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EVIDENCE FOR MULTIPLE SOURCES INFERRED FROM Sr AND Nd ISOTOPIC DATA FROM FELSIC ROCKS IN THE SANTA CLARA INTRUSIVE SUITE, RONDÔNIA, BRAZIL

Leite Júnior, W.B.[1]; Bettencourt, J.S.[2] and Payolla, B.L.[3]

1. Instituto de Geociências e Ciências Exatas, UNESP, Av. 24A, 1515, 13506-900, Rio Claro-SP, Brazil. wleite@rc.unesp.br
2. Instituto de Geociências, USP, Rua do Lago, 562, Cidade Universitária, 05422-970, São Paulo-SP, Brazil. jsbetten@usp.br
3. Centrais Elétricas do Norte do Brasil S/A, SQN 408, Bloco L, Apto 202, 70856-120, Brasília-DF, Brazil. bruno@eln.gov.br

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INTRODUCTION

The Proterozoic rapakivi granites of the Rondônia tin province have been intensively studied in the last three decades. The studies were initially undertaken owing to the important tin deposits spatially associated with some rapakivi granite plutons, and have contributed to understanding the metallogeny of the rapakivi granites in general. More recently these studies have also shown that the rapakivi granites provide important constraints on the tectonic models of the southwestern margin of the Amazonian craton (see e.g. Bettencourt et al., 1987, 1999). The Santa Clara Intrusive Suite (SCIS) is one of the three youngest rapakivi granite suites that are spatially related to Sn-polymetallic deposits, and have been mapped in semi-detailed scales (1:50,000 and 1:25,000) (Leite Júnior, 2002). In this paper, we present Sr and Nd isotopic data from rocks of early- and late-stage intrusions of the SCIS, and the results indicate the involvement of different source regions during magma genesis.

THE SANTA CLARA INTRUSIVE SUITE

The SCIS (1.08 - 1.07 Ga, U-Pb zircon ages) comprises at least one large batholith (Santa Clara massif) as well as smaller batholiths and stocks (Oriente Velho, Oriente Novo, Manteiga-Sul, Manteiga-Norte, Jararaca, Carmelo, Primavera and das Antas massifs) emplaced in to older medium- to high-grade metamorphic rocks (1.75 - 1.43 Ga). The SCIS is composed of several early- and late-stage intrusions, which are presently exposed in different configurations around each batholith or stock (Fig. 1).

The early-stage intrusions are dominant and have been divided into two subgroups: (1) dominant metaluminous to slightly peraluminous subgroup (SiO_2= 63.56 - 75.59%; A/CNK= 0.94 - 1.04) composed of coarse- to medium-grained porphyritic hornblende-biotite quartz-monzonite, and biotite (± hornblende) monzogranite and syenogranite, showing rapakivi textures; and (2) minor and local peraluminous subgroup (SiO_2= 73.17 - 73.73%; A/CNK= 1.05 - 1.07) composed of porphyritic biotite syenogranite and muscovite-biotite microsyenogranite. The volumetrically smaller late-stage intrusions are also divided into two subgroups: (1) metaluminous to peralkaline subgroup (SiO_2= 48.61 - 73.98%; A/CNK= 0.79 - 0.98) composed of hornblende alkali-feldspar syenite and microsyenite, biotite alkali-feldspar quartz-microsyenite, biotite (± sodic amphibole) alkali-feldspar microgranite, trachyandesite, trachyte, and minor basalt; and (2) peraluminous subgroup (SiO_2= 75.03 - 79.74%; A/CNK= 0.96 - 1.15) composed of biotite alkali-feldspar granite, alaskite, Li-mica alkali-feldspar granite, and rhyolite porphyry. The early- and late-stage granites exhibit geochemical characteristics of A-type and within-plate granites, whereas the dominant early-stage rocks also show rapakivi affinities (Leite Júnior, 2002).

ANALYTICAL PROCEDURES AND RESULTS

The preparation of rock powders was carried out at the Laboratory of Geochemistry of the University of São Paulo State (UNESP) at Rio Claro, São Paulo, Brazil. Seven whole-rock Rb-Sr analyses were realized at the Geochronological Research Center of University of São Paulo (USP), São Paulo, Brazil. Ten additional Rb-Sr analyses were obtained from studies done by Priem et al. (1971, 1989). Seven whole-rock Sm-Nd analyses were performed at the Laboratory of Isotopic Geology of the Institute of Precambrian Geology and Geochronology, Russian Academy of Sciences (IPGG RAS) at St. Petersburg, Russia, and other three at the Laboratory of Geochronology of the University of Brasilia (UnB) at Brasilia, Brazil.

