Revista Brasileira de Geociências 30(1):110-114, março de 2000

EVIDENCE OF NEOPROTEROZOIC BACKARC BASIN DEVELOPMENT IN THE CENTRAL RIBEIRA BELT, SOUTHEASTERN BRAZIL: NEW GEOCHRONOLOGICAL AND GEOCHEMICAL CONSTRAINTS FROM THE SÃO ROQUE - AÇUNGUI GROUPS

PETER CHRISTIAN HACKSPACHER[1], ELTON LUIZ DANTAS[2], ANGELO SPOLADORE[3], ALLEN HUTCHESON FETTER[1] AND MARCOS AURÉLIO FARIA DE OLIVEIRA[1]

ABSTRACT The Ribeira Belt (RB) of southeastern Brazil represents an important manifestation of the Brasiliano Orogeny formed during the assembly of West Gondwana. Contemporaneous sedimentation and volcanism within the RB provide a basis for helping understand its tectonic evolution and paleogeography. U-Pb monazite data from the basal metavolcanic rocks of the São Roque Group indicate a crystallization age of 628 Ma and the upper sequence is cut by a 605 Ma (U-Pb zircon) rhyolite intrusion. Zircon and monazite analyses of metavolcanic (mafic) rocks and from metagabbros of the lower Açungui Supergroup yield crystallization ages of 614 and 617 Ma, respectively. This supergroup is intruded by a 607 Ma granite. Geochemical signatures of basal mafic units in both sequences are characteristic of E-MORB subalkaline tholeitic basaltic rocks. Nd isotopic signatures of the metamafic rocks indicate that they were derived in part from the asthenospheric mantle (consistent with emplacement in an extensional setting), whereas the felsic bodies appear to have come from the melting of Paleoproterozoic lithosphere. The paleogeographic reconstruction of part of the RB suggests that the São Roque/Açungui groups represent extensional sequences, with features of backarc basins, which evolved during the syn-collisional phase of the Brasiliano Orogeny. These data support the hypothesis that we have a rapid evolution (10-20 Ma) between extensional and compressional tectonics during the geological history of the São Roque/Açungui Backarc.

Kewords:

INTRODUCTION The Ribeira Belt (RB) (Almeida *et al*. 1973) is a Brasiliano-Pan-African mobile belt along the southeastern Brazilian coast comprising lithologies of different origins and ages. The present work was carried out in the central portion of the RB in the southern part of the São Paulo State and the northeast of the Paraná State. The lateral positioning of blocks and exposure of different crustal levels have hindered the understanding of the Brasiliano Cycle in the area (Fig. 1).

Among the several models for the tectonic history of RB, Trompette (1994) considered an evolution beginning with west-dipping subduction followed by collision between the São Francisco, Congo and Paraná cratons. Formation of a backarc in the region, however, was not considered in that model.

To the north, in the State of Rio de Janeiro, the RB records four tectonic phases (Heilbron *et al.* 1995, Machado *et al.* 1996) subdivided into 1) pre-collisional (630-600 Ma); 2) syn-collisional (590-565 Ma); 3) late-collisional (540-520 Ma) and 4) post-tectonic (520-480 Ma). In the central area, in the State of São Paulo, the RB is subdivided, according Campos Neto and Figueiredo (1995) as Brasiliano Orogeny (670 - 600 Ma) and Rio Doce Orogeny (590 - 480 Ma).

Recent studies based on distinct Sm/Nd signatures recognize the juxtaposition of different terranes related to accretion and reworking in the central section of RB (Dantas *et al*. 1999). Hackspacher *et al.* (1999) proposed the existence of a Neoproterozoic Backarc related to the evolution of the RB.

The late-collisional phase is characterized by intense lateral escape tectonics with related NE/SW transcurrent/transpressive shear zones and associated subalkaline granitogenesis. These tectonic features are responsible for the present block configurations and alternating high and low metamorphic grades in the metasedimentary sequences within the central section of the RB (Hackspacher and Godoy 1999).

The period of the opening and closing of paleo-basins of the RB is still an unresolved controversy. The depositional history of the São Roque Group was believed to have initiated around 1.8 Ga (Van Schmus *et al*. 1986), as post-Transamazonian crustal extension. Campanha and Sadowski (1999), among others, proposed an evolution starting at this time for the Açungui Supergroup. On the other hand, this evolution is difficult to reconcile owing to the presence of the 1.4 Ga Serra do Itaberaba Group (Juliani *et al*. 1986) below the São Roque Group.

