Palaeomagnetism of the Itajai, Castro and Bom Jardim groups from southern Brazil

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SUMMARY
Palaeomagnetic results corresponding to geological units associated with the Brasiliano (Pan-African) cycle (Late Pre-Cambrian – Early Palaeozoic), are presented. A total of 160 hand samples from the Itajai, Castro and Bom Jardim Groups from southern Brazil were submitted to laboratory treatment. 46 acid volcanic samples from the Campo Alegre Formation (Itajai Group) yielded two magnetic components labelled A1 \((D_m = 36^\circ, I_m = -40^\circ, A_{95} = 10^\circ)\) and A2 \((D_m = 44^\circ, I_m = -8^\circ, A_{95} = 4^\circ)\) with respective palaeomagnetic poles CA \((223^\circ E, 57^\circ S, A_{95} = 9^\circ)\) and SV \((200^\circ E, 43^\circ S)\). 20 acid volcanic samples from the Castro Group yielded a single stable direction of magnetization \((D_m = 347^\circ, I_m = -52^\circ, A_{95} = 12^\circ)\) with palaeopole CT \((4^\circ E, 76^\circ S, A_{95} = 15^\circ)\). 12 acid samples from the Acampamento Velho Formation (Bom Jardim Group) yielded two magnetic components labelled B1 \((D_m = 156^\circ, I_m = 69^\circ, A_{95} = 17^\circ)\) and B2 \((D_m = 207^\circ, I_m = -15^\circ, A_{95} = 42^\circ)\) with respective palaeopoles AV1 \((338^\circ E, 61^\circ S, A_{95} = 28^\circ)\) and AV2 \((343^\circ E, 44^\circ N, A_{95} = 37^\circ)\). Seven sedimentary samples from the Vargas Formation (Bom Jardim Group) yielded a magnetic component \((D_m = 108^\circ, I_m = -4^\circ, A_{95} = 12^\circ)\) with palaeopole HI \((228^\circ E, 14^\circ N, A_{95} = 9^\circ)\). These results are compared with APWP's constructed for the Gondwana Continents.

Key words: Brasiliano cycle, palaeomagnetic poles, APW path, Gondwana

1 INTRODUCTION
The South American platform comprises most of the South African continent. Its western margin has been reworked by tectono-orogenic processes of the Andean chain. The northern and the eastern margins are covered by the Atlantic Ocean and the southern part borders the Patagonia platform which was consolidated at the end of the Palaeozoic (Almeida, Hasui & Brito Neves 1976).

The stratigraphic, metamorphic and magmatic evolution of the South American platform shows that the fold belts which developed during upper Proterozoic and Lower Palaeozoic represent the final geosynclinal folding (Almeida et al. 1981). After this phase, the platform was stable until the Mesozoic reactivation which is related to the opening of the South Atlantic, with strong volcanic activity and high rates of sedimentation, especially along the Atlantic continental margin.

The southeastern region of the platform contains the Ribeira and Dom Feliciano fold belts which were formed in the last cratonic cycle during the Late Proterozoic and Early Palaeozoic corresponding to the Brasiliano–Pan-African orogenic cycle. Cordani & Brito Neves (1982) attribute an ensialic nature to the Ribeira belt whereas the Dom Feliciano belt would have been created by a magmatic arch.

The Dom Feliciano, Gariep and Coastal Damara belts are all part of the same geotectonic unit in a pre-drift reconstruction. Several authors such as Ribeiro & Fantinel (1978), Porada (1979) and Fragoso Cesar, Wernick & Soliani Jr (1982b), consider that this geotectonic unit is associated to a plate tectonic process with the formation of a proto-South Atlantic, though with some differences in detail.

Several volcano-sedimentary sequences associated with these geotectonic units have been studied palaeomagnetically with the object of obtaining data which might help clarify the geotectonic interpretations and provide palaeomagnetic poles to improve the definition of the South American APWP.

