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Southeast Brazilian Folded Province: Field Excursions of Araçuai and Ribeira Belts in 1999

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Abstract

Geological field observations were conducted in Brasiliano fold belts in southeastern Brazil, including the Araçuai and Ribeira belts. The Araçuai Belt is characterized by the following tectonic domains from the west to the east: the stable Archaean San Francisco Craton, the thin-skinned tectonic domain composed of overfolded thin cover of the Neoproterozoic San Francisco Supergroup, the thick-skinned tectonic domain composed of the Mesoproterozoic Espinhaço Supergroup, and the backland domain composed of the possible Archaean/Paleoproterozoic basement. The survey route covered two traverses in southern and central part of the belt.

The Ribeira Belt is characterized by Mesoproterozoic clastic sequence and has a principally symmetric signature in their structure and depositional environments from the west to the east; the backland domain composed of possible pre-Ribeira basement, the Itaiacoca Group characterized by the continental and pericratonic carbonaceous sediments, the Votuverava and Ribeira groups composed of distal shelf and oceanic sediments, the Capiru Formation and Setuva Group composed of carbonaceous and coarse clastic continental shelf sediments, and the backland domain composed of the basement granite/migmatite. Extensive Brasiliano granites develop throughout the terrain. All the strata are intensely folded, and cleavage and foliation develop throughout, which dip northwest, being conformable to the general asymmetric fold styles and supposed northeasterly vergence.

Through the present study, good outcrops of major geologic units mentioned above were observed, ascertaining general agreement with recent tectonic interpretations of these belts. Field observations for about 60 outcrops and rock samples of about 50 pieces collected through the present study are planned to be utilized for future studies.

Key-words : Brasiliano belts; Brasiliano Orogeny; Araçuai Belt; Ribeira Belt; Adamastor Suture; Mantiquiera Province.

INTRODUCTION

In southeastern Brazil, Proterozoic mobile belts are identified several tens of km inland, running parallel to the Atlantic coast (Fig. 1). They were previously designated, as a total, the Ribeira Belt (Almeida et al., 1973). However, they are recently identified to form separate mobile belts of different origin (Campanha and Sadowski, 1999). They are, from the north to the south, the Araçuai, Alto Rio Grande (recent authors do not use this name and include to the Ribeira Belt), Ribeira (*sensu stricto*; this belt is also called the Apiai Fold Belt by Basei et al., 2000) and Dom Feliciano belts, and are together called the Southeastern Brazil Folded Province (Almeida et al., 1976) or the Mantiqueira Province (Almeida et al., 1981). Conprehensive reviews of these Brasiliano belts were recently given by Pedrosa-Soares and Viedemann (2000), Trouw et al. (2000), Basei et al.

(2000), and Campos Neto (2000).

In August to September 1999, the senior author had a chance of visiting the Araçuai (10 days) and Ribeira (4 days) belts with students of the Universidad de São Paulo and Benjamin B. Bley Brito Neves, one of the co-authors. Both of these belts run principally between pre-Brasiliano cratons to the west and east. The Southeastern Brazil Folded Province, in general, is considered to form the suture of the past Adamastor Ocean, which runs generally at the boundary between the South American and African shields.

THE ARAÇUAI FOLD BELT

Geologic Outline of the Araçuai Fold Belt

The Araçuai Fold Belt lies at the eastern margin of the São Francisco Craton (cf., Fig. 1) which continues to the Congo Craton eastward (Martins-Neto, 1993: Brito Neves, et al., 1995). A small continental block, the Guanhães Block, is situated to the east of the Araçuai Belt. The Araçuai Belt is the inland fold belt composed of Meso- to Neoproterozoic metasediments affected by the Brasiliano orogeny. This belt is represented by four tectonic domains as follows from the west to the east (Brito Neves, et al., 1995, 1996) (Figs. 2, 3 and 4).

The westernmost domain is the stable foreland with a thin (about 300 meters thick) and undisturbed Neoproterozoic continental cover and shelf sequence (Macauva and Bambui groups of the São Francisco Supergroup (Dardenne, 1978 and Martins- Neto, 1993) underlain by the Archaean (granitic- migmatitic rocks of the Basement Complex, ca 2.7-3.1 Ga) and possible Paleoproterozoic (meta-supracrustal sequence of the Rio Parauna Supergroup) basement. The second domain is controlled by the thin-skin tectonics composed of the São Francisco Supergroup, which is strongly folded in overturned and recumbent styles and is underlain by the Archaean and Paleoproterozoic basement. To the east occurs the third domain composed mostly of the thick Mesoproterozoic supracrustal sequence (the Espinhaço Supergroup, Martins-Neto, 1993) underlain by the Archaean basement (ca 2.5 Ga). This domain is characterized by the thick skin tectonics and the basement is also reworked (refolded) and rejuvenated giving K-Ar ages of ca 0.5-0.8 Ga. Further to the east, the backland of the fold belt occurs. This domain is composed of the basement granite-migmatite of ca 2.5 Ga and Paleoproterozoic greenstone sequence, all of which are partly affected by Brasiliano reworking, and associated with or without younger cover sequence. Further to the east, granitic masses and ophiolitic rocks of Brasiliano cycle occur, suggesting the development of a Brasiliano subduction belt there.

The Southern Traverse Section of the Araçuai Belt

Belo Horizonte is the third or fourth biggest city in Brazil, which was initially welfared by the big production of iron from the Paleoproterozoic Minas Belt (greenstone belt) lying just south of the city. Lagoa Santa, lying about 40 km north of Belo Horizonte, is underlain by limestone sequence (the base of the Bambui Group). A beautiful lake originated in the carst depression adores the centre of the city. From this city, we made an eastward traverse covering all the above domains.

Fig. 1 Outline of Proterozoic fold belts of South America and Africa (Campanha and Sadowski, 1999)
Shaded areas show Brasiliano belts. 1: Ribeira, 2: Dom Feliciano, 3: Gariep, 4: Damara, 5: Kaoko, 6: Alto Rio Grande, 7: Araçuai, 8: Brasilia, 9: West Congo, 10: Borborema, 11: Araguaia, 12: Paraguai, 13: Sierras Pampeanas. Crossed area is cratons. A: Amazon, C: Congo, K: Kalahari, P: Supposed Parana, RP: Rio de La Plata, SF: São Francisco, W: West Africa. Framed areas near letter 6 and 1 are referred to Figs 2 and 10 respectively.

