

$^{40}\text{Ar}/^{39}\text{Ar}$ GEOCHRONOLOGY OF MONTE DE TRIGO ISLAND ALKALINE SUITE: IMPLICATIONS IN THE REGIONAL GEODYNAMIC CONTEXT

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INTRODUCTION

The Monte de Trigo Alkaline Suite is an anorogenic intrusion located at the southeastern Brazil coastline within the Serra do Mar Alkaline Province. This province comprises more than twenty Late Cretaceous igneous intrusions (~90-50 Ma) where potassic felsic rocks prevail, with some mafic/ultramafic varieties occurring as dykes or small bodies.

The Monte de Trigo Island is formed by an undersaturated syenite-gabbroid association, with three main magmatic phases (Enrich, 2005): (1) a cumulate body mainly composed by melatheralites, olivine melagabbros, clinopyroxenites, and nepheline monzosyenites together with synplutonic microtheralite and microessexite dykes; (2) a hipersolvus miaskitic nepheline syenite stock associated with miaskitic and agpaitic synplutonic nepheline microsyenite dykes; (3) a dyke series of lamprophyres, tephrites, phonotephrites, tephriphonolites and phonolites, cross cutting other lithologies.

This short paper presents new biotite and amphibole $^{40}\text{Ar}/^{39}\text{Ar}$ ages from representative lithologies of Monte de Trigo Island magmatic evolution, as well as a discussion on the regional geochronological context.

REGIONAL CONTEXT

Alkaline magmatism in the surroundings of Paraná Basin

A number of Meso-Cenozoic alkaline/carbonatite intraplate igneous centers occurs in the southeastern portion of South American Platform. They have been grouped into several provinces (Fig. 1), distributed in the surroundings of the Paraná Basin (Almeida, 1983; Comin-Chiaramonti & Gomes, 2005).

The Alto Paraguay Province is the oldest magmatic manifestation (Gomes *et al.*, 1996), with a Permo-Triassic age of 250-240 Ma.

Ponta Grossa Arch, Santa Catarina, Ipanema, Moçamedes Arch, Damaraland and Valle Chico alkaline provinces have an Early Cretaceous age (~130 Ma; Morbidelli *et al.*, 1995; Milner *et al.*, 1995; Alberti *et al.*, 1999; Comin-Chiaramonti *et al.*, 1999; Muzio, 2000; Ruberti *et al.*, 2005), and are contemporaneous to the voluminous Paraná-Etendeka toleitic continental basalts.

Final magmatic manifestations occurred following the

Gondwana break-up, with Late Cretaceous to Tertiary age (90-36 Ma). They include Serra do Mar, Poços de Caldas, Alto Paranaíba, Rio Verde-Iporá, Poxoréu, Piratini, and Candelaria provinces, as well as the Lages occurrence (Morbidelli *et al.*, 1995; Gibson *et al.*, 1995; Comin-Chiaramonti *et al.*, 1999; Ulbrich *et al.* 2002).

