THE PROTEROZOIC GRANITE MASSIFS OF CAMPO FORMOSO AND CARNAIBA (BAHIA, BRAZIL) AND THEIR Be, Mo, W MINERALIZATIONS

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I. INTRODUCTION

The granite massifs of Campo Formoso and Carnaíba are located in the northern part of São Francisco Craton (Fig. 1a) and belong to a family of small to medium sized granitoids that include Miguel Calmon, Saúde, Jaguarari, Flamengo and Juazeiro plutons. Rb-Sr radiometric data indicate an age of 1.9 Ga, suggesting that the emplacement of these granitoids occurred during the Early Proterozoic, thus characterizing the Transamazonian phase (Torquato *et al.,* 1978). New field data are presented concerning the generation, emplacement and geological features of these two granites together with the associated Be, Mo, W mineralizations.

II. GEOLOGICAL FRAMEWORK OF THE GRANITES

The Campo Formoso and Carnaíba massifs intrude the volcano-sedimentary terranes of the Serra da Jacobina, apparently related to the Early Proterozoic (Couto *et al.,* 1978). This series is composed mainly by fuchsitic quartzites, pelitic schists, graywackes, amphibolites and chromitiferous ultrabasic bodies. The terranes exhibit a monoclinal structure dipping to the East and show successive imbrications with a western vergence. The imbricated structure is related to the thrusting of the series over a migmatic Archean basement along a "décollement" surface localized in the ultrabasic horizon.

Similar petrographic and structural features from the Campo Formoso and Carnaíba granite massifs provide evidence in favor of a common source and similar thermodynamic genesis conditions for the respective magmas.

III. CAMPO FORMOSO PLUTON

1. Geological and petrographic data

The pluton exhibits a concentric structure characterized by an outer muscovite-biotite leucocratic granite unit (γ_1) and a central biotite-muscovite mesocratic granite unit (γ_2) (Fig. 1a). Radar and field observations show a sharp contact between the two granitic units: in the northern part of the pluton, enclaves of γ_1 are encountered in γ_2 and along the contact, a γ_2 fine grained granite intrudes γ_1. A two-step intrusive mechanism is suggested for the emplacement of the two units.

The outer unit is composed of a light, coarse grained granite characterized by the abundance of muscovite crystals (1-3cm), and contain an assemblage of quartz, oligoclase, albite, microcline (I, II), biotite, allanite, zircon, apatite and opaques. The central unit presents the same mineralogical association but biotite predominates on muscovite. Structural relations permit the separation of two facies in γ_2:

– γ_{2a}, a medium to fine grained two-mica granite, observed in dykes or veins.

– γ_{2b}, an equigranular to porphyritic two-mica granite that forms the main facies of the central unit.

Furthermore, relatively small outcrops of muscovite granite appear within the two units as granitic intrusive dykes.

2. Aplopegmatites and deuteric-hydrothermal evolution

Aplopegmatites are well developed and sometimes form important dyke swarms in γ_2; they are characterized by an assemblage of K-feldspar, quartz, muscovite and garnet, sometimes with tourmaline and plagioclase. Locally, beryl, molybdenite and sulphides mineralizations are observed.

The deuteric-hydrothermal evolution of Campo Formoso pluton is characterized mainly by muscovitisation, greisenisation, episyenitisation and tourmalinisation phenomena.

Muscovitisation: Muscovite appears either in straight relationship with biotite or in isolated flakes. The problem of muscovitisation is very complex and field observation on γ_1 shows the presence of muscovite veinlet swarms inducing a huge muscovitisation in the granite.

These veinlets present a longitudinal extension varying from several centimeters to 3 or 4 meters; no significant distinction can be made between muscovite in the granite and in the veinlets. At the contact zone of the veinlets, the granite does not show any bleaching or alteration: this muscovitisation appears very different from greisenisation.

