40\textsuperscript{Ar}/39\textsuperscript{Ar} age of Mendanha Alkaline Intrusion, Rio de Janeiro, Brazil

Idade 40\textsuperscript{Ar}/39\textsuperscript{Ar} da Intrusão Alcalina do Mendanha, Rio de Janeiro, Brasil

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\textbf{Abstract:} The Mendanha Alkaline Intrusion is one of many alkaline occurrences of the Southeastern Brazil Alkaline Province. It comprises plutonic rocks (alkali-syenites and syenites) and hypabyssal types (trachytes and ignibrites). In this work is presented new 40\textsuperscript{Ar}/39\textsuperscript{Ar} ages for this massif. The last reported ages were about 74 Ma and 65 Ma by K/Ar method published in 1988. The obtained results show ages of about 64 Ma (64.12 ± 0.40, 64.04 ± 0.42) e 58 Ma (58.55 ± 0.45, 57.95 ± 0.69), which are correlated to neighbor magmatic intrusions.

\textbf{Keywords:} Mendanha, Alkaline magmatism, Argon, Geochronology.

\textbf{Resumo:} A intrusão alcalina do Mendanha é uma das diversas ocorrências alcalinas da Província Alcalina do Sudeste Brasileiro. As rochas constituintes compreendem tipos plutônicos (alcali-sienitos e sienitos) quanto hipoabissais (traquitos e ignibritos). Neste trabalho são apresentados novas idades 40\textsuperscript{Ar}/39\textsuperscript{Ar} para o maciço. As últimas idades registradas são de 73 Ma e 65 Ma, pelo método K/Ar em 1988. Os resultados obtidos apresentam idades de aproximadamente 64 Ma (64.12 ± 0.40, 64.04 ± 0.42) e 58 Ma (58.55 ± 0.45, 57.95 ± 0.69), correlatas com intrusões magmáticas vizinhas.

\textbf{Palavras-chave:} Mendanha, Magmatismo alcalino, Argonio, Geocronologia.

1. Introduction

The Rio de Janeiro state has a flat area, which is known as the Baixada Fluminense, that lies between hilly and coastal region, where are observed some residual reliefs, associated with Cretaceous and/or Tertiary alkaline stocks. This alkaline magmatism comprises the Southeastern Brazil Alkaline Province (Almeida, 1983), or either Serra do Mar Province (Thompson et al., 1997). The generation of Southeastern Brazil Alkaline Province’s related intrusions is described as (1) tectono-reactivation model (e.g. Almeida, 1983), based fundamentally on structural studies; (2) Mantle Plumes and/or Hot-Spots (e.g. Gibson et al., 1997) or (3) a combination of these two models above (Fainstein & Summerhayes, 1982).

The Mendanha Alkaline Intrusion (Klein, 1993; Mota et al., 2012) is one of the Southeastern Brazil Alkaline Province main occurrences and is located between the cities of Nova Iguacu, Mesquita and Rio de Janeiro (22°48’S, 43°31’W). This NE-elongated ellipsoidal stock (18 km x 7 km) is parallel with the main structural lineaments of Ribeira Fold Belt (Heilbron et al., 2004) and it is one of the major alkaline occurrences of Rio de Janeiro State. The Mendanha Alkaline Intrusion has maximum altitude of 850 m, and it is surrounded by 5-45 m the Baixada Fluminense plain areas.

2. Objectives

The objectives of this work consist in present new 40\textsuperscript{Ar}/39\textsuperscript{Ar} thermochronological ages obtained in the Mendanha Alkaline Intrusion. The last ages obtained for this alkaline intrusion were 73 My and 65 My, with K/Ar method. These ages were published by Sonoki & Garda (1988), whose recalculates older data from Amaral et al. (1967) and Cordani & Teixeira (1979) with decay constants of Steiger & Jagger (1977).