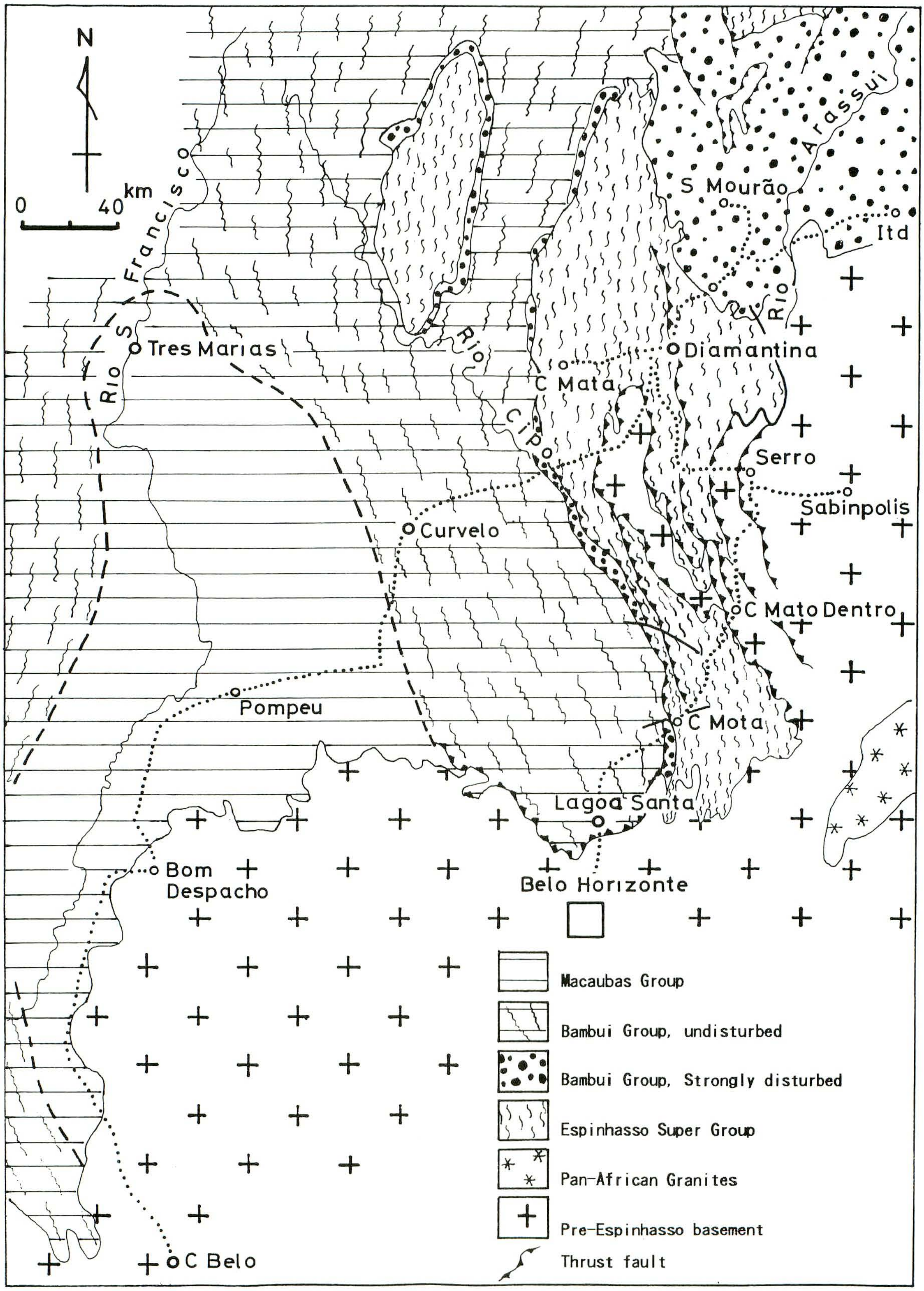

Fig. 2 Outline of the Araçuai Fold Belt and the excursion route (Compiled from Companhia Mineradora de Minas Gerais, 1994). Straight line connecting Curvelo-Sabinopolis shows the transect given in Fig. 3. Dotted line: excursion route, Thick Chain: supposed tectonic boundary, Thick line: fault. Straight line connecting Curvelo-Sabinopolis shows the transect given in Fig. 3.

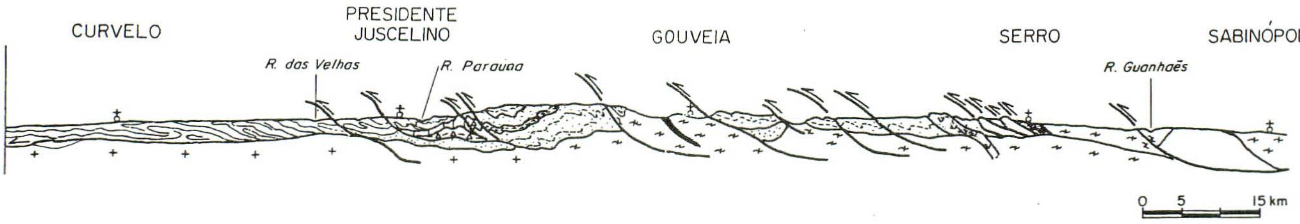

Fig. 3 A schematic cross section of the central part of the Araçuai Belt (Brito Neves, unpublished)

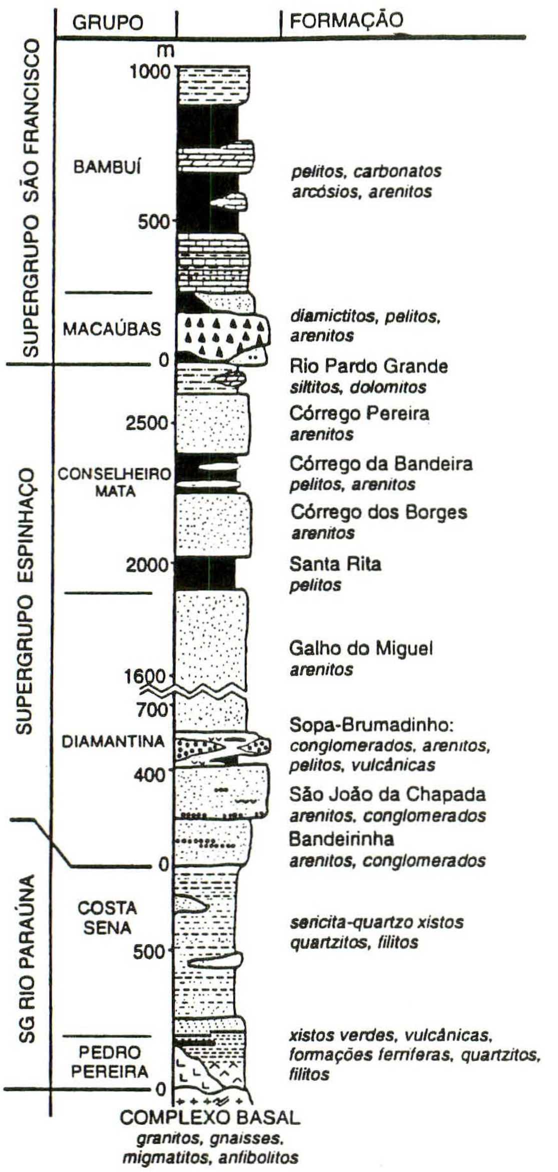

Fig. 4 General stratigraphic section of the Araçuai Belt (Martin-Neto, 1998)

On 4th September, the second day of the trip, the excursion covered the route Lagoa Santa-Cardeal Mota-Lagoa Santa. The first and second outcrops were calcareous banded shale, said to be less disturbed flat cover of the basement. It has a distinct thin banding structure composed of calcareous and pelitic alternations. It however, carries distinct horizontal cleavage and mylonitic structure, and an intersection and a possible mineral elongation lineation are developed. Micro shears with a northwesterly dip develop, resulting in showing small passive folds of the banding with a vergence top to the southeast. This vergence is obviously the opposite sense from the one as is expected from the general explanation of the thrusting westward.

