ISGAM II

EXTENDED ABSTRACT AND PROGRAM

SALVADOR, BAHIA, BRAZIL - AUGUST 24-29, 1997

INTERNATIONAL SYMPOSIUM ON GRANITES AND ASSOCIATED MINERALIZATIONS

Tin-bearing granites of Brazil: a review

J.S. Bettencourt
Instituto de Geociências, USP, P.O.Box 11.348, CEP 05422-970, São Paulo, SP, Brazil.

Tin-bearing granites of Brazil range in age from 1.88 Ga to 0.5 Ga and are found within distinct anorogenic and postorogenic tectonic settings and environments such as: the Amazonian Craton (>2.2 to 1.0 Ga), the Proterozoic Uruaçu Fold Belt and Archean/Early Proterozoic basement of Central Brazil, the Neoproterozoic Ribeira and Don Feliciano orogens (0.8-0.5 Ga) at the south-western part of Brazil and, very rarely, in Archean cores. The sections of these belts deemed relevant to specialized granites and neighbouring tin deposits are the following:

Central Amazon Province (>2.2 Ga)

Subsolvus biotite alkali-feldspar granites and syenogranites which are characterized by high Nb, Sn, F, Be, Rb, Y of the Surucucus (1.58 Ga) and Mucajai (1.54 Ga) rapakivi suites are reported[1-3]. In the Surucucus plateau (indigeneous reserve) no detailed work has been done concerning the establishment of primary and secondary mineralization and spatial relationship to the tin-granites. Alluvium yielded a past production of 563 t/Sn and estimated resources are about 20,000 t/Sn content.

In the eastern block (Xingu basin), hololeucocratic subsolvus HHP biotite syenogranites and alkali-feldspar granites (often containing topaz, fluorite, allanite) associated with tin mineralization occur in the Antônio Vicente, Benedita, Velho Guilherme, Mocambo massifs[4]. The granites dated at 1874±130 Ma (Pb-Pb[5]) are bound to Archean terranes, were emplaced in a rift setting and have been affected by intense late to postmagmatic alteration processes and greisen type mineralization[6]. These granites are characterized by higher Rb/Sr, Rb/Ba, F/Cl and lower Zr/Rb, K/Rb and Th/U ratios than normal granites; also they exhibit very low CaO, MgO, Sr, Ba, Cl, B and strong negative europium anomaly[4]. Economic alluvial Sn-placers have been exploited since 1979 and have produced around 15,000 t/Sn - in concentrate. Reported measured reserves are estimated as 12.000 t/Sn content.

In the central block, Pitinga region, the major types of tin-bearing granites are related to the 1834 Ma Madeira and Água Boa rapakivi granites and important varieties are the following: (a) peralkalic albite granites, often containing cryolite, cassiterite, columbite-tantalite, characterized by high Na_2O, F, Rb, Zr, Sn, U, Y, Th, Li, Pb, Zn, Cs, Be contents, low SiO_2, CaO, P_2O_5, MgO, Ba, Sr contents, strong Eu anomalies and enrichment of HREE[7,8]; (b) sodic episyenite associated with the Água Boa Granite with siderophyllite, cholorite, cassiterite and fluorite, characterized by enrichment in Na_2O, Al_2O_3, Nb, Zr and depletion in SiO_2, K_2O, Rb and Y[9].
In the Pitinga Mine, Sn, F, Zr, Nb, Ta, Y, REE and Rb deposits occur associated with the highly fractionated cryolite Sn-bearing albite granite core of the Madeira Granite. Primary mineralization occur as disseminated and massive cryolite veins and pods restricted to the peralkalic albite granite nucleus facies and disseminated type only with cassiterite, xenotime and columbite-tantalite in the marginal oxidised peraluminous red facies as well as in the nucleus facies. The mine also has mineable ore enrichment, such as malacon, in deeply weathered laterite/saprolite profiles[7]. Measured resources are about 160,000 t/Sn content. In addition further resources of F, ZrO_2, Nb_2O_5+Ta_2O_5 and Y_3PO_4 have been delineated.

