RE-APPRAISAL OF THE SANTA RITA GREENSTONE BELT STRATIGRAPHY, CENTRAL BRAZIL, BASED ON NEW U-PB SHRIMP AGE AND SM-ND DATA OF FELSIC METAVOLCANIC ROCKS

ABSTRACT The Santa Rita greenstone belt represents one of the supracrustal belts of the Archaean terranes of Goiás, central Brazil. The stratigraphic sequence of this greenstone belt comprises a lower unit made of komatiites and basalts and an upper metasedimentary unit made of carbonate schist, chert, iron formation and marble, unconformably overlain by clastic metasedimentary rocks. Felsic metavolcanics occur at the interface between the metabasalts and the upper metasedimentary pile. U-Pb SHRIMP age for zircons from the felsic metavolcanics reveal that it is not part of the Archaean sequence, but represents the product of a Mesoproterozoic (1580 ± 12 Ma) magmatic event. Sm-Nd isotopic data (initial eCHUR values between -10.5 and –14.9) and TDM values of 3.0 and 3.2 Ga, within the range of the surrounding TTG terranes, indicate that the original felsic magmas were produced by re-melting of Archaean crust. The data demonstrate that the Goiás greenstone belt contains infolded and imbricated Proterozoic rocks, as previously suggested by Sm-Nd isotopic analyses of some of the upper detrital metasedimentary rocks.

Keywords: Goiás, Greenstone Belts, U-Pb SHRIMP, stratigraphy

INTRODUCTION The Santa Rita greenstone belt (Danni et al., 1981), or Goiás greenstone belt of Resende et al. (1998), is one of the low grade metamorphic supracrustal rock assemblages of the Archaean terranes of Goiás, central Brazil (Fig. 1). It is approximately 63 km long and, in average, 7 km wide. It consists of a large N50°-70°W trending syncline (Fig. 2) confined between the Caiaçara and Uvá granitoid complexes (Jost et al. 2000). To the northwest, it is in contact with the Faina greenstone belt by a northeast-trending strike-slip fault. To the southeast, Paleoproterozoic metasedimentary rocks overthrust the Santa Rita belt.

The stratigraphic sequence of the belt (Fig. 2) consists of lower metakomatiites followed by tholeiitic metabasalts, and an upper metasedimentary package including, from base to top, carbonate schists, chert, iron formation and marble, unconformably overlying metavolcanics. For almost two decades (see, for example, Danni et al., 1981), a dacitic volcanic center has been traditionally interpreted as part of the stratigraphic sequence. The aim of this paper is to show, based on U-Pb SHRIMP age of zircons, that the felsic metavolcanics do not belong to the Archaean supracrustal sequence, but to a so far unknown Mesoproterozoic volcanic episode.

PREVIOUS STRATIGRAPHIC NOMENCLATURE Danni et al. (1981) first interpreted the Santa Rita greenstone belt as consisting of Archaean supracrustal rocks (Serra de Santa Rita Sequence), overlain by Proterozoic metasedimentary rocks (Serra do Cantagalo Sequence). The Serra de Santa Rita Sequence was further subdivided into a lower unit consisting of ultramafic metavolcanics, an intermediate unit of mafic and felsic metavolcanic rocks, and an upper unit of metasedimentary rocks. The Serra do Cantagalo Sequence was described as consisting of metaconglomerates and quartzites overlain by metapelites and banded iron formations. The presence of clasts of mafic and ultramafic rocks in the metaconglomerates supported the conclusion that the source area is the underlying Archaean rocks. The Serra do Cantagalo Sequence would then rest on the greenstone belt by means of an erosional unconformity.

Teixeira (1981) suggested that the rocks of the greenstone belt should be considered as the Goiás Velho Group. The group was informally subdivided into a basal unit (ultramafic metavolcanics), an intermediate unit (mafic and felsic metavolcanics), and an upper unit (metasedimentary rocks), which included the Serra do Cantagalo Sequence of Danni et al. (1981). Later, Tomazzoli (1985) and Tomazzoli & Nilson (1986) subdivided the Goiás Velho Group into three units. The basal or lower ultramafic unit consists of metakomatiites with local spinifex texture and intercalations of iron-rich metachert, graphitic phyllite, and metapelites. The intermediate or basic unit consists of mafic and ultramafic rocks and felsic metatuffs with intercalations of metachert, graphitic phyllite, and metapelites. The upper or metasedimentary unit includes metapelites, locally graphitic, with minor metachert, banded iron formation, and marble. The authors included the Serra do Cantagalo Sequence into the upper unit, subdividing it into lower metaconglomerates, quartzites and metapelites, and upper metagraywackes with rhythmic intercalations of metapelite and quartzite.