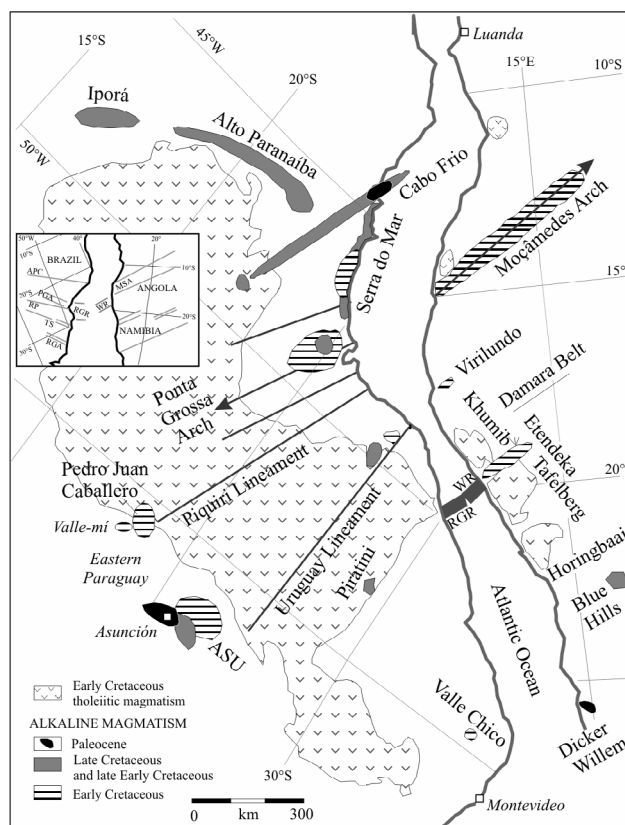


Figure 1. Distribution of the alkaline and tholeiitic magmatism in the Paraná-Angola-Etendeka Province (Comin-Chiaramonti *et al.*, 2002).

Serra do Mar Alkaline Province

The age of Serra do Mar Alkaline Province magmatism varies from 90 to 50 Ma (Morbidelli *et al.*, 1995; Thompson *et al.*, 1998). However, this interval may be divided into two periods.

Older occurrences comprise Monte de Trigo, Búzios, Vitória and São Sebastião on the northern coastline of São Paulo. K/Ar and Rb/Sr data yield ages of 80-90 Ma,

with most data between 81 and 86 Ma (Motoki, 1986; Bellieni *et al.*, 1990; Montes Lauer *et al.*, 1995; Alves & Gomes, 2001).

Younger occurrences comprise several intrusions forming the Itatiaia-Cabo Frio lineament, with K/Ar and Rb/Sr ages ranging between ~80 and 50 Ma (Morbidelli *et al.*, 1995; Thompson *et al.*, 1998; Deckart *et al.*, 1998; Guedes *et al.*, 2005). According to Sadowski & Dias Neto (1981), Thompson *et al.* (1998) and Thomaz Filho & Rodrigues (1999), this age variation is due to the eastward migration of the alkaline magmatism along the lineament. Moreover, a critical review of older K/Ar ages in the Itatiaia-Cabo Frio lineament (e.g. Thompson *et al.*, 1998; Thomaz Filho & Rodrigues, 1999), in addition to recent Ar/Ar data (Deckart *et al.*, 1998; Guedes *et al.*, 2005), seems to define different chronogroups of ~80 Ma, 72-69 Ma, 66-62 Ma and 55-40 Ma.

ANALYTICAL RESULTS

Six samples were analyzed using $^{40}\text{Ar}/^{39}\text{Ar}$ laser step-heating methods with a MAP-215 spectrometer at the Geochronological Research Center of the Instituto de Geociências, Universidade de São Paulo.

Figure 2 plots the $^{40}\text{Ar}/^{39}\text{Ar}$ ages obtained for the Monte de Trigo Island rocks. In general, laser heating steps have provided excellent plateaus.

Biotites from nepheline-bearing olivine gabbro and theralite, which represent the first magmatic pulse, show a plateau age of 86.5 ± 0.5 Ma and 86.5 ± 0.4 Ma and an integrated age of 86.7 ± 0.4 Ma and 86.7 ± 0.2 Ma,

respectively.

Similarly, biotites from the nepheline syenite stock have plateau ages ranging from 86.1 ± 0.4 to 86.7 ± 0.4 Ma and integrated ages between 86.3 ± 0.4 and 86.9 ± 0.4 Ma, respectively.

Biotite from a biotite lamprophyre dyke that cross cuts the nepheline syenite, give an integrated age of 86.9 ± 0.4 Ma and a plateau age of 87.2 ± 0.5 Ma, the latter appearing somewhat older than its country rocks.