Along the border of the Central Amazonian and Rio Negro-Juruena provinces occur the 1.64-1.60 Ga Teles Pires Granitic Suite[10] with associated volcanics (felsic rhyolites, tuffs and ignimbrites) and alkalic rocks. Precise information about petrography, geochemistry and mineralization of this suite is scarce. Nevertheless subsolvus metaluminous or peraluminous alkali-feldspar granites, syenogranites, monzogranites and a few peralkalic-riebeckite granites are reported.

Sn, Nb, Ta with greisen zones and veins are associated with the subsolvus granites. Gold dissemination and gold quartz veins are linked to the latest phases of granitic porphyries of the 1.6-1.3 Ga period. The suite might be considered to be mostly an Au producer with subordinate Sn.

Rio Negro-Juruena (1.8 to 1.55 Ga)/Rondonian San Ignácio (1.45 to 1.3 Ga) Mobile Belts

In the Rondônia Tin Province (RTP) the tin-granites and associated important Sn, W, Nb, Ta, F, REE, topaz and beryl mineralizations are related to the latest phases of different rapakivi granite suites, with ages spanning from 1.34 to 0.99 Ga[11]. The major varieties of granites are lithium or fluorine-rich siderophyllite bearing syenogranites and alkali-feldspar granites of the 1.38-1.31 Ga suites, Li-photolithionite-albite leucogranite and topaz-siderophyllite albite rhyolite (ongonite), respectively, of the subalkalic and alkalic rapakivi suites breaketed at 1.08 to 1.0 Ga.

The syenogranites and alkali-feldspar granites are subalkalic, metaluminous to slightly peraluminous rocks and are characterized by high K_2O+Na_2O, FeO/MgO, Ga/Al, Zr, Y, Nb. The albite leucogranite and ongonite show an alkalic character and very high contents of Rb, Li, Sn[12]. They show the geochemical characteristics of A-type and within-plate granites. Styles of mineralization include cassiterite dissemination in the Li-mica leucogranite as well as in greisen bodies, stockworks of veinlets associated with greisen and quartz-veins, quartz-veins, quartz-vein swarms and breccias, whereas W occurs most of the time as wolframite in quartz veins. Pegmatite-bearing topaz and beryl are also common. In our opinion the present reserves and resources of Rondônia are still of the order of 100,000 t/Sn content at the operational cut-off grades. Also the (RTP) may be considered a main Sn producer though with subordinate Au.

Archean/Early Proterozoic and Mesoproterozoic fold belts, Central Brazil

Two distinct episodes of continental acid magmatism at ca 1770 Ma and 1600 Ma[13] are reported in the Goiás Tin Province, Central Brazil. The related anorogenic tin-bearing granites intrude the Archean/Early Proterozoic and Mesoproterozoic fold belts, in a rift tectonic sitting, and occur mostly in the Rio Tocantins and Rio Paraná sub-provinces[14]. Metaluminous to peraluminous late stage granites and evolved alkalic varieties are the predominant tin-specialized granites and are characterized by, enrichmentf in F, Sn, Rb, Y, Th, Nb, Ga, REE, high Ga/Al, Y/Nb, $(Ce/Yb)_N$ ratios and lower MgO/TiO_2 and Zr/Nb, which identify themselves as A-type granites[14].

Different types of Sn deposits are closely related to the younger biotite granite phases which also host some newly discovered In and Au-quartz vein occurrences[14]. Most of the Sn, Nb, Ta primary and alluvial deposits have been mined as "garimpos" (small workings) but major Sn mines are currently closed. Approximately 15,000 t/Sn in concentrate were produced. Official measured reserves for the whole province (in 1990) were estimated as 27,000 t/Sn content.

In - bearing wood tin cassiterite quartz veins associated with the 1774 - Ma meta-rhyolites at the base of the Espinhaço Supergroup have been described[20].

