatersrand. Total Pb blanks over the period of the analyses range from 15 to 30 pg and a value of 30 pg was assigned as the laboratory blank (^{206}Pb/^{204}Pb=18.97 ± 1, ^{207}Pb/^{204}Pb=15.73 ± 0.5 and ^{208}Pb/^{204}Pb=39.19 ± 1.5). The calculation of common Pb was made by subtracting blanks and then assuming that the remaining common Pb has been incorporated into the crystal and has a composition determined from the model of Stacey and Kramers (1975). Data were reduced using PbDat (Ludwig, 1993). Analytical uncertainties are listed at 2σ and age determinations were processed using Isoplot/Ex (Ludwig, 2000).

Previous geochronological data available

The Barreiros tectonised granitoids were dated at 466 ± 10 Ma (Ordovician) by Gonçalves and Fernandes (1973). Although the method used to obtain this age is not mentioned, Rb-Sr is suspected. According to the mapping of the area by (Gonçalves *et al.*, 1972a), the Endreiros (tectonised) granite SE of Crato (Fig. 1), is recognised as being the same as the Barreiros tectonised granitoids and the same age of 466 ± 10 Ma has been attributed to this granite.

The migmatitic gneisses in the core of the TCSZ have been previously regarded as Mesoproterozoic in the literature (e.g. Gonçalves and Oliveira, 1986; Oliveira *et al.*, 1992; Gonçalves and Carvalhosa, 1994). However, the age of these rocks has remained largely unquantified.The migmatites within the Blastomylonitic Belt have been dated by Ordoñez-Casado (1998) with a sample collected approximately 1 km NNW of

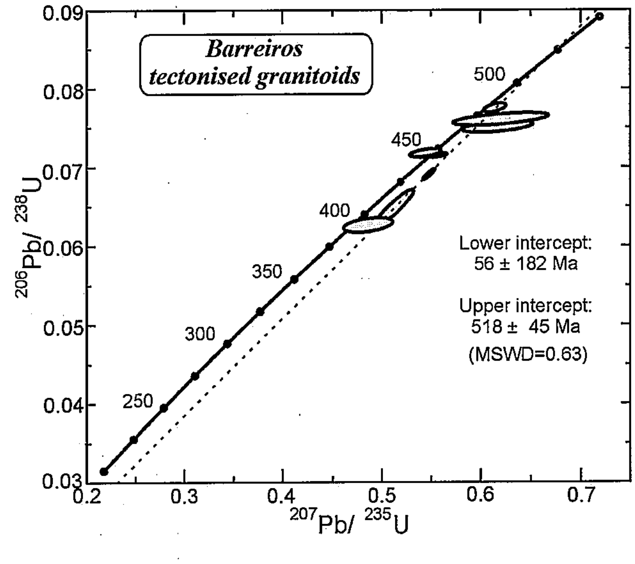

Figure 2.- Concordia plot for zircons extracted from the Barreiros tectonised granitoids at Mte. da Cascalheira NE of Alter do Chão. An upper intercept concordia protolith age of 518 ± 45 Ma is obtained. (Adapted after de Oliveira, 2001).

terpreted as the time of protolith formation of the retrogressed eclogite.

Results obtained and discussion

Zircons extracted from the Barreiros tectonised granitoids were generally translucent and pinkish in colour. Eight single grains were analysed and data are reported in Table I. Plotted in a Concordia diagram (Fig. 2), 6 zircon grains define an upper intercept age of 518 ± 45 Ma (MSWD=0.63) with a lower intercept age of 56 ± 182 Ma and give a weighted mean $^{207}Pb/^{206}Pb$ age of 508.2 ± 8.1 Ma (MSWD=0.69). Two zircon grains (Zr 5 and 7), however, define a concordant age of 442.6 ± 2.6 Ma.