Next six outcrops were mostly pelitic phyllite with the last outcrop of a limestone quarry. All of them represent good mesoscopic folding structures. The most dominant is close to open recumbent and overturned folds, with rare development of small- scale rootless isoclinal folds (Fig. 5). Well developed lineations which are mostly intersection and rarely mineral stretching, and related micro shears represent easterly vergence, with the movement direction southwestward, again in contradiction to the direction expected from the general tectonic interpretation. At least two stages of superposed folding were identified, the earlier recumbent and the later, open to tight overturned shear fold with westerly vergence, but with the movement direction towards east. Some rootless isoclinal folds and eye folds were found, which were difficult to be evaluated as to whether they belong to the further earlier folds or not.

At Rio Cipo, undisturbed horizontal beds of sandstone with beautiful ripple marks and cross beddings occur. This sandstone belongs to the basement of the fold belt and forms the lower part of the Mesoproterozoic Espinhaço Supergroup occurring as a window below the Neoproterozoic folded skin of the São Francisco Supergroup. Evidently, Only ruptural deformation is found in this sandstone formation (cf., Fig. 3).

The road suddenly starts climbing the cliff reflecting the principal thrust boundary between the thin-skinned and the thick skinned domains, the former one being composed of strongly deformed limestone (Fig. 6) and calcareous shale with southeasterly dipping cleavages and west-southwesterly plunging intersec-

Fig. 5 Recumbent and superposed overturned folds of calcareous shale of the Santa Helena Formation. (Roadside outcrop between Belo Horizonte and Caroeal Mota)

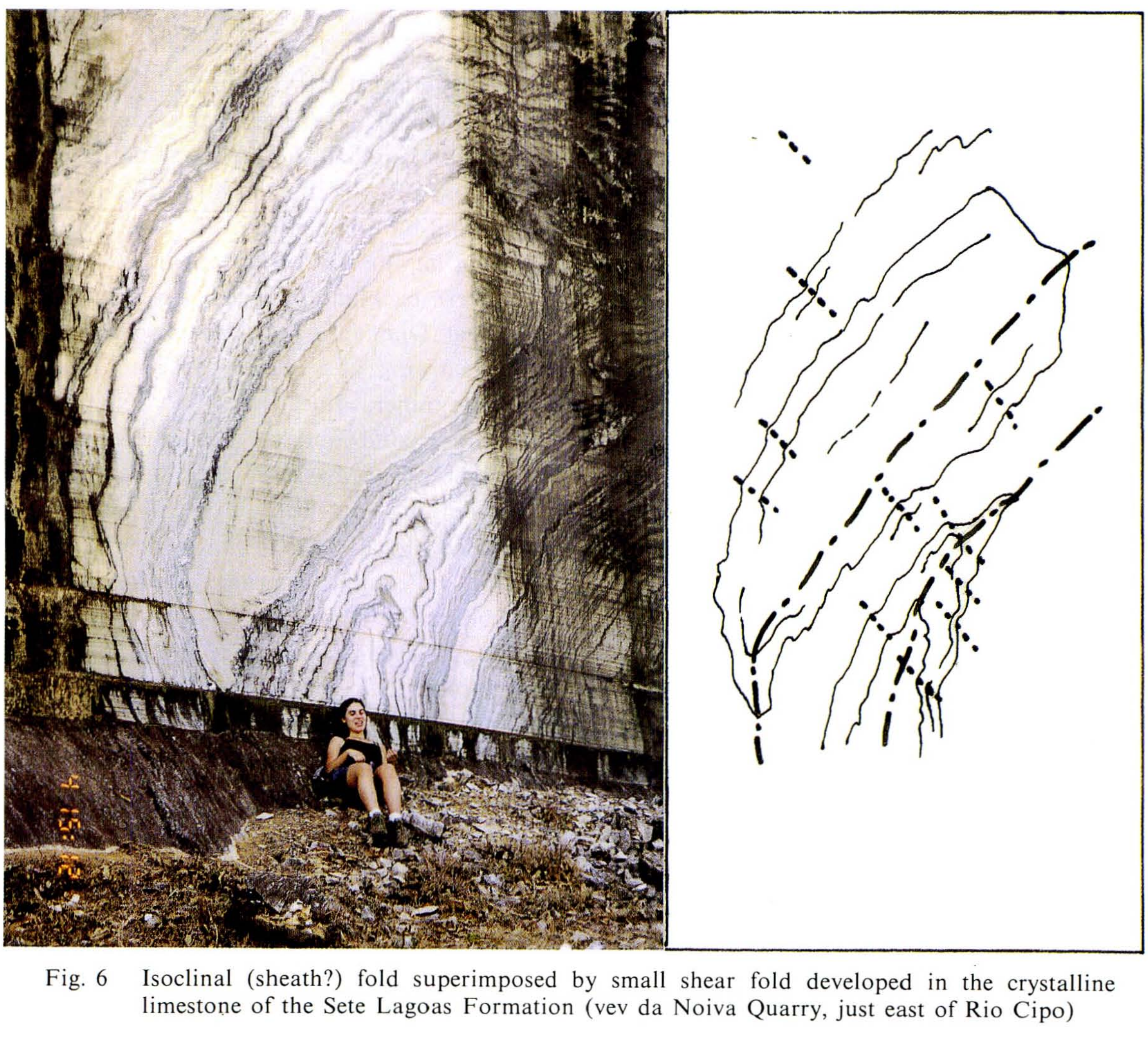

Fig. 6 Isoclinal (sheath?) fold superimposed by small shear fold developed in the crystalline limestone of the Sete Lagoas Formation (vev da Noiva Quarry, just east of Rio Cipo)

tion and stretching mineral lineations. This part is sandwiched between the undisturbed sandstone of the Rio Cipo below and the disturbed sandstone/shale alteration above. The Espinhaço sandstones are very well weathered, appearing as if not the arenites, but arkosic to felsitic, because of deep and total soft weathering. Hard quartzite was only rarely met with.