2 GEOLOGICAL SETTING
Several volcano-sedimentary sequences were formed in the southeastern part of the South American platform at the end of the Brasiliano cycle: in Paraná State, the Castro Group covers an area of about 900 km² (Trein & Fück 1967) with intercalating sedimentary and volcanic (acid to intermediate) sequences which have been dated by Rb/Sr at
425 Ma (Cordani, Halperrn & Berenholc 1974). In Santa Catarina State, volcano-sedimentary sequences are found in the Corupá Graben and in the Campo Alegre and Itajai Basins and they have been called the Itajai Group by Schulz Jr., Albuquerque & Giffoni (1969), who subdivided it, from youngest to oldest, into the Bau Formation which is composed of lithified conglomerates, the Campo Alegre Formation which is composed of rhyolite flows and dykes and tuff sediments and the Garcia Formation which comprises siltstones, sandstones, shales and conglomerate sandstones. Several datings have been effected for the Itajai Group units, such as K/Ar dates of 430 and 460 Ma (Ebert 1971) and a Rb/Sr date of 585 Ma (Teixeira 1982) for the Campo Alegre acid lavas. Volcano-sedimentary sequences of similar age outcrop also in the State of Rio Grande do Sul. Ribeiro & Lichtenberg (1978) placed the whole sequence in the Bom Jardim Group, which consists of the Maricá Formation, a basal unit with arkoses, sandstones and conglomerates lying discordantly over the basement rocks; the Vargas Formation which consists of clastic rocks of tectonic origin and the volcanic Hilário Formation which consists of basalts, andesites, dacites, rhyolites and intercalations of sediments, overlie the Maricá Formation. K/Ar dating of andesites yielded minimum ages between 495 and 560 Myr (Minioli & Kawashita 1971), but granite batholiths, which cut the Vargas and Hilário Formations, yielded Rb/Sr ages of 610 Myr which would place them in the Upper Pre-Cambrian. Fragoso Cesar et al. (1982a) concluded that these units were formed between 700 and 600 Ma. The Acampamento Velho Formation, which overlies older rocks, is an association of volcanites with composition ranging from rhyolites to dacites, tuffs, lavas, sandstones and volcanic conglomerates and it has yielded K/Ar ages of 504 and 530 Myr (Minioli & Kawashita 1971). A Rb/Sr isochron with age corresponding to 520 Ma has been found for the Acampamento Velho acid rocks and post-tectonic granitic intrusions (São Sepé and Ramada Granites) by Cordani et al. (1974).

3 SAMPLING AND EXPERIMENTAL PROCEDURE

Both magnetic and sun compasses were used to orientate a total of 160 sample-blocks from Itajai, Castro and Bom Jardim Groups from sites shown in Fig. 1. Particulars of sampling sites (which were generally quarries and roadcuts) are illustrated in Table 1. Site CA-III, within the Campo Alegre Formation, is a quarry which is cut by a vertical rhyolite dyke 35 cm wide which has been sampled. For the Vargas Formation, each sedimentary sample represents a stratigraphic level.

Generally four specimens were cut from each rock sample, making a total of 640 which were measured with a spinner magnetometer. Samples were submitted to AF and thermal demagnetization and practically all the specimens, especially those from the Bom Jardim Group, were given a complete pilot treatment.

Magnetizations were analysed with the aid of stereonets, Zijderveld diagrams and intensity curves. Fisher's statistics were used for calculating mean values and precision parameters.

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**Figure 1.** Sampling sites within the Itajai (1), Castro (2) and Bom Jardim (3) Groups. (a) simplified version of the northeast region of Santa Catarina state and east of Paraná State after Schobbenhaus Filho (1974). The sampling sites (number 1 in the situation map) are indicated by full circles. (b) Simplified version of the geological map of the Castro region in Paraná State, after Trien & Fück (1967). The sampling sites (number 2 in the situation map) are indicated by full circles. (c) Simplified version of the geological map of Caçapava do Sul region, after Santos et al. (1978). The sampling sites (number 3 in the situation map) are indicated by full circles.
4 PALAEOMAGNETIC RESULTS

4.1 Campo Alegre Formation

The palaeomagnetic results can be classified into two groups: (i) conclusive results could not be obtained from 26 samples collected from road cuts along BR470 (sites CA-VI, CA-VII and CA-VIII), since they showed unstable behaviour; (ii) stable magnetizations were recorded by samples from sites CA-I to CA-V which are located close to the town of Campo Alegre and all these samples were treated by AF demagnetization in fields of 20–30 mT followed by thermal demagnetization at temperatures up to 680°C. Fig. 3a shows the NRM directions of samples from the latter group which are distributed around the present dipole field direction. The polarity of samples from site CA-I became inverted during the thermal treatment as illustrated in Fig. 2a in which a stable direction was obtained between 200°C and 550°C. Most of the samples from the other sites showed a stable northeastern magnetization direction with negative inclination: examples are illustrated in Fig. 2. The main magnetic carriers were identified as magnetite and also in most cases hematite.