In this sense, the main propose of the present work is to constrain the timing of sedimentation and volcanism in the São Roque and Açungui groups and to evaluate a possible correlation between the two (Fig.2). A secondary objective of this work is to develop a geotectonic model for the evolution of the Central RB. To achieve these goals, a systematic study integrating geochronological studies (U/Pb zircon and monazite, and Sm/Nd whole-rock methods), geochemical studies and traditional field investigations of the metasedimentary sequences and surrounding basement was undertaken.

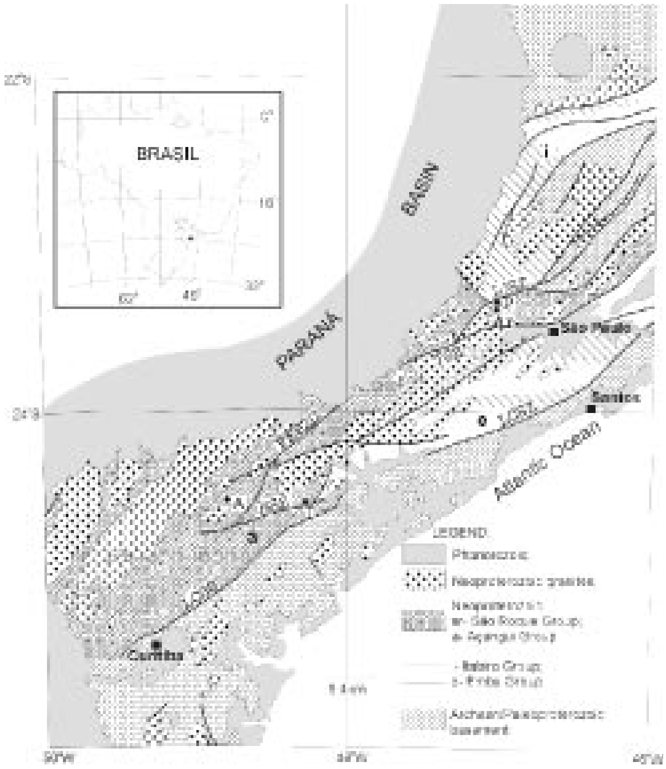

Figure 1 - Schematic geological map of the southern and central parts of the Ribeira Belt. After Schobbenhaus et al. (1981). The dots represent the U-Pb and Sm/Nd sample locations (P-Pirapora do Bom Jesus; Ar- Araçariguama; A- Apiaí; I- Iporanga) and the squares represent cities. IJSZ- Itu-Jundiuvira Shear Zone; FESSZ- Figueira- Espirito Santos Shear Zone; TSZ- Taxaquara Shear Zone; AGSZ- Agudos Grandes Shear Zone; CSZ- Caucaia Shear Zone; LCSZ- Lancinha-Cubatão Shear Zone; RSZ-Ribeira Shear Zone

LITOSTRATIGRAPHY The greenschist facies São Roque and Açungui groups are separated from the higher grade Itapira and Embu groups (amphibolite facies), and Archean and Paleoproterozoic

1 - Instituto de Geociências e Ciências Exatas, Universidade Estadual Paulista. CP 178, CEP 13506-900, Rio Claro, SP, Brasil. E-mail: phack@rc.unesp.br
2 - Instituto de Geociências, Universidade de Brasília. CEP 70910-900, Brasília, DF, Brasil.
3 - Departamento de Geografia, Universidade Estadual de Londrina., Londrina, PR, Brasil.