The third day (Sept. 5th) covered the route Lagoa Santa-Conceiçao do Mato Dentro-Sabinopolis-Serro- Diamantina. It includes the deformed sandstone formations of the Espinhaço Supergroup, all of which carried ESE stretching lineation. North of Lagoa Santa, beautiful peneplains of Post Gondwana, Sud Americana, Velhas, and Paraguasu were observed. An outcrop within the Espinhaço Supergroup was the deformed felsic sandstone on the north of the town called Cardeal Mota. This location was at the foot of stone statue of Mr. Juquinha du Flor, famous in this region and history says that he constantly gave flowers to travelers who just passed through the locality.

At one locality 5-km southeast of Conseiçao do Mato Dentro, strongly phyllonitic psamo-pelitic schist crops out, which was explained to be the deformed rhyolite. Numerous tiny and idiomorphic tourmaline characteristically develop randomly along the cleavage plane which is mostly composed of elongate quartz and sericite. Below this layer occur psamo-pelitic (upper) and psammitic (lower) layers of some meters thick. In the near-horizontally laminated quartz-feldspathic sandstone of the lower psammitic layer, many deformation structures including rootless isoclinal folds and shear folds were scarcely found, the former having near- horizontal hinges trending nearly N-S. In contrast, the upper psammo-pelitic layer, at a glance, appeared to be very much disturbed, strongly phyllitic, and quartz augens of various sizes occur, which included very coarse grained chlorite-mica clots and minor sulphides. The phyllite carries dominant slickenside and stretching lineations plunging ESE.

The Northern Traverse Section of the Araçuai Belt

In the afternoon of the third day, we turned the route northward and drove about 80 km, and entered into the backland terrain composed of basement granite migmatite situated east of the Araçuai Belt.

At about 1 km south of the town Serro, there crops out an ultramafic body, now metamorphosed mostly into talk schist. This rock is considered to be either the early Proterozoic greenstone belt or the Neoproterozoic ophiolite. This rock carried steep banding possibly of the original igneous structure and steep E-W cleavage with near-vertical westerly mineral and intersection lineations.

Two outcrops next to the ultramafic schist were the basement migmatitic gneiss and granodiorite occurring near the Sabinopolis town. The first one carried similar foliation and lineation as the ultramafic rock mentioned above. This rock has been dated by Rb-Sr whole rock isochron and U-Pb zircon methods, as ca 2.5 Ga, and K-Ar method as ca 550-600 Ma. The second one was pink K-feldspar porphyritic biotite granodiorite carrying characteristic mafic porphyroclast now completely recrystallized into flattened aggregates of fine-grained biotite. The last stop, at the town Pedro Lessa, about 20 km west of Serro, was a diabase dyke trending N-S. Badelyite from the dike gave ca 910 Ma U-Pb age. This diabase is interpreted as a part of the Tonian Taphrogenesis, responsible for the fusion of Rodinia (Brito Neves, personal communication).

The night was at the Diamantina City. The Centro de Geologia Eschweg of Universitad de Minas Gerais was our residence, which was founded as a memorial of the veteran geologist of Brazil, Dr. W.L. von Eschweg.

On the fourth day (Sept. 6th), we went northeast from Diamantina, covering the route Diamantina-Couto de Magalhães de Minas-Senador Mourão-São Gonçalo do Rio Preto-San do Modestino Conçalves-Itamaramdiba-Diamantina. To the northeast from Diamantina, the entire São Francisco Supergroup and the eastern backland basement were visited. The first stop near Diamantina was the Espinhaço metasandstone, carrying N-S schistosity with moderate ESE plunging mineral lineation.

The second outcrop near the town of Couto Magalhães de Minas was the diamictite. It carries ENE trending and steeply to gently dipping foliation composed of flat clasts of limestone and biotite schist possibly reflecting the primary bedding which might have been affected by later deformation. Faint gently dipping cleavage trending nearly N-S develops throughout.

After the diamictite, strongly deformed meta-arenitic sandstone/argillite alternations occur, followed by strongly deformed meta-argillites with numerous quartz veins. The above change of sedimentary sequences is considered to represent the change from the proximal to the distal conditions of the turbidite developed at the continental margin of the São Francisco Craton lying west. All the above metasupracrustal sequences carry strong deformation

Fig. 7 Westerly vergent gentle asymmetric fold of sandstone bed, Galho do Miguel Formation (about 18-km west of Diamantina)

structures including foliation, folding and veining. A quartz vein paralleling the banding represented distinct rootless isoclinal folds with a northerly vergence. Some other folding structures show NNW or NNE plunging hinges, and NNW mineral and intersection lineations develop dominantly.

Last three outcrops were basement rocks. At the floor of the Araçuai River, crops out so called green-schist, appearing to be the semi-schistose graywacke. Next outcrop was altered biotite granodiorite with weak schistosity dipping gently east. Faint cleavage trending NE and dipping SE was identified. The last one, near the town of Modestino, 48 km WSW of Itamarandiba, carried distinct schistosity dipping gently ESE and lineation plunging gently ENE.

On the fifth Day (Sept. 7th), the excursion covered the route Diamantina-Conselheiro Mata-Sopa-Guinda-Diamantina. Eight outcrops of the Espinhaço Supergroup to the west of Diamantina were visited. Arenitic sandstone of the Galho do Miguel Group only cropped out, and pelitic formations were all denuded to form the South American Peneplain, over which the weathered iron-manganese ore deposit formed. Two among 8 outcrops visited on this day are worth noting below.

Sandstone layers showing beautiful gentle folds with distinct axial cleavage-fractures were observed, forming a hill at about 18-km west of Diamantina on the road to Conselheiro Mata. This is a classical example of asymmetric gentle folding with northwesterly vergence (Fig. 7). The sandstone layer carry distinct cross bedding structure, which marks also a good example of flexural slip movement of the strata. Here, both the bedding and cleavage run N-S. Bedding is gently waving, and the cleavage is almost constantly dipping steeply east.

At a road side outcrop just west of Datas, about 25 km SSW of Diamantina, very interesting examples of elongated pebbles and sheath-like structure plunging ESE 40°-60° were observed (Fig. 8). Rootless drag isoclinal folds with hinges plunging gently southward apparently showing the west northwestward thrust movement also develop. Thus this outcrop represents both the kinematic axis a and b by the lineation composed of pebble and mineral stretching, and fold hinges respectively.

On the sixth day (Sept. 8th), we went southwest, covering Diamantina-Gouveia-Inimutaba-Curvelo (overnight). The route covered the thick-skinned Espinhaço Supergroup in the east and the thin- skinned São Francisco Supergroup in the west. The first highlight of the day was the recognition of the thrust-nappe of the basement, over some kilometers thick, occurring about 1 km west of Genveia. The nappe is overlain, from the top to the bottom, by the Galho do Miguel Sandstone, Sopa-Brumadinho, and São Joan do Chapade formations, and is underlain by the same sequence of formations. At the lowest horizon of the overlying sequences, i.e., on the thrust boundary with the basement, strongly foliated and lineated aluminous schist associated with aluminous granitic pegmatite occurs which is said to carry gem- quality kyanite. The country meta-argillites are very aluminous and appear to carry altered kyanite.