The Rb-Sr data for samples of the early-stage granites reveal relatively low Rb/Sr ratios (1.26 to 4.21). The best-fit line through six analytical points for the metaluminous to slightly peraluminous granites (MSWD = 0.23) yields an isochron age of 1075±70 Ma (Fig. 2a), which agrees within uncertainties, with U-Pb zircon age of ca. 1082 Ma (cf. Bettencourt et al., 1999). The high initial $^{87}Sr/^{86}Sr$ ratio of ca. 0.709 indicates the involvement of older crustal components in the magma genesis. Crustal contribution is also suggested for one sample of the peraluminous granites (Sr_0 = 0.708). In contrast, the Rb-Sr data of the late-stage rocks show relatively high Rb/Sr ratios (9.01 to 123.72), reflecting their more evolved geochemical character. The best-fit line through three analytical points for the metaluminous to peralkaline rocks (MSWD = 0.53) indicates an isochron age of 1013±15 Ma and initial $^{87}Sr/^{86}Sr$ ratio of ca. 0.707 (Fig. 2b). A concordant age is defined by a regression line based on four analytical points for the late-stage nous granites (1015±75 Ma), despite the higher initial $^{87}Sr/^{86}Sr$ ratio of ca. 0.770 (Fig. 2c). Altho ugh this ratio is poorlydefined (MSWD = 62) due mainly to the strongly evolved geochemical character of these peraluminous granites, the high value favors crustal sources for the parent magma.

The Sm-Nd data reveal distinct isotopic compositions for the four subgroups of rocks investigated. The early-stage metaluminous to slightly peraluminous granites show T_{DM} model ages of 1.66 to 1.85 Ga, and negative ε_{Nd} (1.08 Ga) values between -4.5 and -2.9, suggesting that original magma is the product of re-melting of older continental crust. In contrast, a more negative ε_{Nd} (1.08 Ga) value of -6.2 for the early-stage peraluminous granites indicates a much less radiogenic sialic material was involved in their genesis. The late-stage rocks are more radiogenic than the early-stage rocks. The two samples of metaluminous to peralkaline rocks analyzed show T_{DM} model age of 1.34 and 1.47 Ga, but yielding positive ε_{Nd} (1.07 Ga) values of +1.1 and +2.3, suggesting a dominant mantle source for the parent magma. Inversely, the two samples of late-stage peraluminous granites show older T_{DM} model ages (1.69 and 1.75 Ga) and negative ε_{Nd} (1.07 Ga) values of -1.2 and -2.1, suggesting that the original magma was derived mainly from an older crustal source.

DISCUSSION AND CONCLUSION

In spite of the high uncertainties, the Rb-Sr isochron age for the early-stage metaluminous to slightly peraluminous granites is consistent with the U-Pb zircon age, and the Rb-Sr isochron ages for the late-stage rocks confirm the simultaneous emplacement of these intrusions, although these ages are circa 60 Ma younger than the U-Pb zircon age of ca. 1074 Ma (cf. Bettencourt et al., 1999; Leite Júnior, 2002). The initial $^{87}Sr/^{86}Sr$ ratios, although poorly defined for the late-stages rocks, are relatively high, suggesting that the original magmas are melts derived from older continental crust.

The Nd isotopic characteristics of the early- and late-stage intrusions are shown in ε_{Nd} vs. age diagram (Fig. 3). The time-integrated evolution of the early-stage granites is in close agreement with the evolution of the felsic basement rocks. In addition, the Nd isotopic compositions of the metaluminous to slightly peraluminous granites [ε_{Nd} (1.08 Ga) = -2.9 to -4.5] overlap with those 1.57 - 1.53 Ga granitic and charnockitic rocks at 1.08 Ga [ε_{Nd} (1.08 Ga) = -3.4 to -4.0], whereas the Nd isotopic signatures of the peraluminous granites are less radiogenic [ε_{Nd} (1.08 Ga) = -6.2], and support a contribution of older metapelitic rocks [ε_{Nd} (1.08 Ga) = -8.9 and -9.0] exposed in the area (cf. Payolla et al., 2002). The late-stage intrusions are more radiogenic than early-stage intrusion [ε_{Nd} (1.07 Ga) $\geq$ -2.1]. The late-stage peraluminous granites lie either within or just slightly above felsic basement rocks evolution line at 1.07 Ga, more precisely the Nd isotopic composition of one sample [ε_{Nd} (1.07 Ga) = -2.1] overlap with those 1.43 Ga fine-grained granitic and charnockitic rocks at 1.07 Ga [ε_{Nd} (1.07 Ga) = -2.0 to -3.0] (cf. Payolla et al., 2002). On the other hand, the Nd isotopic compositions of the metaluminous to peralkaline rocks [ε_{Nd} (1.07 Ga) = +1.1 and +2.3] lie between estimates for depleted mantle and 1.75-1.43 Ga felsic basement rocks at 1.07 Ga.