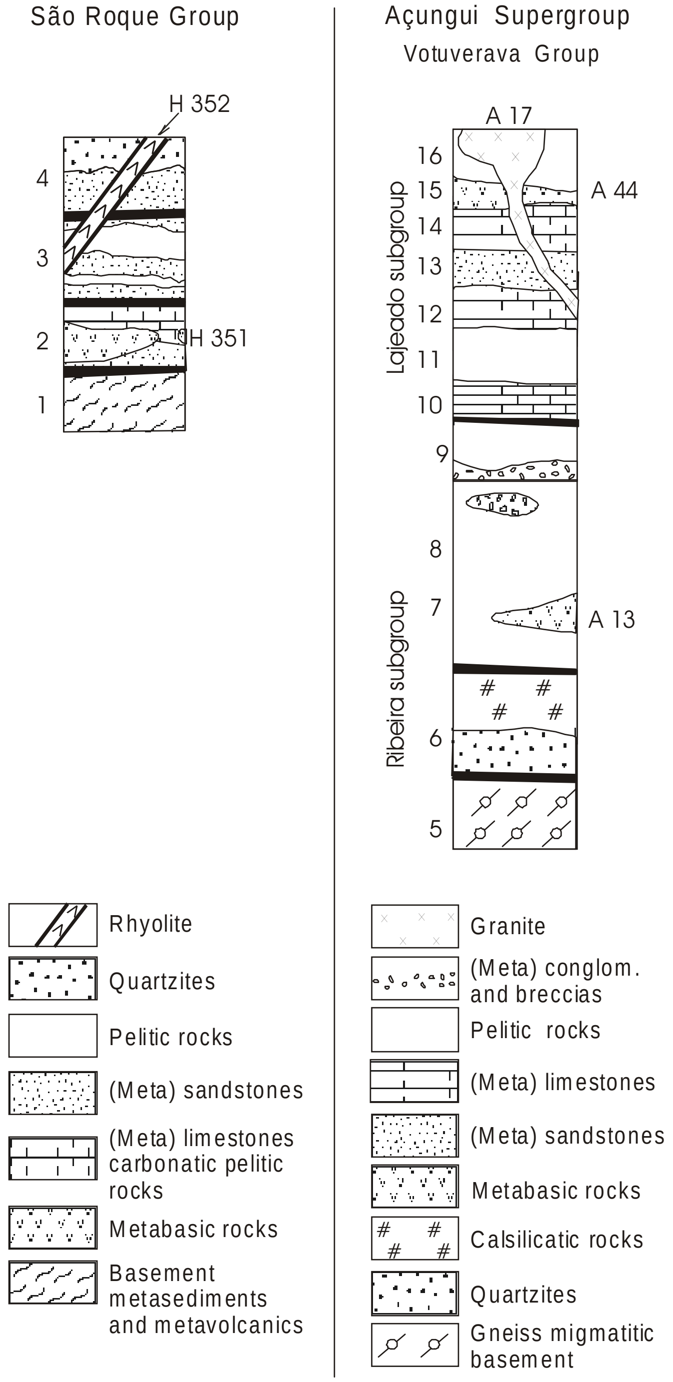

Figure 2 - Lithostratigraphic chart of the São Roque and Açungui groups showing the locations of metamafic and intrusive rocks (H351, H352, A13, A17 and A44). (1) Serra do Itaberaba Group; (2) Pirapora do Bom Jesus Formation; (3) Estrada dos Romeiros Formation; (4) Boturuna Formation; (5) basement; (6) Perau Formation; (7) volcano-sedimentary sequence; (8) Iporanga Formation; (9) Betari Formation; (10) Bairro da Serra Formation; (11) Água Suja Formation; (12) Mina de Furnas Formation; (13) Serra da Boa Vista Formation; (14) Passa Vinte Formation; (15) Apiaí Gabbro; (16) Gorutuba Formation. (modified from Bergman 1988 and Campanha and Sadowski 1999).

basement units (migmatitic gneisses, charnokites, metasediments and ortogneisses) by northeast-southwest trending shear zones (Fig. 1). Dantas *et al*. (1999) and Janasi (1999) considered part of this group to be associated with Brasiliano orogenesis with metamorphism at ca. 620 Ma. Both basement gneisses and the supracrustal sequences are intruded by different Neoproterozoic igneous suites (ca. 620 to 580 Ma).

According to Bergmann (1988) the São Roque Group (Fig. 2) is composed by: the basal Pirapora do Bom Jesus Formation, consisting of metavolcanics and metalimestones/ metadolomites; the Estrada dos Romeiros Formation, made up of metarhythmites, metaarenites and conglomerate layers with smaller intercalations of phyllite and metamafic volcanics; and the Boturuna Formation, composed of quartzites and metasiltstones. All the lithologies are slightly deformed with normal to northwest vergent folds that are strongly stretched adjacent to shear zones. Metamorphism associated with deformation varies between middle and upper greenschist facies. This deformation is intimately associated to late-collisional transcurrent/transpressive processes (Hackspacher and Godoy 1999) responsible for huge shear zones, such as the Itu – Jundiuvira, Taxaquara and others of the Ribeira Belt (Fig.1)

The São Roque Group was deposited over parts of the Serra do Itaberaba Group and probably over sections of the Embu and Itapira groups. Juliani *et al.* (2000) recognized metamorphosed pebbles of the lower Serra do Itaberaba Group in basal metaconglomerates of the São Roque Group. The metavolcanics of the Pirapora do Bom Jesus Formation are probably representative of subaquatic flows, as evidenced by the presence of pillow structures (Figueiredo *et al*. 1982). Chemically, these flows are sub-alkaline tholeitic basalts, have enriched MORB signatures, and appear to have been deposited in an oceanic environment, as evidenced by negative Ce anomalies (Oliveira *et al*. 1999). The depositional environment is consistent with a shallow sea or typical backarc setting, with sediments ranging from proximal deltaic facies to deeper water turbidities, accompanied by subaqueous volcanic activity (Bergmann 1988).