On the other hand, the amphibole from the peralkaline phonolite dyke, the youngest magmatic event in the island, has a plateau age of 84.4 ± 1.0 Ma and an integrated age of 86 ± 1 Ma.

DISCUSSION

Age

$^{40}\text{Ar}/^{39}\text{Ar}$ data for Monte de Trigo Island yields an age 86.5 Ma. The age similarity between the different lithologies of the island suggests a magmatic interval lower than the analytical error, *i.e.*, 0.5 Ma.

This age may be compared to those of the nearest alkaline complexes, *i.e.*, São Sebastião, Vitória and Búzios islands (Motoki, 1986; Bellieni *et al.*, 1990; Montes Lauer *et al.*, 1995; Alves & Gomes, 2001) and to the Cananéia intrusion, within the Ponta Grossa Arch (Morbidelli *et al.*, 1995). On the other hand, the age of the Monte de Trigo Island is evidently older than those of the Itatiaia-Cabo Frio lineament, even including the Poços de Caldas massif (79-76 Ma, Ulbrich *et al.*, 2002).

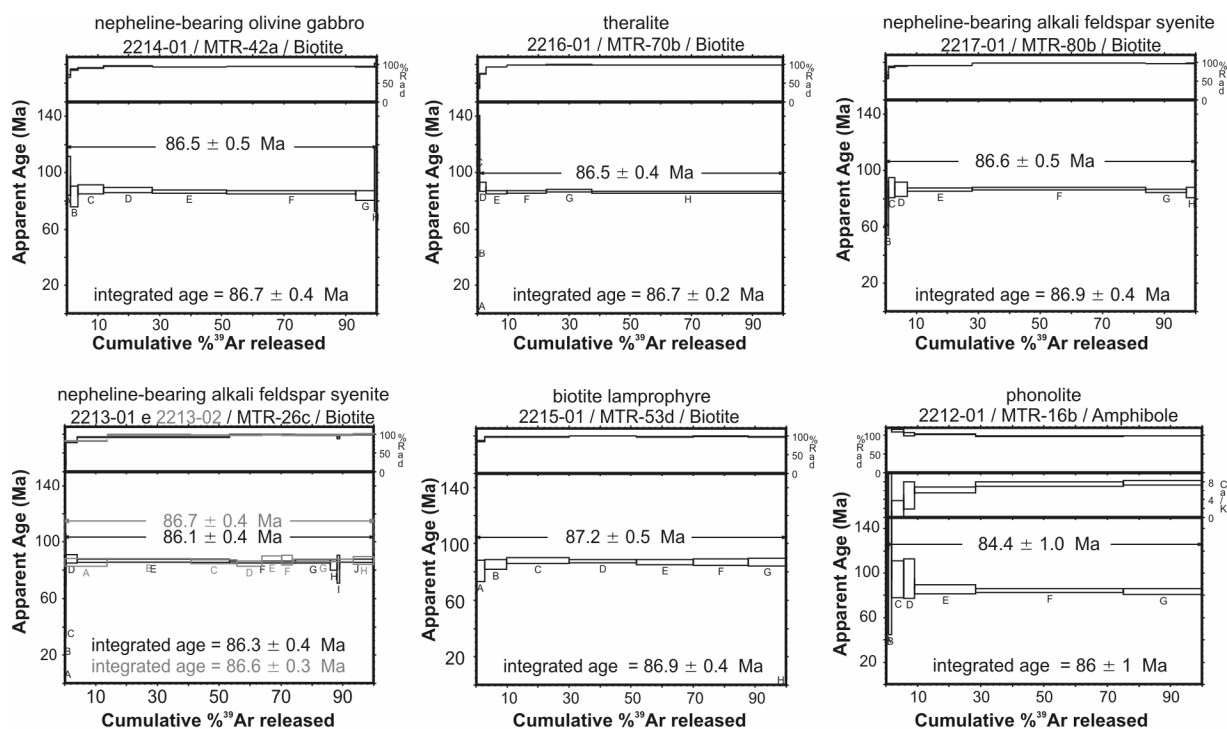


Figure 2. $^{40}\text{Ar}/^{39}\text{Ar}$ step-heating (plateau) and integrated ages on biotites and amphiboles from Monte de Trigo Island.