After this outcrop were mostly shale with minor conglomerate and limestone of the upper Espinhaço Supergroup, all of which carry good easterly cleavage and some open to gentle folds. Vergence and movement direction were mostly west-northwestward, thus conformable with a general tectonic interpretation (e.

Fig. 8 Lineated conglomerate of the Sopa-Brumadinho Formation (just east of Datas)

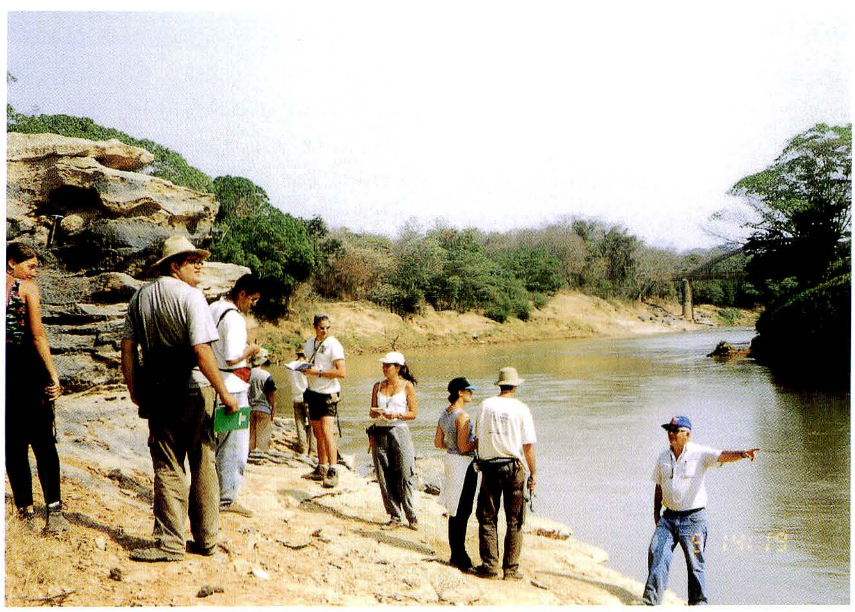

Fig. 9 Flat-lying stromatolitic limestone of the Seta Lagoas Formation, riverside of Rio São Fransisco (27 km west of Bom Despacho)

g., Brito Neves et al., 1995, 1996), in contrast to the observations of the earlier phase of the excursion.

At about 25 km east of the Rio Cipo crossing, the thick-skin tectonics represented by the Espinhaço Supergroup changed into the thin-skin tectonics formed by the São Francisco Supergroup. The Mucauvas and Bambui group rocks, most of which are shale and pelitic sandstone, carry distinct westerly dipping cleavage and are both very weakly to non-metamorphosed.

On the 7th day (Sept. 9th), the excursion covered the route Curvelo-Pompeu-Bon Despacho-Campo Belo (overnight). This route traverses from the thin-skinned tectonic domain to the basement domain with shallow and undisturbed Neoproterozoic Macauvas and Bambui groups.

The city of Curvelo is underlain by the unoxidized shale of the Santa Malena Formation of the Bambui Group; a working quarry for this slate was met with at about 28 km west of the city. At about 50 km west of

Curvelo, the cover sequence changes into completely undisturbed, mostly flat-lying shallow platformal sediments mostly of possible vervite, limestone (Fig. 9), and calcareous shale of the Santa Helena Formation and the Lagoa do Jacare Formation. At the town Bom Despacho, possible vervite of the Macauvas assemblage with sporadic granitic boulders yielded interesting outcrop giving an impression as if of the very weathered unconformity. Basement gneissose granodiorite of possible Archaean with some migmatitic affinities occurs at about 13 km west of Bom Despacho.

The 8th day (September 10th) covered the route Belo Campo-São Paulo. The first tens of kilometers were just the driving over the flat-lying limestone of the Sete Lagoas Formation and diamictite of the Macauvas Group. The excursion arrived in São Paulo at 15:00 in the afternoon.

THE RIBEIRA FOLD BELT

Geologic Outline of the Ribeira Belt

The Ribeira Belt includes the Proterozoic mobile belts between the São Francisco Craton to the north and the Luis Alves Block to the south, thus forming the central part of the Proterozoic fold belts, which in general forms the north-south trending Adamastor Ocean suture. Porada (1979) suggested that it was once contiguous with the Pan-African Damara Belt of southwestern Africa.