The Açungui Supergroup in the State of São Paulo is characterized greenschist facies supracrustal rocks discordantly overlying basement rocks. Campanha and Sadowski (1999) describes i) continental margin assemblages laterally represented by the Itaiacoca Group to the northwest and Capiru Formation to the southeast; ii) a central domain with a carbonate platform in the western part and deeper turbidite facies, with associated mafic rocks (ocean floor and/or immature island arc) to the east (Lajeado and Ribeira subgroups of the Votuverava Group) (Fig. 2). The Iporanga Formation (Ribeira Subgroup) represents both continental and oceanic margin associations that include mafic volcanic rocks whose geochemistry indicates a transition from a tholeitic island arc environment to MORB to the southeast. Campanha (1991) interpreted this association as representing advanced oceanic basin development, while Maniesi and Oliveira (1999) identify E-MORB character as belonging to a young or restricted ocean basin.

The Apiaí metagabbro is intrusive in the superior portion of the Açungui Group, Lajeado Subgroup (Campanha 1991). It was only slightly affected by Brasiliano metamorphism, hence preserves a geochemistry revealing an original magmatic liquid with a saturated tholeitic character, whose ETR patterns present a sub-horizontal alignment corresponding to oceanic basalts with characteristics of enriched MORB (Maniesi *et al*. 1999).

GEOCRONOLOGY To constrain the timing of sedimentation and volcanism in the two groups presented above, U/Pb age determinations of zircons and monazites were done on their basal igneous units and on igneous intrusions that cut the upper levels of the sequences.

Both zircon and monazite fractions from the basal mafic metavolcanic (H351) of the Pirapora do Bom Jesus Formation of the São Roque Group (Fig.2) were analyzed to determine the age of this unit. The best estimate of the crystallization age comes from a nearly concordant monazite age of 628 ± 9 Ma (Fig. 3a). Numerous single grain analyses of zircons in this rock demonstrate the presence of several inherited populations, ranging between 730 and 2000 Ma (Table 1), suggesting a complex basement structure, as well as the presence of some Neoproterozoic crust. High Samarium enrichment (relative to Nd) in sample H351 precludes obtaining any meaningful Sm-Nd data from it. Additional samples from this unit are required to assess whether or not this enrichment is pervasive throughout the body.

Mafic metavolcanic rocks (A13) of the Iporanga Formation (Fig.2) contain two different zircon populations, the first with light pink prismatic grains, yielding nearly concordant data with the upper intercept of 614 ± 19 Ma (Fig.3c), reflecting the age of crystallization of this rock. Other populations of metamictic, broken, prismatic, milky grains define different components of isotopic inheritance between 1.8 and 2.2 Ga (Table 1). The positive $Epsilon_{Nd(t=600)}$ of 0.85 obtained from this rock unit indicates that was derived primarily from

Table 1 - U-Pb results for the studied rocks.

Concentration[2]				Obs[3]	Atomic Ratios[4]			Ages (Ma)[5]		
Fraction[1]	Size (mg)	U (ppm)	Pb (ppm)	$^{206}Pb/^{204}Pb$	$^{206}Pb/^{238}U$	$^{207}Pb/^{235}U$	$^{207}Pb/^{206}Pb$	$^{206}Pb/^{238}U$	$^{207}Pb/^{235}U$	$^{207}Pb/^{206}Pb$ (2σ)
H351										
M(1)	0.004	636	56	392	0.08743	0.7155	0.05935	540	548	580 (6)
M(0.75)2	0.006	1287	1280	2546	0.10080	0.8433	0.06068	619	621	628 (9)
M(0.75)6	0.004	978	725	454	0.06750	0.5446	0.05851	421	442	549 (6)
M(0.75)1	0.006	1066	1668	1700	0.10152	0.8348	0.05964	623	616	591 (15)
M(2)	0.005	418	41	540	0.09417	0.8252	0.06356	580	611	727 (5)
M(0)3	0.004	409	35	234	0.07876	0.6884	0.06339	489	532	721 (10)
M(0)15	0.005	772	57	406	0.09710	0.6004	0.06306	431	478	710 (5)
M(1)16	0.022	474	92	3448	0.18901	2.7831	0.10679	1116	1351	1745 (1)
H352										
NM(0)14	0.010	286	33	301	0.09918	0.8219	0.06010	609	608	607 (7)
M(0)15	0.012	1624	50	352	0.02490	0.1952	0.05687	159	181	486 (5)
M(0)91	0.013	7334	580	95	0.04008	0.3213	0.05814	253	283	535 (12)
M(0)92	0.010	6096	462	471	0.06730	0.5485	0.05911	420	444	571 (3)
A13										
M(1)	0.007	148	17	113	0.09908	0.8235	0.06281	608	614	614 (2)
M(0)	0.011	1059	159	442	0.12699	1.5320	0.08748	770	942	1371 (1)
NM(0)	0.003	668	152	1072	0.20012	3.1923	0.11569	1176	1455	1890 (1)
A17										
M(-1)1	0.006	748	72	286	0.07606	0.6318	0.06068	473	497	613 (5)
M(-1)2	0.014	495	55	678	0.09134	0.7566	0.05851	563	572	606 (3)
NM(-1)	0.012	602	75	357	0.09554	0.7919	0.06011	588	592	608 (5)
A44										
M(0.75)1	0.003	4966	1238	2162	0.09867	0.8209	0.06034	606	608	616 (2)
M(1)	0.002	495	55	152	0.08933	0.7402	0.06009	551	562	607 (15)
M(0)1	0.008	826	91	851	0.09682	0.8482	0.06355	596	624	727(3)
M(0)2	0.007	333	42	402	0.11503	1.4451	0.09111	702	908	1449(4)
M(0)3	0.006	419	155	1109	0.33443	5.9037	0.12803	1860	1962	2071(2)