The age of 518 ± 45 Ma is interpreted as the age of protolith formation. This is important because previously the age of these rocks was reported to be 466 ±10 Ma (Gonçalves and Fernandes, 1973). Hence, rocks that were considered to be of Ordovician age may be Cambrian in age even though the large error of ±45 Ma

Sample	U ppm	Pb ppm	$^{206}Pb/^{204}Pb$	$^{206}Pb/^{238}U$	+/- %	$^{207}Pb/^{235}U$	+/- %	$^{208}Pb/^{206}Pb$	+/- %	$^{207}Pb/^{206}Pb$	+/- %	$^{207}Pb/^{206}Pb$ age (Ma)	Correlation Coefficient	Zircon colour
Zr 1	100	8	181	0.0751	0.9	0.6133	5.0	0.1935	1.0	0.0592	1.0	575 ± 100	0.54	P, T
Zr 2	224	20	484	0.0776	0.6	0.6144	1.5	0.1591	1.4	0.0574	1.3	507 ± 28	0.55	P, T
Zr 3	96	8	281	0.0763	0.9	0.6206	6.3	0.1303	5.0	0.0590	5.9	567 ± 130	0.57	P, T
Zr 4	420	28	710	0.0648	3.0	0.5120	3.3	0.1537	1.2	0.0573	1.3	503 ± 28	0.92	P, T
Zr 5	394	31	431	0.0713	1.0	0.5388	3.5	0.1613	3.0	0.0548	3.1	403 ± 70	0.48	P, T
Zr 6	295	21	291	0.0616	2.7	0.4840	5.4	0.1500	4.2	0.0569	4.4	490 ± 97	0.60	P, T
Zr 7	504	38	243	0.0709	0.8	0.5447	2.9	0.1800	2.3	0.0557	2.5	442 ± 55	0.56	P, T
Zr 8	1339	100	611	0.0687	0.7	0.5444	0.9	0.1451	0.5	0.0574	0.4	508 ± 9	0.88	P,T

Table I.- U-Pb data obtained for 8 zircons from the Barreiros tectonised granitoids. (P- pink; T- translucent).

Arronches. Inherited concordant U-Pb ages at ca. 535 Ma and discordant U-Pb age with $^{206}Pb/^{238}U$ of ca. 940 Ma and a $^{207}Pb/^{206}Pb$ age ca. 1.7 Ga were obtained in the inner cores of zircons (Ordoñez-Casado, 1998). The Arronches migmatite sample shows evidence of partial melting processes, i.e. leucosome formation, that yield SHRIMP zircon ages of 465 ± 14 Ma in the magmatic cores, while the outer rims yield an age of 335 ± 4 Ma (Ordoñez-Casado et al., 1997; Ordoñez-Casado, 1998). Ordoñez-Casado (1998) interprets the former age as the time of protolith formation of the ortho-derived precursor of the migmatites and the latter as reflecting the age of migmatisation. In this area, Ordoñez-Casado (1998) has also analysed a garnet-rich amphibolite (sample ARRO-4) that outcrops in the Caia River south of Arronches. The concordia diagram shows two spots with inherited zircons giving an age of ca. 800 Ma while the Tera Wasserburg diagram shows a main cluster of spots yielding an age of 490 ± 17 Ma (Ordoñez-Casado, 1998, Figs. 4.64b; 4.64c respectively), which is interpreted as the time of protolith formation of the retrogressed eclogite.

places the Barreiros tectonised granitoids in the interval Middle Cambrian – Lower Ordovician. The concordant age of ca. 442 Ma is interpreted as the age of gneissification (partial melting) and ties in closely with the age of 466 ± 10 Ma that would be a reset age reported previously by Gonçalves *et al.* (1972a). The age obtained for the Barreiros tectonised granitoids is not unique within the northern domains of the Ossa Morena Zone and similar ages of magmatism, from other Spanish granitoids, have been obtained, e.g. the Pallares granodiorite, that intruded Precambrian rocks of the Tentudía succession in the Arroyomolinos area, dated at 518 ± 15 Ma and the Ahillones pluton dated at 552 ± 10 Ma (Ordoñez-Casado, 1998), although ages between ca. 545 Ma (Mosquil granite; Ochsner, 1993) and 585 Ma (Ahillones granites; Schäffer, 1990) have been obtained for this pluton.