Some samples from site CA-III (Fig. 2c) showed three magnetic components which we call (A1, A2 and A3). Component A3 was practically eliminated at 300°C and is probably a viscous magnetization. The second component (A2) which was apparent until 600–620°C was obtained by vector subtraction, typically for temperatures of 500–600°C. The third direction (A1) is isolated at the highest demagnetization temperatures. Demagnetization curves indicate that the magnetic carriers of the components A2 and A1 are magnetite and hematite, respectively. Probably component A2 has been caused by the heating associated with the intrusion of a vertical rhyolite dyke which cuts the outcrop since samples farther away from the dyke presented only component A1. Unfortunately samples from the dyke itself were magnetically unstable so that it was impossible to identify a characteristic direction.

Figures 3c and 4 show sample and site mean CARM directions, respectively, for the Campo Alegre Formation. Site CA-IV yielded two groups of directions according to the magnetic behaviour of the samples which are labelled IV-a and IV-b. Component A2 (Fig. 3b), found by vector subtraction is also indicated in Fig. 4. All the palaeomagnetic results are summarized in Table 2.

4.2 Castro Group

The 22 samples from this group were treated in a similar manner to those from the Campo Alegre Formation as illustrated in Fig. 5.

Figure 6 shows the sample mean directions before and after thermal treatment. The results of the different treatments are summarized in Table 3. All the samples from site CA-I showed a stable northeastern magnetization direction with negative inclinations: examples are illustrated in Fig. 2. The main magnetic carriers were identified as magnetite and also in most cases hematite. Some samples from site CA-III (Fig. 2c) showed three magnetic components which we call (A1, A2 and A3). Component A3 was practically eliminated at 300°C and is probably a viscous magnetization. The second component (A2) which was apparent until 600–620°C was obtained by vector subtraction, typically for temperatures of 500–600°C. The third direction (A1) is isolated at the highest demagnetization temperatures. Demagnetization curves indicate that the magnetic carriers of the components A2 and A1 are magnetite and hematite, respectively. Probably component A2 has been caused by the heating associated with the intrusion of a vertical rhyolite dyke which cuts the outcrop since samples farther away from the dyke presented only component A1. Unfortunately samples from the dyke itself were magnetically unstable so that it was impossible to identify a characteristic direction.

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Figure 2. Examples of the magnetic treatment for the Campo Alegre Formation. (a) sample CA-2-A2/site CA-I; (b) CA-10-B1/CA-II; (c) CA-32-B1/CA-III. The Zijderveld diagrams (left side—open (full) circles are vertical (horizontal) projections). Wulff stereographic projection of the magnetization directions during treatment (top/right—open (full) circles are negative (positive) inclinations) and normalized intensity curve (bottom/right) are shown for each sample.

Table 1. Particulars of sampling sites.

<table>
<thead>
<tr>
<th>SITES</th>
<th>FORMATION/GROUP</th>
<th>LITHOLOGY</th>
</tr>
</thead>
<tbody>
<tr>
<td>CA-I</td>
<td>CA-IV</td>
<td>RAMADA GRANITE</td>
</tr>
<tr>
<td>CT-I</td>
<td>CT-IV</td>
<td>CASTRO RHYOLITE</td>
</tr>
<tr>
<td>RG-I</td>
<td>AC. VELO/BOM JARDIM RHYOLITE</td>
<td></td>
</tr>
<tr>
<td>RG-IV</td>
<td>AC. VELO/BOM JARDIM NYLONITE</td>
<td></td>
</tr>
<tr>
<td>BG-V</td>
<td>HILARIN/BOM JARDIM ANDESITE</td>
<td></td>
</tr>
<tr>
<td>MG-VII</td>
<td>BOM JARDIM ANDESITE</td>
<td></td>
</tr>
<tr>
<td>MG-IX</td>
<td>BOM JARDIM SANDSTONE</td>
<td></td>
</tr>
<tr>
<td>MG-X</td>
<td>BOM JARDIM SANDSTONE</td>
<td></td>
</tr>
<tr>
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</tr>
<tr>
<td>MG-XII</td>
<td>BOM JARDIM ANDESITE</td>
<td></td>
</tr>
</tbody>
</table>

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after cleaning for the four sites from the Castro Group while Table 2 summarizes the palaeomagnetic results. Since the total number of sites is only four it is probable that the secular variation has not been completely eliminated.

4.3 Bom Jardim Group

All samples from this Group were submitted to detailed cleaning and AF followed by thermal treatment was found to be the most effective.