[1]: M = magnetic, single digit numbers in parentheses indicate side tilt used on Frantz separator at 1,5 amp, (0.75) = 0.75 amps at 10 degree side tilt (indicates monazite).
[2]: Total U and Pb concentrations corrected for analytical blank.
[3]:Not corrected for blank or non-radiogenic Pb.
[4]:Radiogenic Pb corrected for blank and initial Pb: U corrected for blank.
[5]:Ages given in Ma using decay constants recommended by Steiger and Jäger (1977)
Values of inherited zircon grains and zircon grains with inheritance shown in italics

asthenospheric mantle rather than from the older surrounding Paleoproterozoic lithosphere. The presence of some older zircons, however, do show that older lithosphere was involved in the genesis of this body. Owing to an enriched $^{147}Sm/^{144}Nd$ ratio (i.e. >0.150), the calculated T(DM) age of 1.79 Ga is an overestimate of the mantle extraction age and should be ignored (Table 2).

The Apiaí metagabbro (A44) is intrusive in the Açungui Supergroup (Fig.2). One zircon and one monazite fraction (very close to concordia) yield an upper intercept age of 617 ± 4 Ma (Fig 3d), which we interpret to be the age of crystallization of this rock. Three other zircon fractions (Table 1) yield an upper intercept age of around 2.1 Ga, interpreted to reflect inherited wallrock grains entrained during the intrusion of the gabbro. An $\text{Epsilon}_{Nd(t=600)}$ value of –0.89 from this sample also indicates that it was derived in large part from asthenospheric mantle, but the slightly negative $\text{Epsilon}_{Nd(t=600)}$ value and the presence of older zircons attest to contributions from older lithosphere. This body also has an enriched $^{147}Sm/^{144}Nd$ ratio (i.e. >0.150), thus calculated T(DM) age of 2.03 Ga is an overestimate of the mantle extraction age and should be ignored. Spidergram anomalies of Rb, Ba and Th also suggest that the origin this body is comparable to that of E-MORB (Maniesi *et al*. 1999).

A rhyolite dike (H352) near Araçariguama (Fig.2), that cuts the upper Estrada dos Romeiros Formation, places constraints on the minimum age of deposition. Four zircon fractions from this rhyolite plot on a cord having an upper intercept age of 607 ± 28 Ma (Fig.3b), which we interpret to be the crystallization age. Because one of the

Table 2 - Sm-Nd results for the studies rocks.

Sample ID	Nd ppm	Sm ppm	$^{147}Sm/^{144}Nd$	$^{143}Nd/^{144}Nd$	2σ	ε(Nd) (today)	(t) Ga	ε (Nd) (t)	T(DM) Ga
H352	13.34	2.89	0.1305	0.511422	12	-23.72	0.6	-18.67	2.99
A13	11.52	3.36	0.1764	0.512602	70	-0.71	0.6	0.85	1.79
A17	240.22	40.67	0.1024	0.511322	9	-25.66	0.6	-18.45	2.36
A44	5.69	1.63	0.1730	0.512499	13	-2.70	0.6	-0.89	2.03

fractions yields a concordant age, the error on this upper intercept age is highly overestimated. An $\varepsilon_{Nd(t=600)}$ value of –18.67 from this sample shows that it represents a melt of the older surrounding lithosphere. A T(DM) of 2.99 Ga suggests that Archean lithosphere may exist in the region, but additional studies are required to evaluate this possibility.