Eguíluz *et al.* (2000) mention the fact that (within the TCSZ) of SW Spain occur Cambrian-Ordovician age orthogneiss units. This age is interpreted as repre-

U ppm	Pb ppm	$^{206}Pb/^{204}Pb$	$^{206}Pb/^{238}U$	+/- %	$^{207}Pb/^{235}U$	+/- %	$^{208}Pb/^{206}Pb$	+/- %	$^{207}Pb/^{206}Pb$	+/- %	$^{207}Pb/^{206}Pb$ age (Ma)	Correlation coefficient	Zircon colour
518	167	1403	0.3103	0.7	5.675	1.0	0.0505	0.8	0.1326	0.6	2133 ± 14	0.74	T, P
312	35	399	0.1066	1.7	2.171	2.6	0.0112	1.5	0.1477	2.0	2320 ± 46	0.65	T, Y
153	35	237	0.1788	0.7	2.718	1.2	0.2530	0.6	0.1102	0.9	1803 ± 15	0.68	T, Y
65	15	307	0.1914	1.3	3.038	2.6	0.2159	1.3	0.1151	2.0	1882 ± 37	0.64	T, P
327	25	196	0.0693	1.6	0.419	10.6	0.0955	1.5	0.0439	10.1	-116 ± 12	0.40	T, Y
128	23	197	0.1452	1.1	2.149	2.5	0.2279	1.0	0.1073	2.1	1754 ± 38	0.54	T, P
112	30	366	0.2220	1.5	3.525	2.0	0.1864	1.4	0.1151	1.2	1882 ± 23	0.79	T, P
260	18	506	0.0677	6.3	0.458	7.8	0.0499	6.2	0.0490	4.4	149 ± 7	0.82	T, Y
199	28	167	0.1106	1.6	0.901	11.8	0.0469	1.3	0.0591	11.0	571 ± 63	0.54	T, P
214	47	104	0.1372	2.5	1.794	2.7	0.0828	2.1	0.0948	0.8	1525 ± 12	0.96	T, P

Table II.- U-Pb data for zircons extracted from the migmatitic gneisses. (P- pink; T- translucent; Y- yellow).

sentative of the time of emplacement of granitoid plutons subsequently transformed into orthogneiss. Eguíluz et al. (2000, Fig. 3) document (U-Pb) protolith ages of metamorphic rocks and Cadomian granites and metamorphism ranging from 610 to 500 Ma. However, most protolith age data clusters around 510 Ma and that for Cadomian granites and metamorphism clusters around 545-527 Ma. Therefore, the age obtained for the Barreiros tectonised granitoids falls within the range of ages reported for the protolith ages of metamorphic rocks. Also, these tectonised granitoids may be regarded as representing an episode of Cambrian magmatism within the TCSZ.

Zircons extracted from the migmatitic gneisses north of Arronches were predominantly pinkish in colour with a few yellowish grains. Ten single zircon grains have been analysed and data are reported in Table II. Plotted in a concordia diagram (Fig. 3), the data do not define a simple, single group or trend, which may indicate the presence of more than one age population and probably the effects of more than one Pb-loss event. Nevertheless we interpret this complex age pattern as follows. Two zircons (Zr 5 and Zr 8) are in a slightly reverse discordant position and give a mean $^{206}Pb/^{238}U$ age of 431.2 ± 6.4 Ma. One grain (Zr 2.1) is in a concordant position with a $^{207}Pb/^{206}Pb$ age of 571 ± 63 Ma. The remaining grains are in a scattered position in the diagram showing various degree of discordance. A regression through these points assuming a lower intercept of 431.2 ± 6.4 Ma gives an upper intercept age of 2146 ± 91 Ma. This latter age is interpreted as the minimum age of the protolith formation. No tectonothermal event within the Blastomylonitic Belt has been recorded at the concordant age of 431.2 ± 6.4 Ma so far. But this age is identical within error to the age of 442.6 ± 2.6 Ma obtained for the Barreiros tectonised granitoids. The close correlation in ages obtained from these two distinct lithologies points towards a leucosome formation event (partial melting) within these domains of the Ossa Morena Zone. Indeed, a regional thermal event has been detected at 490-460 Ma in basic protoliths of retrogressed eclogites (Arronches and Pocillos) and