Locally, the muscovitisation is developed following magmatic planar structures, marked by the joining of muscovite crystals and feldspars phenocrysts, and formed during a plastic granitic deformation stage. This development seems to result from an early concentration of fluids closely associated with magma during the first stage of crystallisation. However, the muscovite veinlets can cross aplopegmatitic joins or sometimes dykes of γ_{2a}. These different chronologic relations appear to show a con-

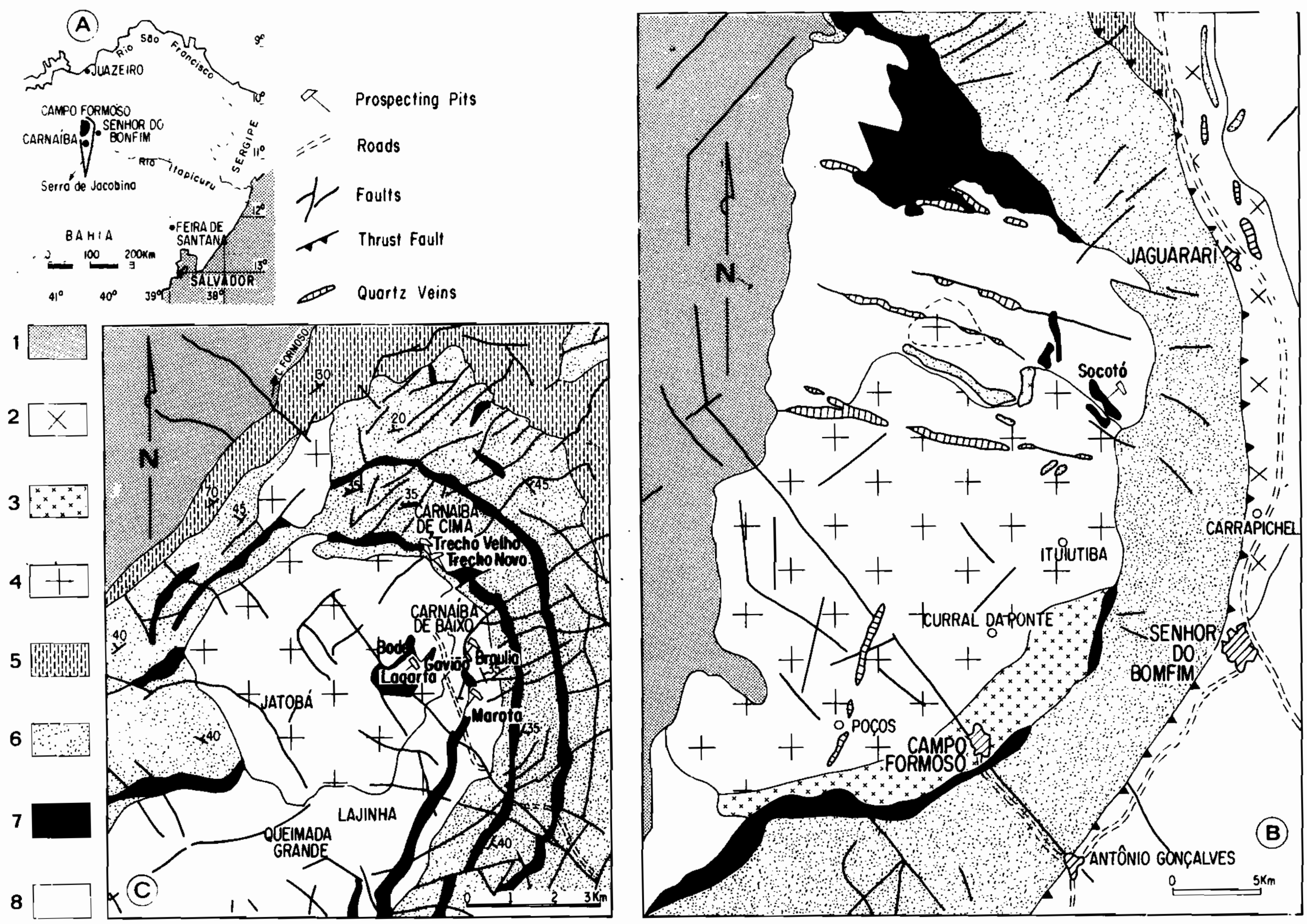

Figure 1.

Scheme of localisation of the granitic massifs; B and C Geologic skech maps of the Campo Formoso and Carnaíba granites. 1: Proterozoic superior cover; 2: Jaguarari granite; 3: Two-mica granite; 4: Porphyroid two-mica granite; 5: Chloritoschist phyllites; 6: Quartzites and volcano-sedimentary formations; 7: serpentinites; 8: Archean gneisses, metatexites and diatexites.