Recently, Resende (1998) and Resende et al. (1998) put forward a formal stratigraphic nomenclature (Fig. 2) for the Santa Rita greenstone belt. Under this model, the lower metavolcanic rocks

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comprise the Serra de Santa Rita Group, subdivided, from base to top, into the Manoel Leocádio and Digo-Digo Formations. The former consists of about 600 m of metakomatiites with minor oxide-facies banded iron formations. The latter contains a lower and an upper member. The lower member (up to 1,000 m thick) consists of tholeiitic metabasalts with minor intercalations of banded iron formations and, towards the top, also carbonaceous schists. The upper member consists of about 200 m thick of felsic metatuffs with minor intercalations of metachert, locally rich in pyrite.

Tomazzoli (1985) and Resende et al. (1998) describe that the contact between the felsic metavolcanic rocks and the underlying metabasalts is gradational, and given by an approximately 100 m thick section with intercalations of rocks of both units. Resende et al. (1998) describe that the felsic volcanics are laterally interfingered with carbonaceous schists of the lower sections of the upper metasedimentary sequence. These arguments led to interpret the felsic volcanic rocks are an intimate part of the stratigraphic sequence of the Santa Rita greenstone belt. They would represent an eruptive event of the final stages of the basaltic volcanism and coeval with the onset of the upper sedimentary unit. Therefore, the Santa Rita greenstone belt volcanism was interpreted as typically bimodal, a feature not observed in any of the other Archaean belts of Goiás.

MAIN CHARACTERISTICS OF THE FELSIC METAVOLCANICS  The felsic metavolcanics occur as a ca. 5 km long lens, with a maximum width of 200 m, situated near the core of the Santa Rita greenstone belt synclinorium. They consist mostly of sericite-chlorite-quartz schists with relicts of original pyroclastic textures varying from recrystallized ash to coarse tuffs, including abundant layers with lapilli-size fragments. Their composition is dominantly dacitic with minor thin rhyolitic terms.

The metadacites contain millimetric plagioclase phenocrysts in a fine-grained groundmass of quartz, sericite, chlorite, and biotite. Microcline, magnetite, ilmenite, epidote, titanite, apatite, rutile are accessory, and zircon is rare. Leucoxene and carbonate are secondary minerals. In general, the lapilli fragments have the same mineralogical composition as the matrix.

U-Pb and Sm-Nd ISOTOPIC RESULTS  U-Pb analyses were carried out using the SHRIMP-II (Sensitive High Resolution Ion Microprobe) at the Research School of Earth Sciences of the Australian National University, Canberra. In order to assess the internal structure of the zircons, cathodoluminescence (CL) imaging of the zircon concentrates was carried out before isotopic analyses. The sample investigated (GOV-2) corresponds to a porphyritic metadacite. Zircons are pink and form euhedral prismatic crystals. CL images did not reveal obvious cores or overgrowths. Twelve spots were analyzed (Table 1) and nine analytical points plot close to the concordia curve defining the upper intercept age of 1580 ± 12 Ma (MSWD = 0.9) (Fig. 3). The spots analyzed correspond to parts of the crystals displaying thin zoning alternating high- and low-U areas, characteristic of magmatic zircons. This age is interpreted as the crystallization age of the original felsic volcanic rock.

Figure 2 – Detail of the Santa Rita greenstone belt in the vicinities of the felsic volcanic unit (modified from Promo 1993).