3. Geology of Mendanha alkaline intrusion

The Alkaline Intrusion Mendanha (Fig. 1) has mostly trachytic to phonolitic composition, consisting of plutonic and hypabyssal rocks. It has an elliptical shape, which is parallel with reactivated structural lineaments of Ribeira Fold Belt.

The contact between the intrusion and gneisses of the Costeiro Domain (Ribeira Fold Belt) is characterized by formation of intrusive breccias, ranging between 50 and 200m thick. The breccias have characteristic structures of volumetric expansion due to magma pressure itself, thermal differentiation and action of volatiles (Mota & Geraldes, 2006). The magmatic breccias also have compositional zoning of fragments.
The constituent rocks correspond to alkali-syenites and syenites with equigranular and porphyritic textures. Mineralogy is usually composed by sanidine, orthoclase, amphibole and/or biotite and has accessory minerals such as pyrite and chalcopyrite and rarely, barite (Menezes & Klein, 1973).

Trachytic rocks are observed mainly near the contact of the intrusion, interspersed with pyroclastic breccias and in dikes. These trachytes have colors from light to dark gray, with aphyric texture, sometimes with disseminated sulphides and less than 1 cm amygdales. It is also common to find typical trachytic texture and magmatic flow features.

The alkaline dikes generally are composed by trachytes and rarely lamprophyres with regular NE-SW direction with near vertical dip, parallel to the lineaments inside the alkaline stock, which allows to associate these structures. By relative dating it is observed that lamprophyric dikes are younger than the trachytic ones.

To the northeast, the dyke directions exhibit a random pattern, which can be associated with differential efforts and in addition to the presence of pyroclastic rocks of different granulations with approximately concentric distribution, this area is known as the “Nova Iguaçu Volcano”.

The ignimbrites are irregularly distributed over the massif. Generally consist of fragments of trachyte, sometimes little amygdales filled by sulphides, carbonates, fluorite and others. The angular fragments shows little or no rounding, that indicates absence or low intensity of transport, while in other outcrops, the presence of rounded fragments may indicate underwater reworking or abrasion. The matrix is formed by lapilli and ash in variable proportions, the structure of these breccias can be supported by matrix or fragments depending on the distance between the source and site of deposition.

According (Silveira et al., 2005), the Mendanha Alkaline Intrusion could be considered as a highly explosive cretaceous volcano and composed predominantly by volcanic ash and pyroclastic rocks. The current condition of residual relief is consistent with the exposure of chamber magma, pyroclastic conduits and feeder dykes, verified by geophysical (e.g. Mota et al., 2012) and volcanological studies (e.g. Motoki et al., 2008).
4. Methodology

The analytical procedures were performed at Laeter John Centre for Isotope Research, Curtin University (Australia). K and Ar isotope abundances were obtained by mass spectrometry. The procedures include neutron activation to transform $^{40}$K into $^{39}$Ar and step-heating fusion of the whole sample.

After the analytical process, two values are obtained for ages: (1) age-plateau, using criteria of Lamphere & Dalrymple (1976) and (2) isochron age, with isotopic data extracted from each step of fusion of the same sample. Correction for atmospheric Ar ($^{40}$Ar/$^{36}$Ar = 295.5) was also performed. It is presented in conjunction with the plateau ages diagram, the ratio K/Ca diagram associated with each heating step. These indices help to indicate which mineral phases can be degasified at certain temperatures.

The probability of success of the plateau/isochronic ages is done by examining the Pearson’s chi-square ($X^2$) distribution (Wendt & Carl, 1991). This statistical method uses as input parameters the values of MSWD and the number of steps that define the plate (one degree of freedom), or the points that define the isochron age (two degrees of freedom).

5. Results

Two samples were selected for dating by the $^{40}$Ar/$^{39}$Ar method by step-heating fusion. For alkali-syenite lithofacies, it was collected a grain of biotite (VNI-bio). A lamprophyre dike sample (VNI-01-wr) was analyzed for whole-rock. The results obtained for the construction of diagrams are shown in table 1 and table 2.

