

BRAZILIANO-PAN AFRICAN Sm-Nd AND Ar-Ar DATING RESULTS FROM THE CANINDÉ DO SÃO FRANCISCO GABBROS - SERGIPANO BELT – BRAZIL

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INTRODUCTION

This work presents part of the isotopic results of the project Petrology and Metalogenesis of the Mafic and Ultramafic Rocks of the Low São Francisco River. This project has been carried out by the Geological Survey of Brazil in the northern sector of the Sao Francisco Craton. It deals with the study of layered mafic-ultramafic intrusions that outcrop within Pan-African-Palaeoproterozoic belts. This project is geared to produce a full assessment on the petrology and metalogenesis of the individual intrusive mafic-ultramafic bodies in order to evaluate their potential for Ni-Cu-EGP mineralization. The study area is situated in the Canindé Domain of the Sergipano belt, which consists of a metavolcano-sedimentary sequence intruded by a mafic-ultramafic layered complex (the Canindé Gabbroic Suite). This suite is the main issue of this contribution, where we recognized a need for detailed precise chronological framework to tie in with well-constrained isotopic stratigraphic sections, which are critical for developing models for the evolution of this igneous system. Unfortunately, many mafic rocks lack readily datable minerals, such as zircon, for precise U-Pb dating, therefore, mineral phases such as olivine, pyroxene, plagioclase, primary magmatic micas and amphibole were used to undertake Sm-Nd and Ar-Ar geochronology. In this study we report preliminary Ar-Ar ages on igneous phlogopite and plagioclase and Sm-Nd mineral isochrons for troctolite samples of the Canindé Gabbroic Suite together with Sm-Nd data from nine selected samples.

GEOLOGICAL BACKGROUND

The Canindé Gabbroic Suite consists of a 40x6 km WNW-ENE trending sheet that extends from the SW portion the State of Alagoas and NW part of the State of Sergipe towards the NW part of the State of Bahia (Fig. 1). It lies within the Canindé Domain of the Sergipano Belt, which is comprised of a metavolcano-sedimentary sequence intruded by Neoproterozoic peraluminous, calcalkaline and soshonitic granitoids. It is considered to be an ophiolite complex (Silva Filho, 1976) and an island arc-type volcano sedimentary sequence (Jardim de Sá et al., 1986, Bezerra et al., 1990, Bezerra, 1992 and Bezerra et al., 1992). However, Oliveira & Tarney (1990) suggested an intra-continental environment, similar to the

Paraná Basin Flood Basalt Province, which was later corroborated by Nascimento et al (2005). Oliveira & Tarney (1990) and Bezerra (1992) stated that the gabbroic complex comprises three main rock groups:

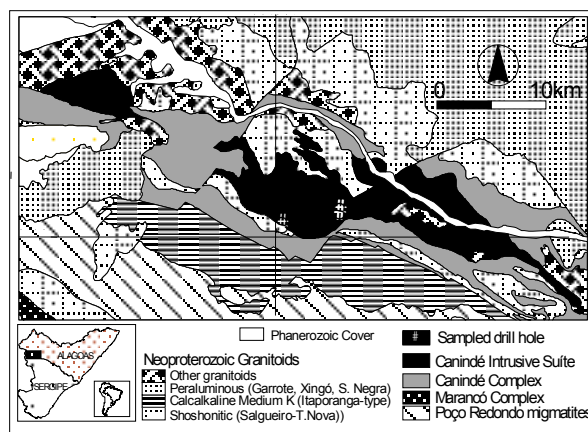


Figure 1. Geological map of the Canindé Complex.

(1) leucogabbros: troctolites, leucotroctolites, olivine gabbros, leucogabbros, anorthosites, and quartz leucogabbros; (2) Fe-Ti oxide gabbros: fine-grained olivine gabbros and olivine norites with Fe-Ti oxide layers; (3) mafic-ultramafic cumulates: melatroctolites, norites, piroxenites, and hornblendites. The gabbro, troctolite and peridotite layers are composed predominately of cumulus olivine and plagioclase, intercumulus clinopyroxene, orthopyroxene, hornblende and phlogopite. This mineral assemblage occurs in different modal proportions in the different differentiate types. Santos et al. (1990) identified within the intrusion two kind of low grade Ni-Cu mineralization, both hosted by gabbro and gabbro-norite. The first is disseminated nickel-copper sulfide enriched intervals and the second is related to irregular masses of remobilized sulfide mineralization. The ore mineralogy consists of pentlandite, chalcopirite, pirite, pirrotite, chalcocite, covellite, ilmenite and magnetite (Santos et al., 1990). The iron-titanium oxides may sometime increase their whole rock volumetric proportion to form sub-metre layers of magnetic iron ore, which contain 6.5-7% TiO₂ and 30% FeO. The oxide-rich layers also contain gold with values from 0.11 to 0.23 ppm. CPRM has estimated reserves as large as ca. 4 million tons of sulfide ore carrying 0.34% Cu and 0.35% de Ni at the Fz. Quiribas Target (Tesch,

et.al. 1980, 1982 and Santos et al. 1990). These authors also detected a base metals content enrichment in the sulfide-bearing intervals, as high as 0.25% Co; 0,10 ppm Au; 2.5 ppm Ag; 0.015 ppm Pt and 0.03 ppm Pd.