The Apiaí granite (A17) is intrusive in the Açungui Supergroup (Fig.2) being considered related to the late-collisional magmatism. Data from four zircon fractions define a collinear array with an upper intercept age of 605 ± 3 Ma (Fig 3e), which we interpret to be the age of crystallization of this rock. A T(DM) of 2.36 Ga from this unit indicates that it was probably derived from older Paleoproterozoic lithosphere.

The data above suggest that the rocks of the São Roque and Açungui groups represent identical and continuous paleogeographical environments in which a Paleoproterozoic (and possibly some Archean) crust suffered rifting with subsequent incipient ocean formation during the Neoproterozoic.

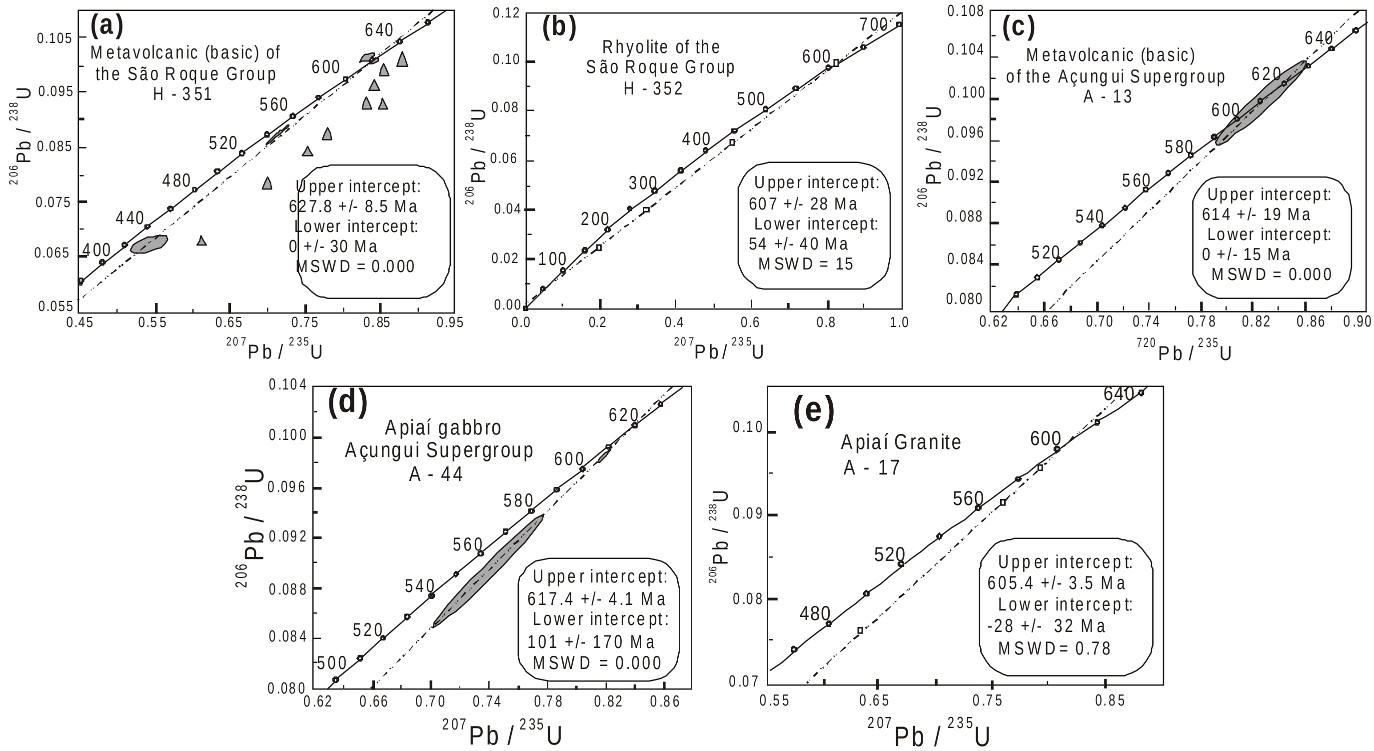

Figure 3 - Concordia diagrams for: a) metavolcanic (mafic) rock of the São Roque Group, Pirapora do Bom Jesus Formation. Monazite defines a 628 Ma crystallization age. b) metarhyolite dike cutting the São Roque Group. The zircons define a 607 Ma crystallization age. c) metavolcanic (mafic) rock of the Açungui Group-Iporanga Formation. The zircons define a 614 Ma crystallization age. d) Apiaí Gabbro cutting the Açungui Group. Monazite and zircon define a 617 Ma crystallization age. e) Apiaí Granite cutting the São Roque Group. The zircons define a 605 Ma crystallization age.