The age plateau defined is $64.12 \pm 0.40$ My (41% probability), calculated at 95% of $^{39}$Ar released. The MSWD calculated for the analysis is 1.03, value considered acceptable. The K/Ca ratio obtained from each fusion step shows that the first 65% of the sample values indicates higher relative concentration of K. From this point until total consumption of the sample, the ratio K/Ca remains constant. Thus, it is possible to suggest that there is a compositional zoning in biotite, where the center of the mineral is depleted in K in comparison to mineral borders.

Table 2. Analytical data for sample VNI-01-wr (whole-rock in lamprophyre dyke).

The values of isochronic age was calculated in $64.04 \pm 0.42$ My (55% probability), with MSWD of 0.90. The initial $^{40}$Ar/$^{36}$Ar ratio, calculated by method of least squares regression, is 306.5 ± 14.0, which indicates a little excess of $^{40}$Ar isotope, associated with presence of atmospheric argon, but sufficient to make the obtained age with geological significance.

The sample VNI-bio (Fig. 2) shows plateau age diagram with homogeneous steps in approximately the last 95% of the $^{39}$Ar released. Although the first 5% of fusion was observed a slight gain of radiogenic argon, due to excess argon in the sample, probably acquired in contact with host rocks, which are alkaline or not.

The sample VNI-01-wr (Fig. 3) shows plateau age diagram with homogeneous steps in approximately the last
65% of $^{39}$Ar. The first 35% of the fusion is observed a slight gain of radiogenic argon.

The age plateau calculated is 58.55 ± 0.45 My (23% probability), obtained at 65% of $^{40}$Ar released. The MSWD for this analysis is 1.36, value considered acceptable. The K/Ca ratio obtained shows that the first 11% and last 60% of the $^{40}$Ar released, the values remains less than 1, indicating greater relative concentration of Ca, associated with a higher concentration of minerals such as amphibole and plagioclase. Between 11 and 40%, the values indicate greater relative concentration of K, related to K-feldspar and possibly biotite.

The first 35% of the fusion process define a "plateau" of older ages, denoting excess of radiogenic argon. Possibly, the excess $^{40}$Ar observed could be associated assimilation of alkaline host rocks at the intrusion moment. The main plateau is defined in last steps and the calculated age could have geological significance.

The isochronic age obtained was 57.95 ± 0.69 My (20% probability), with MSWD with value of 1.30. The initial $^{40}$Ar/$^{39}$Ar ratio is 527.7 ± 91.0, which indicates excess of $^{40}$Ar isotope, associated with the presence of atmospheric argon. This value is considered high and age had to be corrected.

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6. Discussions and conclusions

The age of crystallization/cooling attributed for the Mendanha Alkaline Intrusion is measured in 64.12 ± 0.40 (plateau) and 64.04 ± 0.42 (isochronic) My, with respective probability of 42 and 55%. These ages are statistically considered reasonable to good, since both have slight excesses of radiogenic argon, associated with inhomogeneity in the distribution of argon in the sample.

The lamprophyre dyke was dated in 58.55 ± 0.45 My (plateau) with probability of 23% and 57.95 ± 0.69 My (isochronic), is considered with regular quality. This is justified by the analysis be done on whole-rock sample, which according decreases the effectiveness of interpretative analytic techniques. Due to field relationships and significant difference in ages of intrusive rock and syenitic host rock (greater than 5 My), this obtained age has geological significance.

In comparison with ages obtained in previous studies and other rocks of the Southeastern Brazil Alkaline Province and field relations, it is clear that Mendanha Alkaline Intrusion had at least three distinct magmatic events. In other point, some other alkaline bodies have contemporary ages with one of these magmatic events: (1) 73 My, age not found in this study (Rio Bonito, Morro Redondo). (2) 65-62 My, (Tinguá, Morro de São João) and (3) 58 My (Itáua, Cabo Frio).

The ages obtained define an important magmatic event in southeastern of Brazil and may be interpreted as mantelic activity due deep crustal faults formed during Cenozoic reactivation of South America Platform.

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References