Geodynamic context

Source region pressure release, general increase of lithospheric mantle temperature and the influence of volatile phases lowering the mantle *solidus* temperature could be factors promoting the mantle partial melting that caused the alkaline magmatism in the surroundings of Paraná Basin.

Some authors have addressed the presence of two mantle plumes in this region: Tristan da Cunha producing large-volume magmatism in Early Cretaceous (~130 Ma), on both South American and African plates and promoting the continental break-up; and Trindade, whose impact on the north of the Paraná Basin would have produced the Late Cretaceous alkaline magmatism (O'Connor & Duncan, 1990; Renne *et al.*, 1992; Wilson, 1992; Gibson *et al.*, 1995; Thompson *et al.*, 1998).

These models of two mantle plumes explaining intraplate alkaline magmatism in the South American Platform have been severely questioned by some authors, since they do not clearly explain the genesis and distribution of some alkaline igneous centers, as those of Eastern Paraguay and Lages (*e.g.* Alberti *et al.*, 1999; Comin-Chiaramonti *et al.*, 2002, 2005). Ernesto *et al.* (2002) point to regional thermal anomalies as the cause of mantle temperature increase. On the other hand, Smith & Lewis (1999) and Comin-Chiaramonti *et al.* (2005) suggest that pressure release together with rifting related to movements of the South American plate and the presence of volatile phases in the mantle (*wet spot*) are the major agents responsible for the alkaline magmatism generation, its space and time distribution.

For the genesis of the Serra do Mar Alkaline Province, Thompson *et al.* (1998) proposed that during the westward displacement of the continental platform, between ~80 and 55Ma, the Trindade mantle plume would have migrated several hundred kilometers to a thinner lithosphere in the South, due to the presence of the thicker São Francisco Craton in its track. This model only could explain the space and time distribution of alkaline magmatism along the Poços de Caldas-Itatiaia-Cabo-Frio lineament.

However, both the ages of the Monte de Trigo Island (86.5 Ma) and of the coeval occurrences in the northern São Paulo state coastline (81-86 Ma) and the estimated distance from these bodies to the plume axis when it impacted the lithosphere, of ~1000 km, are not compatible with the influence of Trindade mantle plume on the genesis of these alkaline magmas.

Therefore, it is more likely that pressure release associated with rifting and volatile phases in the mantle (Smith & Lewis, 1999; Comin-Chiaramonti *et al.*, 2005) would have produced the alkaline magmatism of the Monte de Trigo Island and its surroundings. An eventual temperature increase could be related to a regional thermal anomaly (Ernesto *et al.*, 2002) or to a residual heating from the Tristan da Cunha mantle plume (Vandercar *et al.*, 1995).

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RESUMO

A Suite Alcalina da Ilha Monte de Trigo é formada de rochas tipo sienito-gabroides do Cretáceo Superior, pertencentes à Província Alcalina Serra do Mar, SE Brasil. Os resultados geocronológicos de Ar/Ar nas diferentes litologias forneceram uma idade de 86,5 Ma, com um intervalo magmático provavelmente menor que o erro analítico, *i.e.*, 0,5 Ma.

As idades obtidas são consistentes com as dos demais corpos alcalinos do litoral norte paulista (81-86 Ma; K/Ar; Morbidelli *et al.*, 1995). Estas não são compatíveis com o modelo magmático da pluma de Trindade proposto por Thompson *et al.* (1998) para a região da Serra do Mar, por serem mais antigas. Outros fatores, como a despressurização da região fonte e a presença de fases volatéis, devem ter contribuído para a fusão parcial do manto.