GEOCHRONOLOGICAL BACKGROUND

The isotopic data from the Canindé Domain has been very scarce until the work undertaken by Nascimento et al. (2005). They produced a robust data set including Sm-Nd and U-Pb ID-TIMS to date most of the stratigraphic units of this domain, so they could establish a geological history in the region spanning from 900 Ma (Novo Gosto metacarbonates) until 634 Ma (Garrote syncollisional granitoids). Nascimento (2005) determined the age of the Canindé Gabbroic Suite at 690 ± 16 Ma (U-Pb SHRIMP) obtained from a porphyritic leucogabbro. They also dated a monzodiorite sample from the Gentileza unit, which yielded an age of $684 \text{ Ma} \pm 10$ Ma that they believed is coeval to the gabbroic suite.

SAMPLING AND ANALYSES

Sm-Nd systematics and Ar-Ar dating was carried out on drill cores samples from the Canindé do São Francisco Project. Sm and Nd were separated by standard ion-exchange techniques. The Sr and Nd isotopic analyses were performed at the Geochronology Laboratory of the University of Brasília in static mode using a multi-collector Finnigan MAT-262 mass spectrometer. Analysed samples correspond to cumulitic-textured (mesocumulate) troctolite, olivine gabbro, leucogabbro, and peridotites from outcrops in the northwest part of the gabbroic suite. They consist of 1-2mm cumulus plagioclase and intercumulus olivine, strongly pleocroic reddish brown clinopyroxene, pinkish orthopyroxene, mica, spinel and sulfides. Clinopyroxene exhibits exsolution lamellae, whereas orthopyroxene shows spectacular graphic intergrowths with spinels. The Ar-Ar data presented in this study were undertaken at the Western Australian Argon Isotope Facility, operated by a consortium of Curtin University and University of Western Australia. Ar-Ar dating were carried out on mica and plagioclase phenocrysts from the sample PR-15-30, which corresponds to phlogopite-bearing oxide plagioclase lherzolite (Fig.2), which outcrops in the southwest part of the intrusion.

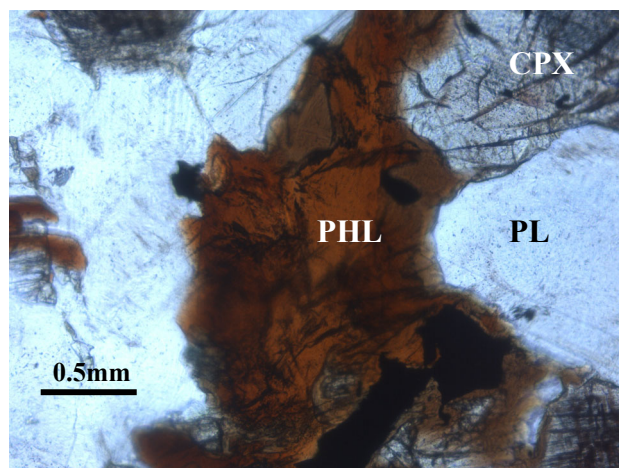


Figure 2. Photomicrograph of the gabbro sample PR-15-30, exhibiting intergranular phlogopite (PHL), with plagioclase (PL) clinopyroxene (CPX) and Fe-Ti-oxide.

Sm-Nd RESULTS

Sm-Nd systematics on plagioclase lherzolite sample Pr-26-23.75 from the southwest region yield two Sm-Nd internal isochron ages: (1) a plagioclase-orthopyroxene age of 672 ± 66 Ma, with an initial $^{143}\text{Nd}/^{144}\text{Nd}$ ratio of 0.511856 and (2) a orthopyroxene-whole rock age of 867 ± 96 Ma, with an initial $^{143}\text{Nd}/^{144}\text{Nd}$ ratio of 0.511627 ± 0.000097 . Representative samples consisting of troctolite, olivine gabbro, leucogabbro, and peridotites from the northwest part of the gabbroic suite, yield T_{DM} ages of 1.3-1.5 Ga and $\epsilon_{\text{Nd}(867\text{Ma})}$ values varying from +1.30 to +6.28, whereas the plagioclase lherzolite sample Pr-26-23.75, yielded a T_{DM} age of 1.3 Ga, with a $\epsilon_{\text{Nd}(867\text{Ma})}$ value of +2.30. As plagioclase equilibrates at lower temperatures than orthopyroxene we consider that, despite the larger error, the 867 Ma age as a crystallization age and the younger age of 672 Ma as being related to cooling of this rock. The rather large errors could be related to cumulus-intercumulus isotopic re-equilibrations due to slow cooling and also due to radiogenic Nd losses via high temperature hydrothermal fluids related crystallization of hydrous phases such as hornblende and phlogopite.