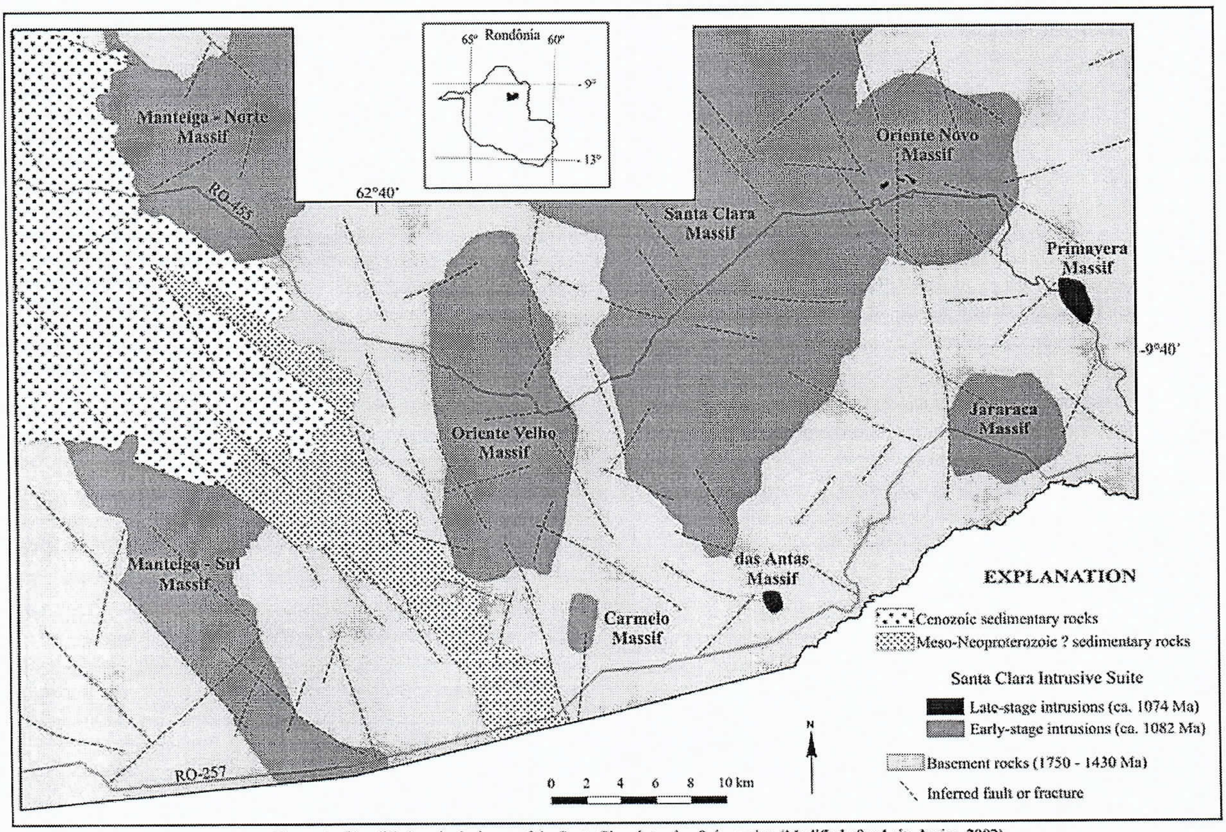

Figure 1 - Simplified geological map of the Santa Clara Intrusive Suite region (Modified after Leite Junior, 2002).

In conclusion, the Sr and Nd isotopic data for the early and late intrusions of the Santa Clara Intrusive Suite suggest different sources for the magmas of the four subgroups of rocks recognized in this suite. The early-stage intrusions seem to represent crustal anatectic melts, with the metaluminous to slightly peraluminous magmas originated mainly from re-melting of 1.57-1.53 Ga granitic and charnockitic rocks, whereas metapelitic rocks appear to be an important crustal component for the peraluminous magmas. The late-stage metaluminous to peralkaline rocks may be products of mantle-derived mafic magmas with minor crustal input, in contrast with the late-stage peraluminous magmas that may have originated from older crustal source with minor mantle input. It is interpreted that this source was the residue of the source from which the metaluminous to slightly peraluminous granites were previously extracted, although the 1.43 Ga fine-grained granitic and charnockitic rocks should not be ignored. Polymeta llic (Sn, W, Nb, Ta, Zn, Cu, Pb) primary deposits are spatially and temporally associated with these late-stage peraluminous granites.

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