DISCUSSION AND CONCLUSIONS Age constraints on the initiation and termination of magmatism and sedimentation in the São Roque and Açungui groups suggest that formation of backarc complex in the central RB, between the states of São Paulo and Paraná, began between 628 and 614 Ma and continued until around 607 and 605 Ma. This indicates that these localized basins formed and evolved rapidly, i.e., ca. 10 to 20 m.y., during the syn- and late-collisional phases of the Brasiliano Orogeny.

Based on the available data, we propose the following paleogeographic reconstruction for this scenario: i) a beginning platformal deposition the Embu, Itapira and corresponding sequences (possibly around 700-750 Ma based on the presence of detrital zircons of this age in other regional supracrustal units); ii) westward subduction of oceanic crust beneath the RB; iii) syn-collisional phase through collision with the formation of a cordilleran magmatic arc around 620 Ma (Hackspacher *et al*. 1999), along with migmatization and calcium-alkaline plutonism, represented by the Piedade/Ibiúna body in the Embu Complex, the Cachoeira body in the Itapira Complex and and other related granite in the Setuva Complex. Janasi (1999) defined a main phase of metamorphism at 625 Ma related to this collisional process. At present, it is unclear if this collisional phase in the RB involved any exotic terranes, but further studies should help to resolve this question. Structurally, this collisional process in São Paulo State involved a northwest main thrusting, and in the State of Paraná transport was to the southeast, which may reflect a backthrust. T(DM) model age of metasediments of the Itapira Complex possess values between 1.9-2.0 Ga, while Embu has values among 1.6-1.8 Ga, suggesting the existence of different sedimentary sources (Dantas *et al*. 1999), possibly with some Neoproterozoic contributions; iv) the extensional phase (rifting) is represented by a continental backarc with the formation of a restricted shallow ocean, with submarine mafic volcanism, in the São Roque and Açungui groups, between 628 and 614 Ma. The Apiaí gabbro may be a magmatic representative associated to the extensional process of the backarc. The E-MORB character of the metamafic rocks is shown by the tholeitic subalkaline geochemistry. The Nd data indicate that these mafic bodies were derived largely from Neoproterozoic asthenospheric mantle, further reinforcing the rifting hypothesis; v) the late-collisional phase, around 600 Ma is characterized by lateral escape tectonics with the northeast/southwest shear zones and emplacement of granitic bodies (Hackspacher and Godoy 1999). As magmatic representatives we have calc-alkaline to alkaline granites of the I-type, locally S-type in the São Roque, Sorocaba, and San Francisco granitic bodies (Godoy 1989); vi) the pos-tectonic phase is represented by the Itu granite, (Rapakiwi Province) at 580 Ma (Töpfner 1996, Galembeck 1997) and the beginning of the extensional phase and future structuring of the Paraná basin.

The syn-collisional phase, in the central part of RB, has an older evolution, when compared with same phase of deformation in the State of Rio de Janeiro to the north. This fact, associated with the presence of an extensional phase (backarc) in São Paulo/Paraná, indicates a diacronism in the evolution of the belt.

Acknowledgements To Fapesp (grants 97/06544-8, 97/1397-7 and 99/00358-3) and CNPq (grant 52.2388/95-7) for finnancial support and two annonymour referres of RBG for their crytical review of the manuscript.

References

Almeida F.F.M., Amaral G., Cordani U.C., Kawashita K. 1973. The Precambrian evolution of the south American cratonic margin south of the Amazon River. Nairn E.M., Stehli F.G. (Eds.). The Ocean Basins and Margins 1. Plenum. p. 441-446.

Bergmann M. 1988. Caracterização estratigráfica e estrutural da sequência vulcano-sedimentar do Grupo São Roque, na região de Pirapora do Bom Jesus- SP. 167p. (Master Thesis, IG/USP).

Campanha G.A. 1991. Tectônica Proterozóica no Alto e Médio Vale do Ribeira, Estados de São Paulo e Paraná São Paulo. 296p. (Dr. Thesis, IG/USP).

Campanha G.A. and Sadowski G.R. 1999. Tectonics of the southern portion of the Ribeira Belt (Apiaí Domain). *Precambrian Research*, **98**:31-51.

Campos Neto M. and Figueiredo, M. 1995. The Rio Doce Orogeny, southeastern Brazil. *Journal South America Earth Science*, **8**:143-162.

Dantas E., Hackspacher P.C., Godoy A.M., Sato K., Pimentel M., Oliveira M.A.F., Fetter, A. 1999. Characterization of the generating sources of continental crust of the Ribeira belt through isotope of Nd in the State of São Paulo, SE of Brazil. In: IGRM South American Symposium on Isotope Geology 2, Villa Carlos Paz, Actas, 192-195.