4.3.1 Acampamento velho Formation—Bom Jardim Group

The twelve rhyolite and ignimbrite samples measured did not behave uniformly when submitted to AF and thermal treatment as illustrated in Fig. 7.

Sample RG-6-A1 (Fig. 7a) presented two components with negative inclinations: component B1 has steep inclinations while another component B2 has inclinations around 20°. Both of these components were found only for site RG-II: all the other sites revealed only one of these
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Figure 3. Sample mean directions for the Campo Alegre Formation. (a) Natural Remanent Magnetization (NRM); (b) A2 component found for site Ca-111 after treatment; (c) A1 component found for all sites after treatment. Open (full) circles are negative (positive) inclinations. The symbols * and CB are the present geomagnetic field and the dipolar field, respectively.

Figure 4. Site mean directions for the Campo Alegre Formation. Symbol © is the mean of site directions. Site 1 is of inverse polarity. Conventions as in Fig. 3.

Table 2. Summary of palaeomagnetic results.

<table>
<thead>
<tr>
<th>Site</th>
<th>Number of Sites</th>
<th>Number of Samples (disks)</th>
<th>Mean Declination (°)</th>
<th>Mean Inclination (°)</th>
<th>Cone of Confidence (P=0.05)</th>
<th>Precision Parameter (K)</th>
<th>Latitude (S)</th>
<th>Longitude (E)</th>
<th>Palaeomagnetic Pole</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>(a) Campo Alegre F. - Itajai Group (Age: 1.3 Ga; Rb/Sr: 580Ma)</td>
<td>46</td>
<td>10</td>
<td>34</td>
<td>7</td>
<td>13</td>
<td>1</td>
<td>33</td>
<td>7</td>
<td>WV</td>
<td></td>
</tr>
<tr>
<td>(b) Castro Group (Age: Rb/Sr: 430Ma)</td>
<td>8</td>
<td>2</td>
<td>4</td>
<td>8</td>
<td>2</td>
<td>2</td>
<td>35</td>
<td>2</td>
<td>WV</td>
<td></td>
</tr>
<tr>
<td>(c) Acampamento Velho F. - Bom Jardim G. (Age: 1.3 Ga; Rb/Sr: 580Ma)</td>
<td>13</td>
<td>3</td>
<td>2</td>
<td>4</td>
<td>3</td>
<td>3</td>
<td>31</td>
<td>3</td>
<td>WV</td>
<td></td>
</tr>
<tr>
<td>(d) Vargas F. - Bom Jardim Group (Age: 600-700Ma)</td>
<td>3</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>28</td>
<td>2</td>
<td>WV</td>
<td></td>
</tr>
<tr>
<td>(e) Hildoro F. - Bom Jardim Group (Age: 600-700Ma)</td>
<td>8</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>30</td>
<td>2</td>
<td>WV</td>
<td></td>
</tr>
</tbody>
</table>

Components, with either negative or positive inclination. Samples in Fig. 7b and c illustrate respectively the presence of components B1 and B2. However, one sample with a stable direction different from both B1 and B2 was discarded from the mean and one sample behaved unstably.

The three Ramada granite samples were submitted to AF followed by thermal treatment and yielded a stable direction with positive inclination which was similar to component B1, see Fig. 7d.

Figure 8 shows the sample mean directions before and after cleaning and Table 2 summarizes all the results from the Acampamento Velho Formation, including the Ramada Granite samples. The components B1 and B2 yielded respective palaeomagnetic poles labelled AV1 and AV2 in Table 2. For the Acampamento Velho Formation, the number of sites may not have been sufficient to average out palaeosecular variations.

4.3.2 Vargas Formation—Bom Jardim Group

Almost all ten samples taken from this Formation yielded a stable eastern remanent magnetization with positive inclination (Fig. 9) after AF, thermal and mixed treatment, though they exhibited varied reactions to demagnetization, even for specimens from the same sample.

Figure 10 shows the sample mean directions before and after treatment and the palaeomagnetic results are presented in Table 2, except for three samples showing a different behaviour.

4.3.3 Hildoro Formation—Bom Jardim Group

The results from the 37 samples from this Formation have been divided into two groups. The first corresponds to 12 samples collected near to the town of Lavras do Sul: three samples from site RG-XVII presented good magnetic stability as illustrated for specimen RG-61-B2 in Fig. 11a while the other samples were rather unstable. Even so it was
possible to isolate a characteristic component in all samples (except one) which is coherent with that found for samples from site RG-XVII. See Fig. 11b for typical result.