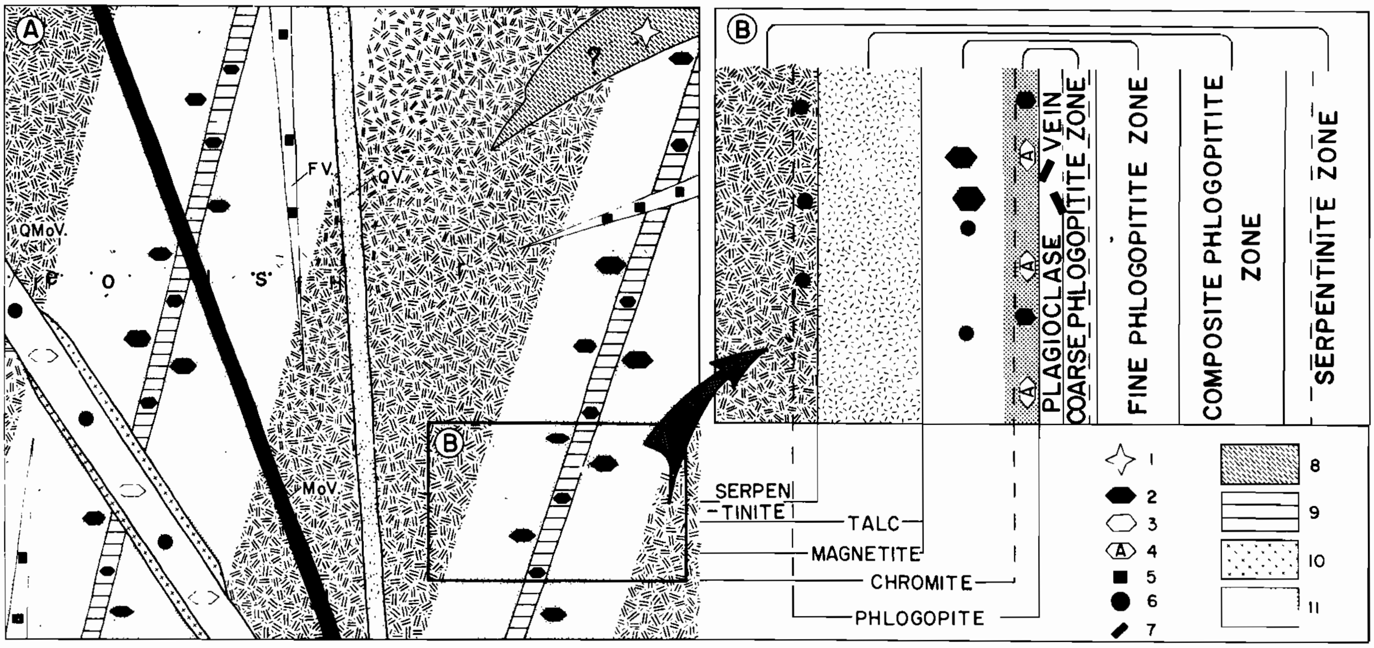

Figure 2.

Schematic diagram showing the evolution of the Carnaíba and Socotó hydrothermal system. Aplopegmatitic and/or plagioclasic veins inducing the development of metasomatic phlogopite zones in the serpentinite formations. Development of an important swarm of veins: – barren (QV.) or molybdenite bearing quartz veins (QMoV.) producing generally a muscovite salband alteration; – fluorite veins (FV.); – massive molybdenite veins (MoV.). (Fig. 2A)

Metasomatic zoning developed at the contact of a plagioclase vein with serpertinites: CARNAÍBA-BRAULIA prospecting pit. 1: scheelite; 2; emerald or green beryl; 3: pale green beryl; 4: apatite; 5: fluorite; 6: molybdenite; 7: tourmaline; 8: Tremolitic zone; 9: plagioclase vein; 10: Muscovite salband alteration; 11: metasomatic phlogopite zone (Fig. 2B)

CONCLUSIONS

The Campo Formoso and Carnaíba granites present several petrographic and deuteric-hydrothermal alterations which indicate that the magma was saturated in water. Muscovitisation and chloritisation of biotite and replacement of plagioclase by K-feldspar are good examples of post-magmatic replacement and reflect with the presence of aplopegmatite joins, episyenite veins and tourmalinite veinlets, an important fluid circulation and granite transformation. The problem of muscovitisation is more complex and the muscovite appears partly as a primary consti-

The emerald mineralization is developed in phlogopitite that results from the interaction of the fluids associated with the aplopegmatitic and/or plagioclasic veins, with serpentinite rocks. The metasomatic zoning characterized by the development of zones with variable mineralogical composition from a mono-mineralic central zone (phlogopitite) to peripheric zones (serpentinites), separated by sharp metasomatic fronts, illustrates an infiltration metasomatic process (Korzhinskii, 1970).

In another way, the presence of Be and Mo mineralizations both

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