Figure 3 – Concordia diagram for sample GOV-2
Table 1 – Summary of SHRIMP U-Th-Pb zircon results of sample GOV-2

<table>
<thead>
<tr>
<th>Grain spot</th>
<th>U (ppm)</th>
<th>Th (ppm)</th>
<th>Th/U</th>
<th>206 Pb/238 U</th>
<th>εNd (T=1.58 Ga)</th>
<th>206 Pb/238 U</th>
<th>207 Pb/238 U</th>
<th>208 Pb/238 U</th>
<th>Radiogenic Ratios (in Ma)</th>
<th>Ages (Ma)</th>
</tr>
</thead>
<tbody>
<tr>
<td>GOV-2</td>
<td>3.810</td>
<td>18.21</td>
<td>0.198</td>
<td>0.511079(15)</td>
<td>3.21</td>
<td>-14.9</td>
<td></td>
<td></td>
<td>0.0091(10)</td>
<td>1.6644(10)</td>
</tr>
<tr>
<td>GOV-3</td>
<td>3.328</td>
<td>15.47</td>
<td>0.307</td>
<td>0.511416(26)</td>
<td>3.00</td>
<td>-10.5</td>
<td></td>
<td></td>
<td>0.0006(15)</td>
<td>1.6644(10)</td>
</tr>
</tbody>
</table>

1. Uncertainties given at the one σ level.
2. εNd (T) % denotes the percentage of 206 Pb that is common Pb.
3. Correction for common Pb made using the measured 204 Pb/206 Pb ratio.
4. For % Conc., 100% concordant a analysis.

Zircon 10.1 yielded a concordant analysis at 615 Ma (206 Pb/238 U age), indicating recrystallization during the Brasiliano/Pan-African orogeny. Two other analyses of one crystal also show the effect of the Neoproterozoic thermal event (spots 8.1 and 2.1 in Table 1). The high 206 Pb/207 Pb ratios of these analyses, however, render poorly defined 207 Pb/206 Pb ages of 600 and 546 Ma, respectively (Table 1). Brasilian zircons have also been found in orthogneisses of the surrounding TTG terranes in the Goiás and Crixás areas, demonstrating the influence of the Brasiliano/Pan-African thermal event (spots 6.1 and 2.1 in Table 1). The high 206 Pb/207 Pb ratios of the Goiás greenstone belt samples confirm that the Archaean terranes of Goiás are allochtonous with respect to the older rocks being overturned respectively to the younger ones. Additionally, Sm-Nd model ages (TDM) across the siliciclastic rock sequence of the upper stratigraphic units vary from 3.1 to 2.8 Ma. This contrasts with the 2.3 Ga Sm-Nd model age of the matrix of metagranulites of the Serra do Cantagalo Sequence, indicating that this indicates that this unit is not Archaean, but at the most, Palaeoproterozoic. These data, combined with the results of the present study, clearly indicate that the Santa Rita greenstone belt does not contain only Archaean supracrustal rocks, as previously inferred, but even Proterozoic supracrustal rocks as thrusted and imbricated slices. The detailed structural relationships between the younger and older rocks remain to be more clearly explained, but it probably happened during the Brasiliano deformation. Jost et al. (1996), Fortes (1996), Queiroz and Jost (1998) and Queiroz et al. (1999) describe similar situations in the greenstone belts in the northern section of the Archaean terranes of Goiás. This leads to the conclusion that the greenstone belts of Goiás underwent pronounced structural and stratigraphic modifications, with conspicuous mixing with rock units belonging to Paleo-, Meso- and Neoproterozoic event, raising enormous difficulties in unraveling the original Archaean sequences.

Table 2 – Sm-Nd isotopic results of felsic metavolcanics of the Santa Rita greenstone belt

<table>
<thead>
<tr>
<th>Sample</th>
<th>Sm(ppm)</th>
<th>Nd(ppm)</th>
<th>143Sm/144Nd(150)</th>
<th>147Sm/144Nd</th>
<th>εNd(T=1.58 Ga)</th>
</tr>
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<tbody>
<tr>
<td>GOV-2</td>
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</tbody>
</table>

Figure 4 – Nd isotopic composition of the felsic metavolcanic rocks.
respect to the tectonic evolution of the Brasília Belt, being accreted to its western margin towards the end of the Neoproterozoic.

Acknowledgements To Conselho Nacional de Desenvolvimento Científico e Tecnológico – CNPq for a Research Grant to H. Jost (Proc. n° 35.1597/97-2), and for funding part of the field works (Proc. n° 52.0682/94), to two anonymous referees of RBG for their critical review of the manuscript and helpful suggestions, To FAP-DF (Proc. N° 193.000.068/96) and CAPES for funding field and laboratory work.

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Contribution IGC-176

Received March 8, 2000
Accepted for publication April 26, 2000