

Geochronology of the South Bahia Alkaline Province (NE Brazil)

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The South Bahia Alkaline Province (SBAP) covers an area of about 6,500 km² and is formed by an association of twenty alkaline massifs, elongated in NE-SW direction and predominately composed of silica subsaturated rocks. The SBAP hosts blue sodalite syenite, which represents the most important ornamental stone of Brazil. These alkaline massifs are emplaced in Archaean to Paleoproterozoic granulite, migmatite and anorthosite terrains forming the interface between the São Francisco Craton (east) and Araçuá mobile belt (west).

The four most important syenitic intrusions are: Itabuna Massif (north, 430 km²), Floresta Azul Complex (northeast, 180 km²), Serra das Araras Massif (southwest, 220 km²), and Itarantim Massif (south, 150 km²). Previous geochronological studies link the SBAP to Neoproterozoic magmatism. The age data (Rb-Sr, K-Ar) are very heterogeneous and range from 500 Ma to 740 Ma. A baddeleyite from the Itabuna Massif gives a relatively precise U-Pb age of 676 ± 5 Ma.

In this paper, we will present preliminary results of a systematic geochronological investigation of the other three massifs by ²⁰⁷Pb/²⁰⁶Pb zircon evaporation and Rb-Sr whole rock techniques. The data were obtained at the Laboratory of Isotope Geology of the Federal University of Pará (Pará-Iso). The Floresta Azul Complex is composed of rocks associated with four distinct magmatic pulses. Single zircon ²⁰⁷Pb/²⁰⁶Pb evaporation data give 699 ± 11 Ma for a granite and 688 ± 2 for a diorite. A quartz syenite rock from the Serra das Araras Massif shows a ²⁰⁷Pb/²⁰⁶Pb age of 739 ± 2 Ma. The nepheline and sodalite syenite rocks from Itarantim Massif yields a Rb-Sr isochron age of 727 ± 30 Ma (MSWD = 1.5).

The results indicate that the SBAP was probably formed between 690 and 730 Ma and thus can be linked to the Rio Pardo rift. The alkaline intrusions become successively younger towards the São Francisco Craton, which implies that the isotopic system (Pb/Pb) was not disturbed during the Araçuá belt collision.

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Modeling the effects of reaction kinetics, diffusion-dispersion, and fluid infiltration on mixed-volatile (CO₂-H₂O) metamorphic reactions

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We evaluate the effects of reaction kinetics, diffusion-dispersion coefficient, and fluid infiltration rate on infiltration-driven decarbonation reactions with a 1-D model of coupled heat and mass (CO₂) transport. Our modeling results show that the positions of reaction fronts (isograds) and the thickness of reaction zones--observable features in natural systems--are functions not only of the fluid infiltration rate (v); reaction rate constant (k_0); and diffusion-dispersion coefficient (D), but of the direction of fluid flow with respect to temperature gradient and the bulk composition (that is, the abundance of reactant minerals), in addition to the time-integrated fluid flux. None of these parameters will exert exclusive control on the observed positions of isograds and widths of reaction zones in contact metamorphic aureoles.

At fluid infiltration rates sufficient for the advection-controlled transport of CO₂ ($> 10^{-10}$ m³/m² sec), the modeling results show that reaction fronts will advance into the wallrocks at significantly higher rates (factor of ≥ 2) for up-temperature flow compared to down-temperature flow, for the same conditions of reaction rate and transport. These differences arise from the very different spatial profiles of $X(\text{CO}_2)$ along the flowpath. Bulk composition has significant impact on the rate of advance of a reaction front (isograd) in down-temperature flow but not in up-temperature flow. As fluid infiltration rate decreases below 10^{-10} m³/m² sec where the transport of CO₂ becomes diffusion-controlled, the rate of advance of the reaction front in down-temperature flow increases to rates, for equivalent kinetic conditions, equal to those for up-temperature flow. This change occurs because the $X(\text{CO}_2)$ profiles become progressively more similar as advective transport of CO₂ decreases. At these low values of infiltration rate, the maximum rate of advance of the reaction front--at a given kinetic rate constant-- is limited by the rate of diffusive transport for CO₂ in the pore fluid.

For the same bulk composition and the same conditions of transport and reaction kinetics, the reaction zone developed in up-temperature flow will be considerably wider than that developed during down-temperature flow. Despite these inherent differences, reaction zones well beyond 100 m in thickness can be developed during down-temperature flow at conditions of sufficiently low reaction rates ($k_0 \leq 10^{-13}$ mole cm⁻² s⁻¹) or with fluid infiltration rates at or below $v = 10^{-8}$ m s⁻¹. If such conditions are obtained in natural contact aureoles, occurrences of reaction zones of significant width are not unambiguous indicators of up-temperature fluid flow.