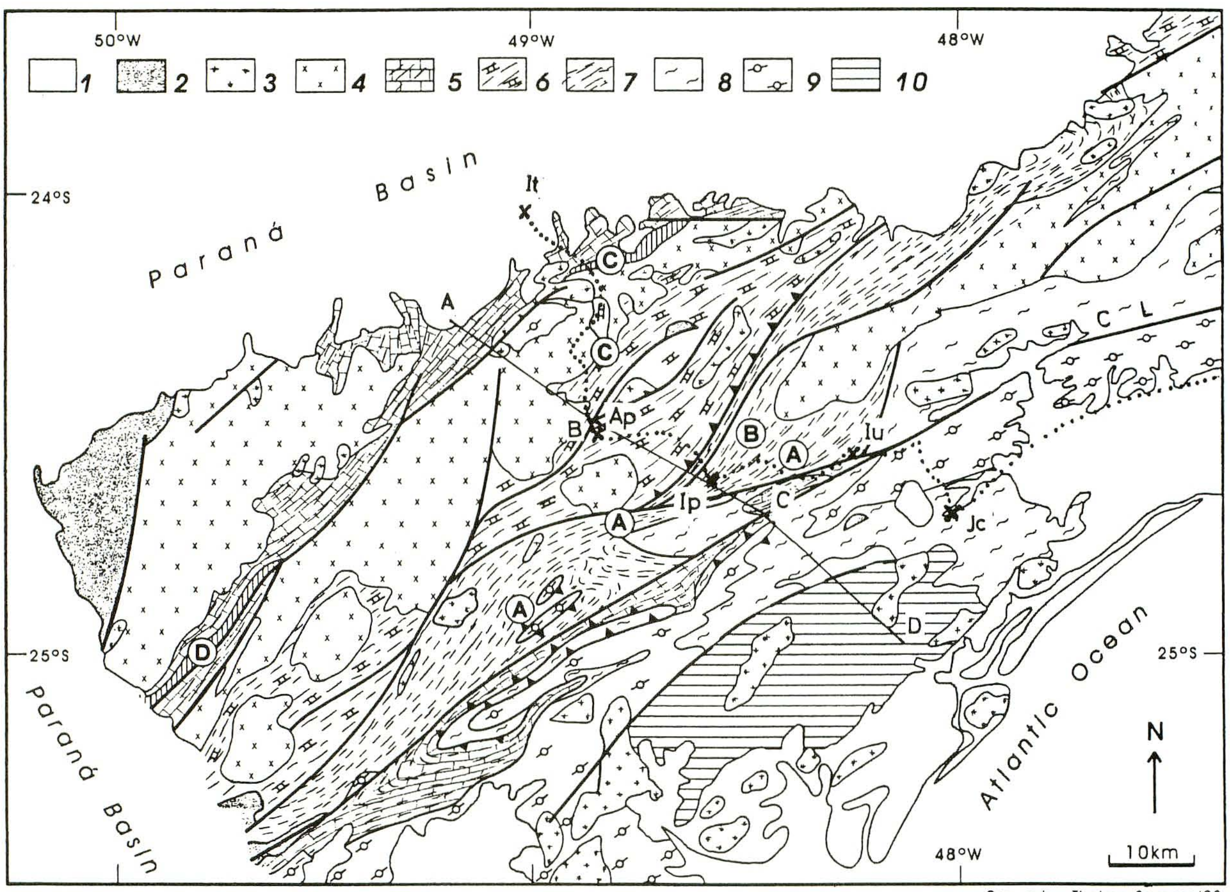

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Fig. 10 Geologic outline of the southwestern part of the Ribeira Belt and the traverse route (cited from Campanha and Sadowski, 1999).
1: Phanerozoic covers and intrusive rocks; 2: Late pull-apart basins; 3: Post-tectonic granites; 4: Syn- to late tectonic granites; 5: Shallow water carbonatic platforms; 6: Distal (open sea) carbonatic platforms; 7: Turbiditic, basic volcanics and pelagic sequences; 8: Schists of unknown environment; 9: Gneiss migmatitic complex; 10: Coastal Complex (Luis Alves).
Dotted line shows the excursion route. It: Itapeba, Ap: Apiai, Ip: Iporanga, Iu: Itapeuna, Jc: Jacupiranga, CL: Cubatao Lineament, A ~D with circle: Tectonic signatures of igneous rocks, after Campanha and Sadowski, 1999. Line A-B-C-D: Location of cross section shown in Fig. 11.

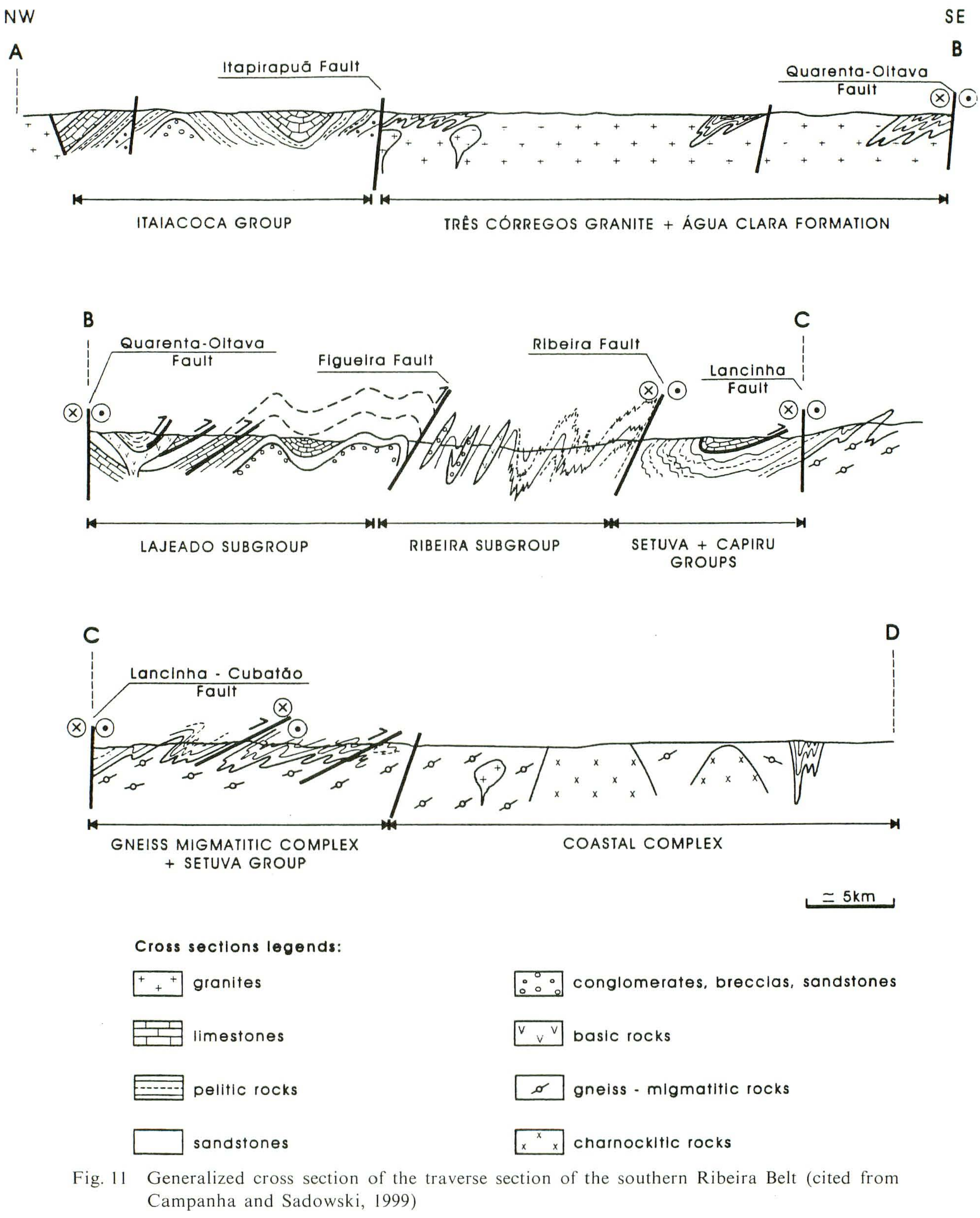

Fig. 11 Generalized cross section of the traverse section of the southern Ribeira Belt (cited from Campanha and Sadowski, 1999)

The Ribeira Belt has a general symmetric organization (Campanha and Sadowski, 1999); from the northwest to the southeast (Figs. 10, 11), the backland basement composed of a supposed Parana Craton (Archaean?), the Mesoproterozoic to Neoproterozoic Assungui Supergroup composed of continental shelf deposits (Itaiacoca Group), distal shelf and oceanic deposits (Agua Clara Formation and Votuverava Group) and continental shelf deposit (Capiru Formation and Setuva Group) (Fig. 12), and the foreland