Ar-Ar RESULTS

The best estimate of the age of the plagioclase was a weighted mean age of the two youngest ages from 2 steps, yielding an age of 595.6 ± 5.3 Ma (95% confidence). Because of the presence of excess Ar in this sample, the weighted mean age should be considered a maximum age. The best estimate of the age of the phlogopite phenocrysts is obtained from the oldest high-temperature steps, which yielded a weighted mean age of 702.3 ± 5.5 Ma (95% confidence). White mica possesses an Ar closure temperature of ca. 350°C (Hames and Bowring, 1994). In comparison, plagioclase has a lower Ar closure temperature of ca. 250°C (McDougall and Harrison, 1988), which would explain the younger 595.5 ± 5.3 Ma ages preserved by the plagioclase. This may indicate resetting or partial resetting of the plagioclase Ar-Ar ages.

DISCUSSION

Sm-Nd and Ar-Ar isotopic systematics have proven to be reliable for age dating purposes when compared to the U-Pb ion microprobe data previously published for the Canindé Gabbroic Suite. The Sm-Nd internal isochrons reported here for the Fe-Ti oxide-bearing lherzolite yielded an age which is within error of the reported 690 ± 16 Ma U-Pb SHRIMP age (Nascimento et al, 2005). The 702.3 ± 5.5 Ma Ar-Ar age from the phlogopite-bearing olivine gabbro is also within error of the reported 690 ± 16 Ma U-Pb SHRIMP, and 672 ± 66 Ma Sm-Nd isochron age. If we accept Bezerra (1992) assumptions that the gabbros, troctolites and pegmatitic gabbros may be part of the same intrusion, although they might be produced by different magma pulse, the age data should indicate they have been crystallized almost at the same time. In fact we observe the opposite, i.e. that both U-Pb SHRIMP and Sm-Nd internal isochrons are crystallization ages, so the obvious conclusion is that they confirm Oliveira and Tarney's (1990) previous ideas that the porphyritic gabbro is intrusive into the layered cumulates. It is observed in other layered intrusions, such as the Niquelandia Complex (Pimentel et al (2002), that leuco varieties usually considered as the top of layered series may only be a spatially associated individual intrusion, which may be even younger than the more mafic main igneous body. Thus we conclude that the Canindé Gabbroic Suite is not a single intrusive igneous body, but in fact is a composite intrusion, related to a magmatic system that started to operate at 867 Ma, and has remained active until 670 Ma.

On the other hand, if the Ar-Ar ages are related to the cooling history of the cumulate pile one should acknowledge that the layered cumulates cooled from 702Ma to 595Ma, when the resetting of the Ar-Ar system occurred, which may be related to the thermal event associated with the intrusion of 634 Ma syncollisional granitoids.

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RESUMO

Estudos isotópicos dos sistemas Ar-Ar e Sm-Nd foram realizados em separados minerais de cumulos máficos e ultramáficos da Suíte Gabróica Canindé. Duas isócronas internas Sm-Nd foram obtidas: (1) plagioclásio-ortopiroxênio indicou idade de cerca 672 ± 66 Ma, $^{143}\text{Nd}/^{144}\text{Nd} = 0.511856$ e (2) ortopiroxênio-rocha total com idade calculada em 867 ± 96 Ma, $^{143}\text{Nd}/^{144}\text{Nd} = 0.511627 \pm 0.000097$. A sistemática Ar-Ar realizada em plagioclásio forneceu uma idade de 595.6 ± 5.3 Ma, enquanto que flogopitas magmáticas revelaram uma idade de 702.3 ± 5.5 Ma. Os resultados indicam que a Suíte Gabróica Canindé é uma intrusão composta relacionada a um sistema magmático ativado em aproximadamente 867 Ma, e permaneceu ativo até cerca de 670 Ma. As idades Ar-Ar foram interpretadas como relacionadas à história de resfriamento dos cumulos máfico-ultramáficos, a qual provavelmente estendeu-se de 702Ma até 595Ma. A idade Ar-Ar mais jovem foi explicada como relacionada ao efeito termal produzido pela intrusão de granitoides sincollisionais datados de 634 Ma