Figure 12 shows the sample mean directions before and after treatment and Table 2 summarizes the palaeomagnetic results.

The second group, comprises 25 samples collected close to the town of Caçapava do Sul (sites V, VI, IX, X, XII, XIII and XIV in Fig. 1c). This Group presented stable magnetization which however showed between-site incoherences which can probably be attributed to unidentified tectonic movements: the structural correction was doubtful.
5 DISCUSSION

5.1 Gondwana results

Although the main longer term objective of our work is to present new palaeomagnetic data to improve the definition of South American Early Palaeozoic and Late Pre-Cambrian apparent polar wander path, it is difficult to relate our new results to already published data for South America because these are still scarce and of unsatisfactory quality.

However, the palaeomagnetic data indicate that Gondwana existed as a single continent from 720 Ma to the Cretaceous era (McElhinny & Embleton 1976) and possibly back to 1000 Ma (Vilas & Valencia 1978) and we may form a larger body of data by considering also newer palaeomagnetic results for the Gondwana. All these data, with ages ranging from Late Pre-Cambrian to Cambrian, have been assembled by Kröner et al. (1980), McWilliams & Kröner (1981) and McWilliams & McElhinny (1980) who identified separate APWP's for Africa and Australia for certain time intervals. Furthermore, McWilliams (1981) has shown that APWP's for west Gondwana (South America and Africa) and East Gondwana (Australia, India and Antarctica) are quite different although they seem to coincide for Early Palaeozoic. A comparison of our new data with African data is also supported by the demonstration by Torquato & Cordani (1981), using geochronological data, that many of the largest linear fault zones of Palaeozoic-Proterozoic age can be traced through the South America–Africa margin in a pre-drift reconstruction.

It has already been stressed that the Dom Feliciano fold belt from the South American side and the Gariep and Coastal Damara belts from the African side are part of the same geotectonic unit on a pre-drift map and they have been interpreted in a plate tectonic framework with the formation

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Figure 6. Sample mean NRM directions (a) and characteristic remanent magnetization directions after treatment (b) for the Castro Group. Conventions as in Fig. 3. Directions in parentheses were discarded from the mean.

Figure 7. Examples of results of magnetic cleaning of samples from the Acampamento Velho Formation. (a) sample RG-6-A1/site RG-II; (b) RG-9-B2/RG-III; (c) RG-11-B2/RG-III; (d) RG-2-B1/RG-I. Wulff stereographic projection of magnetization directions during the treatment (left) and normalized curve (right) are shown. Open (full) circles are negative (positive) inclinations.
of a proto-South Atlantic (Fragoso Cesar et al. 1982a,b; Porada 1979). Such an interpretation, however, does not invalidate our combination of South American and South African data since the Formations studied here correspond to the final stage of the geotectonic cycle (Fragoso Cesar et al. 1982a,b) during which the proto-South Atlantic ocean would already have been closed up.

In Fig. 13, poles obtained in this study (see Table 2) have been rotated to Africa and plotted against the background of the APW curve for Southern Africa proposed by McWilliams & Kröner (1981) for the interval 900–470 Ma. It is convenient to comment upon the various poles separately.
Figure 8. Sample mean NRM directions (a) and CARM directions of the B1 component (b) and B2 component (c) for the Acampamento Velho Formation. Conventions as in Fig. 3.

Figure 10. Vargas Formation: sample mean NRM directions (a) and characteristic remanent magnetization directions obtained after treatment (b). Conventions as in Fig. 3.

Figure 9. Example of the magnetic treatment for the Vargas Formation. Sample RG-24-A/site RG-VII. Commentaries and conventions as in Fig. 7.
5.2 Results from the Campo Alegre Formation—CA and SV poles

This Formation has yielded the most reliable palaeomagnetic results. Component A1 which is well defined is interpreted as corresponding with the primary direction for this Formation whereas component A2 is identified with the thermal effect of a rhyolite dyke at one of the outcrops. If this interpretation is correct, an inspection of Fig. 13 could suggest an Ordovician age for the antipole SV (component A2—Table 2) and an age of 650 Myr for the pole CA (component A1—Table 2). The Rb/Sr age of 585 Myr obtained for the Campo Alegre acid volcanics is less than the palaeomagnetic age.

The pole for A1 component is in agreement with the Cambrian South American poles as the Campanário do Sul (South of Tilcara and North of Tilcara, Creer 1970) and the dyke swarm of the Sobral region, Ceará State (565 Ma, Guerreiro & Sial 1982).