Figueiredo M.C.H., Bergmann M., Penalva F., Tassinari C.C.G. 1982. Ocorrência de *pillow lavas* no Grupo São Roque, Estado de São Paulo. *Ciências da Terra*, **2**:6-8

Godoy A.M. 1989. Caracterização faciológica, petrográfica e geoquímica dos maciços Sorocaba e São Francisco. 221p. (Dr. Thesis, IG/USP).

Gallenbeck T.M. 1997. O Complexo Múltiplo, Centrado e Plurisserial Itu- SP. 374p. (Dr. Thesis, IGCE/UNESP).
Hackspacher P.C. and Godoy A.M. 1999. Vertical displacement during late-collisional escape tectonics (Brasiliano Orogeny) in the Ribeira Belt, São Paulo State, Brazil. *Journal of African Earth Sciences*, **29**:25-32.
Hackspacher P., Dantas E.L., Godoy A.M., Oliveira M.A.F., Fetter A., Van Schmus W.R. 1999. Considerations about the evolution of the Ribeira Belt in the São Paulo State - Brazil, from U/Pb geochronology in metavolcanic rocks of the São Roque Group In: IGRM South American Symposium on Isotope Geology 2, Villa Carlos Paz, Actas, 310-313.
Heilbron M., Valeriano C., Valladares C.S., Machado N. 1995. A Orogênese Brasiliana no segmento central da Faixa Ribeira, Brasil. *Revista Brasileira de Geociências* **25**:249-266.
Janasi V.A. 1999. Petrogênese de granitos crustais na Nappe de Empurrão Socorro-Guaxupé (SP-MG): uma contribuição da geoquímica elemental e isotópica. 304 p. (Livre Docência Thesis,. IG/USP).
Juliani C., Beljavskis P., Schorcher H.D. 1986. Petrogênese do vulcanismo e aspectos metalogenéticos associados: Grupo Serra de Itaberaba na região de São Roque-SP. In: SBG Congresso Brasileiro de Geologia 34 Goiânia, *Anais* **2**:730- 747.
Juliani C., Hackspacher P.C., Dantas E.L., Fetter A.H. 2000 The Serra Do Itaberaba Group: a Mesoproterozoic volcano-sedimentary sequence embasement of São Roque Group at São Paulo State, Brazil. In: International Geological Congress 31 Rio de Janeiro, Abstract. In press.
Machado N., Valladares C.S., Heilbron M., Valeriano C.M. 1996. U-Pb geochronology of the central Ribeira belt (Brazil) and implications for the evolution of the Brazilian Orogeny. *Precambrian Research*, **79**:347-361.
Maniesi V.and Oliveira M.A.F. 1999. Petrogênese dos anfibolitos com afinidade dos toleitos de fundo oceânico das regiões de Adrianópolis e Campo Largo, PR. Revista Brasileira de Geociências, in press
Maniesi V., Oliveira M.A.F., Zanardo A. 1999. Petrologia do metagabro de Apiaí– dados preliminares. In: SBG-SP Simpósio de Geologia do Sudeste 6 São Pedro-SP, *Boletim de Resumos*, 36
Oliveira M.A.R., Maniesi V., Nardy A.J.R., Malagutti M.I.A. 1999. Anomalias negativas de Ce em rochas metabásicas de Cajamar Grupo São Roque São Paulo. In: SBG-SP Simpósio de Geologia do Sudeste 6 São Pedro-SP, *Boletim de Resumos*, 32
Schobbenhaus C., Campos D.A., Derze G.R., Asmus H.E. 1981. Mapa geológico do Brasil e da área oceânica adjacente incluindo depósitos minerais. 1:2 500 000. *Departamento Nacional de Produção Mineral*, Brasília.
Steiger R.H. and Jäger E. 1977. Subcommission on Geochronology- convention and use of decay constants in geochronology and cosmochronology. *Earth and Planetary Science Letters* **36**:359-362.
Töpfner C. 1996. Brasiliano-Granitoide in den Bundesstaaten São Paulo und Minas Gerais-eine vergleichende Studie. *Münchner Geologische Hefte* **A17**:258 p.
Trompette R. 1994. Geology of western Gondwana (2000-500 Ma) Pan-African-Brasiliano aggregation of South America and Africa.. A. A. Balkema. 350 p
Van Schmus W.R., Tassinari C.C.G., Cordani V.G. 1986. Estudos geocronológicos da parte inferior do Grupo São Roque. In: SBG Congresso Brasileiro de Geologia 34 Goiânia, *Anais.*, **3:**1399-1406.

Contribution IGC-134
Received March 1, 2000
Accepted for publication April 30, 2000