Brasiliano Cycle (0.8-0.5 Ga)

The most important tin-bearing granites are represented by the youngest intrusive phases of the post-orogenic 620-580 Ma rapakivi complexes of the Itu Rapakivi Province[15] or the Itu Belt (620-580 Ma)[16]. The fertile varieties are highly fractionated fluorite and topaz-bearing subalkalic and metaluminous to weakly peraluminous A-type granites varying from syenogranite to alkali-feldspar granite in composition[15,17]. The granites have low CaO, FeO, MgO, TiO_2 and high SiO_2, K_2O, Sn, F, Li, Rb and strong Eu anomaly compared to average low-Ca granites, which are typical features of specialized granites. Mineral deposits within the Ribeira Fold Belt include polymetallic Sn, W, Zn, Cu, Pb (Mo) mineralization. Greisen, quartz veins, greisenized host rocks and minor wrigllite skarn are associated with late-stage topaz-rich albite granites and syenogranites. Of economic importance are the complex Sn, W, Zn, Cu, Pb deposits, related to the latest topaz-rich muscovite albite granite of the Correas Massif.

Many additional W, Sn, Mo, Be, F greisen and vein-type styles of mineralization associated with alkalic A-type granites of ages breaketed between 647-550 Ma, though of minor economic significance, are also reported[18,19], among others.

References

1. Santos, J.O.S. & Pinheiro, S. da S., *I Symp. Amazônico, Public. Esp. n° 10*, Puerto Ayacucho, Venezuela, p.273-289 (1985)
2. Dall'Agnol *et al., Rev.Bras.Geoc.*, 17(4):382-403 (1987)
3. Fraga, L.M. & Reis, N.J., *IGCP-315, Belém. Symp.* Abs., p.31-32 (1995)
4. Dall'Agnol *et al., An.Acad.bras.Ci.*, 65(Supl.1), p.33-50 (1993)
5. Lafon, J.M. *et al., C.R.Acad.Sci.Paris*, 320:937-944 (1995).
6. Dall'Agnol, R., These. Université Paul Sabatier, Tolouse, France (1980)
7. Horbe, M.A. *et al., Jour. Geochem. Explor.*, 40:227-249 (1991)
8. Costi, H.T. *et al., IGCP-315*, Belém Symp.Exc.Guide, p.20-21 (1995)
9. Costi, H.T. *et al., IGCP-315*, Belém Symp. Exc. Guide, p.16 (1996)
10. Silva, G.H. et al., Projeto Radambrasil (eds.) Folha SC.21 - Juruena. Levantamento de Recursos Naturais, 20:21-116 (1980)
11. Bettencourt, J.S. *et al.*, In: Bettencourt, J.S. & Dall'Agnol, R. (eds.) Symp. Rapakivi Granites Rel. Rocks, Excurs. Guide, Belém, p.5-14 (1995)
12. Leite Jr., W.B. *et al.*, In: Sial, A.N. et al. (eds.) *Workshop Magmatismo Granítico e Mineralizações Associadas*, Resumos, Rio de Janeiro, p. (1993)
13. Pimentel, M.M. *et al., Precamb. Res.*, 52:321-335 (1991)
14. Botelho, N.F. *et al.*, In: Sial et al. (eds.) *Workshop Magmatismo Granítico e Mineralizações Associadas*, Resumos Expandidos, Rio de Janeiro, p.5-8. (1993)
15. Goraieb, C., Msc. thesis, IG/USP, Brazil (1995)
16. Wernick, E., *29th Intern.Geol.Cong., Abstracts*, v.2, p.563 (1992)
17. Borges, R., Ph D Dissert.- IGCE/UNESP, Brazil (1977)
18. Vlach, S.R.F. *et al., Anais do 36° Congr. Bras. Geol.* 4:1700-1711 (1990)
19. Castro, N.A.. *et al.*,. (This Symposium).
20. Kaul, P.F.T., Anais XXX Cong. Bras. Geol., SBG, v.6, p. 2815-2825 (1984)
21. Oga, D.P. & Botelho, N.F. (This symposium).