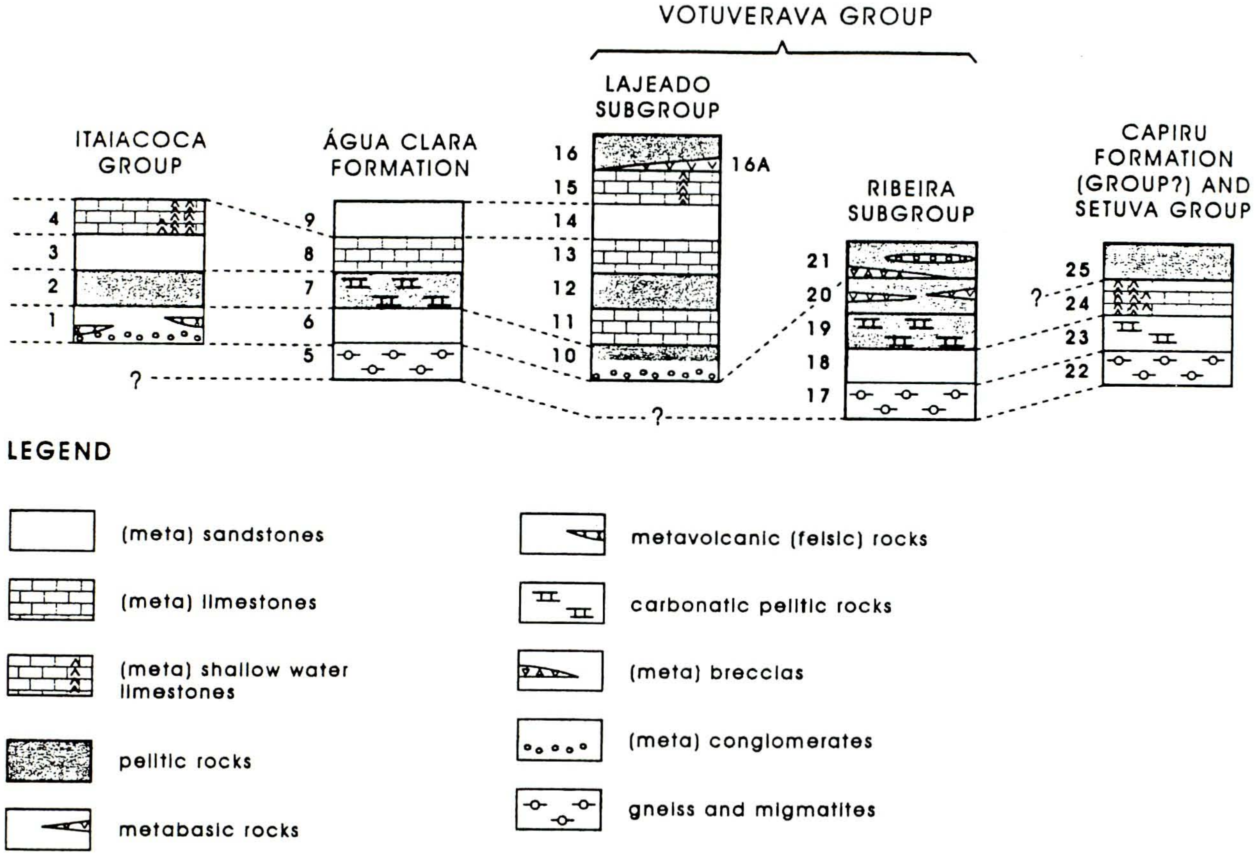

Fig. 12 General stratigraphic section of the Ribeira Belt (cited from Campanha and Sadowski, 1999). A distinct symmetric signature in sedimentary facies, i.e., proximal-distal-proximal from northwestern (left two columns of the figure), central (Votuverava Group, central two), to southeastern (rightmost column) is found in this figure.

basement Apiai Domain which is considered to be the northern extension of the Rio de La Plata Craton. All rocks of the above units are cut across by the vast amount of granitic masses of the Brasiliano age. All the geologic units mentioned above suffered thrusting with an eastward vergence. Upright gentle to open folds of later generation develop throughout, some part of which changes into the overturned type with an eastward vergence. Late stage (ca 500 Ma) escape structures create distinct strike slip faults often along the previous thrust faults, and some sedimentary units within pull- apart basins were identified. All the sediments suffered low to middle grade metamorphism, the latter is assumed to be caused as a result of superposition by the granite intrusions. Dolomite sills of the Brasiliano age are also found intruding into the distal sedimentary piles.

The Southern Traverse Section of the Ribeira Belt

In 1999, I had a chance of visiting the southern part of the Ribeira Belt (cf. Figs. 10, 11, 12) for four days from August 24th to 27th, escorted by Ginaldo A. da C. Campanha, one of the co-authors. The traverse of the Ribeira Belt from west to east was made from Itapeva to Jacupiranga, and an about 100-km cross section of the belt was observed. The route included a traverse from the Parana Basin to the east coast through the Ribeira Mountains and the Ribeira River (cf. Figs 13, 14).

During the first day (August 24th) and early half of the second day, the northern domain composed of large calc alkaline granitoid complexes and shallow shelf sequence of the Itaiacoca Group were observed, along the route Itapeva-Apiai. At a phyllite quarry for ceramic material, some kilometer southeast of Itapeva, flat-lying Devonian strata of the Parana Basin sediment (the Gondwana) covered the strongly disturbed phyllite of the Itaiacoca Group with a distinct unconformity (Fig. 15). Quartzite occurring at about 5 km SE of Itapeva is hard, carrying flat and horizontal cleavage. Other outcrops observed were limestone with either or both stromatolite and oolite structures,

Fig. 13 Mountain range of the Ribeira Belt (east of Iporanga)

Fig. 14 The Ribeira River west of Itapeuna

partly with strong phyllitic structure and alternated with dolerite sills near the Itapirapua lineament. Within the wide zone of granites, medium grained and massive, pink K-feldspar porphyritic biotite hornblende granite, and weakly schistose small-grained biotite granite were observed, these granites belonging to the calc-alkaline Brasiliano granites.

The later half of the second day and most of the third day covered the central domain composed of the shelf and deep water Agua Clara Formation and the Votuverava Group. The route was Apiai-Iporanga-Barra do Turvo-Iporanga. They are calcareous shale, limestone and quartz-feldspathic sandstone. S-planes dip variably and gentle southwesterly plunging intersection lineations are more or less common. Most of sediments in this domain represent distinct s-l structures and partly suffered late thermal effect, showing sporadic development of porphyroblasts of biotite, chloritoid, and/or garnet.

Beautifully folded limestone outcrops were observed at Apiai Town, along the railway (Fig. 16). The axial surface of the fold trends NE-SW and dips steeply west, with its hinge plunging gently southwest.

A Brasiliano dolerite dike was observed, intruding the sandstone sequence of the Lajeado Subgroup near Iporanga. The metabasite within the Ribeira Sub-

Fig. 15 Devonian Parana Basin sediment unconformably rests over strongly disturbed phyllite strata of the Itaiacoca Group (south of Itapeva)

Fig. 16 Beautifully folded limestone of possible Agua Clara Formation (at Apiai Town)

group is reported to be the island arc basalt.