5.3 Castro Group—CT pole

Pole CT (Table 2) has been found for the Castro Group. Two possible interpretations of this direction must be considered. The first is that this direction represents a secondary component, probably of chemical origin since the APWP's constructed for the Gondwana (Upper Palaeozoic) suggest an Upper Carboniferous age for it. The Castro Group is cut by many basic dykes of Cretaceous age, Fig. 1b (Trein & Fuck 1967), but this age would be much younger than that inferred from the palaeomagnetic results.

The second interpretation is that this direction represents
the origin of the magmatic event. Inspection of Fig. 13 suggests an age of 600 Myr for pole CT, which is older than the radiometric age (425 Myr).

The acid volcanic units which outcrop in the southeast region of the South American platform (Campo Alegre Formation, Castro Group, Acampamento Velho Formation), occurred in the same phase of the Brasiliano cycle, and similar ages for these volcanic episodes (between 500 and 600 Myr) cannot be disregarded. This question is discussed in more detail in a separate publication in which a palaeomagnetic age slightly younger for the CT pole (570 Myr) is suggested.

5.4 Acampamento Velho Formation—AV1 and AV2 poles

Two components of magnetization B1 and B2 have been identified. The laboratory work (see Fig. 7), showed that the component B2 has the higher blocking temperatures (sample RG-6-A1; Fig. 7a) and therefore would be considered of older age, if both components are of thermal origin. However, three samples of the Ramada Granite, of the same age (520 Myr), yielded a magnetization direction, that resembles the component B1. Therefore, if this is the primary magnetization of the Ramada Granite, then component B1 must be older than component B2.

Figure 13 shows that the AV1 pole (B1 component) lies close to the CT pole determined for the Castro Group. However, as for the Castro Group, this figure suggests an age for this component older than the radiometric age (520 Myr).

Comparison of the AV2 pole (B2 component) with the curve of Fig. 13, suggests an age slightly older than that inferred for the VGP (SV) found for the Campo Alegre samples (A2 component).

5.5 Vargas Formation—VA pole

After magnetic treatment, it was possible to isolate a characteristic direction for almost all samples of Vargas Formation which led to the VA pole presented on Table 2.

Fragoso Cesar et al. (1982a) have suggested, from geological evidences, an Upper Pre-Cambrian age for the Vargas Formation lithologies, which are older than the other units already described (Castro Group—CT pole, Campo Alegre Formation—CA pole, Acampamento Velho Formation—AV1 pole). However, the position of the VA pole related to the curve of Fig. 13 suggests a secondary origin for this component.

An yet younger age (Devonian) may be possible if the VA pole is compared with the Middle-Upper Palaeozoic Gondwana APWP's.

5.6 Hilário Formation—Hi pole

The andesitic samples from Lavras do Sul region, after thermal treatment, presented only one direction of magnetization, which led to the Hi pole of Table 2.

Fragoso Cesar et al. (1982a) have studied samples of Vargas Formation lithologies, which are older than the other units already described (Castro Group—CT pole, Campo Alegre Formation—CA pole, Acampamento Velho Formation—AV1 pole). However, the position of the VA pole related to the curve of Fig. 13 suggests a secondary origin for this component.

An yet younger age (Devonian) may be possible if the VA pole is compared with the Middle-Upper Palaeozoic Gondwana APWP's.

6 CONCLUSIONS

This article presents palaeomagnetic results for several geological units related with the Brasiliano–Pan-African cycle.

A characteristic remanent magnetization from almost all studied units has been obtained, but it was not possible to construct an APWP from these results alone. They may however be compared with an APWP constructed for southern Africa in which case either a secondary origin for the component analysed or an age older than that of the radiometric age must be inferred. An analysis of this path is
being published elsewhere and a slightly modified path (based on coherent motions of the South America–Africa continent) is proposed which improves the agreement of the present poles.

The difficulty of interpretation may be associated with local rotational movements around vertical axes and palaeolatitudinal movements of sub-blocks, as suggested by Irving & McGlynn (1981) who argued that it is practically impossible to construct an APWP from geological units that were affected by plate tectonics such as those of the Western Cordillera of North America.

Most of the samples from this work were collected near the border of the Dom Feliciano belt and probably were affected intensively by plate tectonics. Otherwise, the samples from the Campo Alegre basin are situated far from this tectonic site, and this possibly explains why the best results were obtained for the Campo Alegre Formation.

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