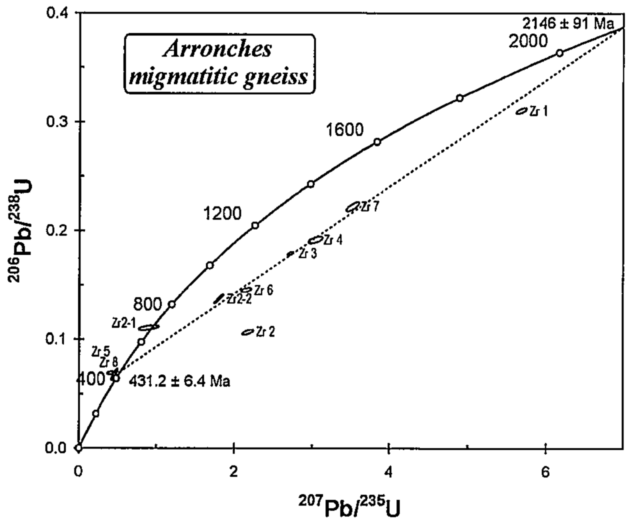

Figure 3.- Concordia plot for zircons extracted from the Arronches migmatitic gneisses in the Blastomylonitic Belt south of Nave do Grou. Discordia ages pointing to somewhere around 2143 Ma are shown by the majority of zircons. One zircon is concordant at ~640 Ma and a lower intercept age of 431.2 ± 6.4 Ma is obtained.

acidic protoliths (Aceuchal, Ribera del Fresno, Almedralejo, Arronches and Higuera de Llerena) that have been interpreted as a result of bimodal magmatism from anaorogenic rifting (Ordoñez-Casado, 1998).The age of 571 ± 63 Ma coincide with the ages of basic protoliths (530-600 Ma) (Ordoñez-Casado; 1998) whose intrusion may have caused a partial melting event that is now recorded in some of the zircon population analysed during this study.

Conclusions

The Barreiros tectonised granitoids are rocks whose protolith age, as a result of this study, can be considered in the range Middle Cambrian to Lower Ordovician. Therefore, the Ordovician age of the Barreiros tectonised granitoids should be questioned without further quantification of the ages of these rocks.

The Arronches migmatitic gneisses, in this study, yield ages far older that any reported thus far ranging from 2237 to 2055 Ma (given the error obtained of 91 Ma). Therefore, this study places these rocks in the Palaeoproterozoic rather than the Mesoproterozoic previously indicated by other authors, e.g. Gonçalves and Oliveira (1986); Oliveira *et al.* (1992); Gonçalves and Carvalhosa (1994).

The migmatitic gneisses NNW of Arronches have yielded Palaeoproterozoic protolith ages (2237 to 2055 Ma), which thus far is unknown in the TCSZ. However, Schäffer *et al.* (1993) have admitted the possibility of source rocks for the Tentudía Group (Série Negra) being in the range 2.5 to 2.1 Ga. Since the migmatitic gneisses represent the core of the TCSZ and hence are the oldest, the protolith age is within the range of the ages reported.

Furthermore, within the northern domains of the Ossa Morena Zone there is evidence for a leucosome formation event as indicated by concordant ages in the Barreiros tectonised granitoids and projected lower intercept ages for the migmatitic gneisses at ca. 440 Ma.

Open questions and future work

1. Cross-cutting relationships between the Série Negra and other intrusive rocks are few in the field and there is a need to obtain geochronological data that will allow the separation and quantification of the span of geological time between (geologic) events.

2. It is imperative that the age difference between syntectonic and late-tectonic granitoids be determined, e.g. Mte. Aguilhão, Bedanais and Mte. Barquete granites vs. Nisa/St[a] Eulália granites.

3. Rhyolitic lavas E of Alter do Chão are clearly extrusive through the Série Negra metasedimentary rocks and the Barreiros tectonised granitoids (de Oliveira, 2001). Their age and therefore episodes of lava extrusion remains unresolved.

4. The age of basic volcanism in São Martinho and the relationships between it and rhyolite lavas remains unresolved due a to a lack of geochronological data.

5. The Endreiros tectonised granite, which is shown as the equivalent of the Barreiros tectonised granitoids in the 1:50.000 geological map (Gonçalves *et al.*, 1972b) has no geochronological data backing up this claim.

6. The Carrascal granite has previously been suggested to be 350 Ma old and part of the deformed early Hercynian granitoids (Burg *et al.*, 1981) but its absolute age is yet unknown.

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