The route of the late afternoon of the third day and the full fourth day (August 27th) was Iporanga-Itapeuna-Jacupiranga-Peruibe, the last town lies on the coast about 100-km ENE of Jacupiranga. The route crossed the southern domain composed of the Setuva Group, and the foreland basement migmatite gneiss and charnockitic migmatite. At about 35-km SE of Iporanga, well deformed chlorite schist and graphite-chlorite-sericite schist of possible Setuva Group were observed. S-plane generally runs NW-SE and is vertical, with an intersection lineation plunging mildly southeast. Further southeastward, biotite-garnet- (sillimanite?) gneiss occurs, having foliation trending NE-SW and dipping mildly NW and horizontal intersection lineation.

All other outcrops were basement migmatitic rocks (Fig. 17), although outcrops were poor. An outcrop east of Iporanga, along the new road cut, is composed of distinct mylonite of migmatite origin

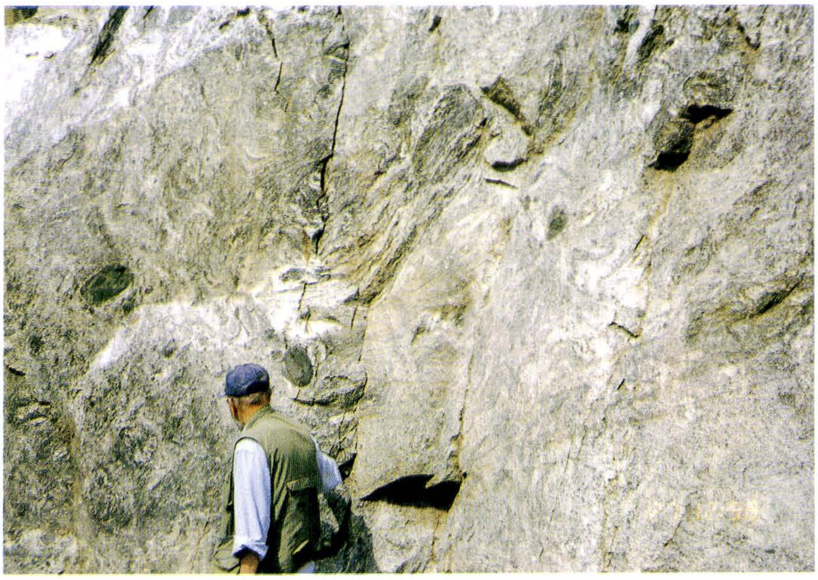

Fig. 17 Basement migmatitic rocks (northeast of Jacupiranga)

Fig. 18 Mylonite of granitic rocks origin, developed along the Cubatano Lineament (northeast of Jacupiranga)

(Fig. 18), with syntectonic pink granite/pegmatite veins and pools. This outcrop is situated on the Cubatão Lineament running generally at the boundary between the central to southern domains. After about 50-km drive towards northeast, coastal outcrops east of Peruibe (cf. Fig.1), composed of charnockitic migmatite were visited. Major structure runs generally N-S. Labradoritic pegmatite occurs as the matrix of the migmatite, and fragments of folded charnockitic/enderbitic gneisses are embedded within it, being rotated randomly.

DISCUSSION AND SUMMARY

Geological field observations in Brasiliano fold belts in southeastern Brazil, including Araçuai Fold Belt for 10 days and Ribeira Fold Belt for 4 days were conducted. The Araçuai Belt is characterized by the following different tectonic units from the west to the east (Brito Neves et al., 1995, 1996). The stable São Francisco Craton with sporadic occurrences of Neoproterozoic continental cover and shelf sequence (the Macauva and Bambui groups of the São Francisco Supergroup), the thin-skinned tectonic domain composed of over folded thin cover composed of the São Francisco Supergroup which is underlain by reworked Archaean basement, the thick-skinned tectonic domain composed of folded and faulted thick distal sediments of the Mesoproterozoic Espinhaço Supergroup, which is juxtaposed to the east the backland domain composed of the possible Archaean/Paleoproterozoic basement..

Brito Neves et al. (1995, 1996) stressed that the Araçuai Belt suffered compressional tectonics by the collision of the Archaean cratons on both sides, thus resulting in the structural style as mentioned above with the westward vergence. Their tectonic scheme appeares to be a reasonable explanation through the present observations, with some provisional comments given below.

(1) *Vergence of folds*. The westerly vergence was recognized throughout. However, there were several observations in the thin-skinned tectonic domain that the easterly vergence clearly develops, which does not conform to the westerly vergence of previous interpretation. This evidence needs to be interpreted in the tectonic model above.

(2) *Heterogeneity in the intensity of deformations*. Strongly lineated structures observed at some places might require an interpretation within a regional/local tectonic domain, considering the heterogeneity of deformations within the study area.

(3) *Two stages of glaciations*. Vervite-like thinly laminated clayey sediments with sporadic granite/migmatite boulders observed at the lower horizon of the Bambui Group is possibly the glacial sediment. If it is the case, it results in the occurrence of two horizons of glacial deposits in foreland domain of the Araçuai terrain. A detailed study is awaited on this point.

The Ribeira Belt has a principally symmetric signature from the west to the east as follows as pointed out by Campanha and Sadowski (1999). The backland domain composed of possible pre-Ribeira basement of Parana Craton, the Itaiacoca Group which is mostly continental and pericratonic sediments, the Votuverava and Ribeira groups composed of distal shelf and oceanic sediments, the Capiru Formation and Setuva Group composed of carbonaceous and coarse clastic continental shelf sediments, and the backland domain composed of the basement granite/migmatite possibly referred to the northern extension of the Rio de La Plata Craton. Extensive Brasiliano granites characteristically develop throughout the terrain. Through the present observations, following points can be pointed out which may have important meaning in the interpretation of tectonic characterization of the Ribeira Belt.

(1) General development, although not homogeneous in intensity, of cleavage structures with a westerly dip, suggesting the asymmetric overturned style of mega-folds in the belt are conformable with the structural scheme presented by Campanha and Sadowski (1999).

(2) Almost all lineations observed are intersection lineations, and have horizontal or gentle plunges. Only a few lineation having a dip plunge, or with a signature of stretching was observed. Further detailed structural observations on the S and L structures may improve the kinematic interpretation of the Ribeira Belt.

(3) Sudden change in metamorphic grade for the western half of the belt appears to reflect considerable displacement among the belt.

(4) The greenschist developed in the western part of the belt represents, at a glance, similar appearance with the high-pressure type schist elsewhere in the world. Detailed petrological examinations with regards to the metamorphic facies series of the belt from the very low- grade to the higher-grade portions of the Ribeira Belt may provide important information in examining the tectonic model of this belt.

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