

Ages and isotope geochemistry of two pre-brasiliano magmatic events in the Borborema Province of NE Brazil

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Introduction

The Zona Transversal (ZT) of the Borborema Province in northeast Brazil preserves a long and complex history of tectonic activity. The assembly of western Gondwana during the Brasiliano-Pan African orogeny marked the most recent phase of tectonism and magmatism in the ZT, which modified preexisting continental crust. Deciphering the exact nature of preexisting crust in the ZT, including the ages and petrogenesis of crustal blocks and belts that comprise it, allows ZT history to be extended back beyond the Brasiliano event and to understand better the assembly history of West Gondwana.

U-PB geochronology

Basement Gneisses. Within the central ZT, a broad, NE-SW trending band of post-Transamazonian gneissic rocks is exposed. Here we report new ages for four of these orthogneisses: Ambó, Fazenda Arroz, Palmeira, and Serra Talhada; analyses of additional gneisses are in progress.

Three zircon fractions from the Ambó gneiss, 20 km S of Teixeira, give an upper intercept age of 1003 ± 29 Ma when the lower intercept is forced through 600 Ma. The Fazenda Arroz gneiss, 44 km SW of Teixeira, yields a preliminary concordia age of 961 ± 16 Ma when the lower intercept is forced through 600 Ma. The Palmeira gneiss, 38 km W of Ambó, yields an upper intercept age of 956 ± 24 Ma and a lower intercept of 418 ± 200 Ma. Gneiss a few km NW of Serra Talhada contains two populations of zircon, the older of which yields a preliminary concordia age of 975 ± 75 Ma. The younger population, when regressed, gives a preliminary age of 631 ± 15 Ma.

In summary, our initial data indicate that the protoliths of all four gneisses formed between 1030 and 950 Ma with no apparent inherited zircon, and all four were subsequently affected to varying degrees at about 600 Ma during peak Brasiliano metamorphism. These results are similar to single zircon $^{207}\text{Pb}/^{206}\text{Pb}$ ages of 927 ± 25 Ma for orthogneiss of Serra do Machado¹, ca. 26 km SSW of Teixeira, and U-Pb zircon ages of 999 ± 50 Ma and 1037 ± 30 Ma for orthogneisses south of Salgueiro (Serra das Vassouras) and north of Floresta, respectively, in the southern part of the belt². Rb-Sr whole-rock ages of about 950 to 970 Ma on several orthogneisses including these^{1,3} are in general agreement with the U-Pb ages, suggesting that their Rb-Sr systems were not greatly affected by Brasiliano metamorphism and deformation.

Metavolcanic Rocks. Metavolcanic rocks crop out north and west of the orthogneiss belt in volcanosedimentary sequences of the Piancó-Alto Brígida fold belt⁴ (SPAB), in areas surrounding Irajá to the SE of Afogados da Ingazeira in the Pajeú-Paraíba fold belt⁴ (SPP), and in the vicinity of Floresta in SW SPP. Several of these were sampled for geochronologic analysis.

The Piaus felsic metavolcanic from SPAB contains zircons which give a preliminary U-Pb age of 930 ± 25 Ma. This age is younger than a composite U-Pb age of 1055 ± 20

Ma which includes zircon from the same unit²; the 1995 result may be biased by inherited zircons, since it was based on larger, multigrain sample sizes. The Serra do Pinheiro felsic metavolcanic, between Manaíra and Santana de Mangueira in SPAB, contains two populations of zircon, the younger of which has an age of approximately 984 Ma. The older population indicates that there is an inherited component with a minimum age of 1400 Ma; more work is required to resolve the exact nature of inheritance in this felsite. A felsic metavolcanic from near Manaíra (SPAB) containing very few zircons was previously studied² including one fraction with a composite age of 1055 ± 20 Ma. U-Pb ages of 1008 ± 30 Ma and 1012 ± 18 Ma for metavolcanic rocks are also reported in the Floresta region of SPP².

Another felsic metavolcanic unit from SPAB comes from Fazenda Mocambo, SE of Nova Olinda. Preliminary U-Pb work on this sample suggests that the age of this rock is about 730 Ma, which is much younger than other extrusive igneous rocks from the SPAB. A well-exposed package of metavolcanic rocks from the Irajá complex exists near Baixa Grande in SPP. A felsic tuff from this locality has been analysed, yielding a concordia age of about 725 Ma. There is some indication that an older component is present in the Baixa Grande rhyolitic tuff, although additional work is required to refine the precise crystallization age and age of the inherited component.

In summary, metavolcanic rocks from both SPP and SPAB represent at two different magmatic events - an older event between about 1050 and 930 Ma, and a younger, newly recognized pulse of magmatism that occurred about 730 Ma.

Plutonic Rocks. The Solidão batholith from the central ZT is generally agreed to be of Brasiliano age. U-Pb geochronology conducted for this granitoid confirms that the batholith has a minimum age of 574 ± 54 Ma. There is a large inherited component present in the rock that has a minimum age of 1991 ± 90 Ma. This inherited component is also present in another Brasiliano pluton, the Palmeira granite, which has a lower intercept minimum age of 505 ± 4 Ma with an upper intercept age about 2032 ± 15 Ma; both ages need further refinement.

Sm-Nd isotope geochemistry (Table 1)

The ca. 1000 Ma gneisses all possess $\epsilon(\text{Nd})$ (1.0 Ga) from -1.1 to 1.7, with depleted-mantle model ages, $T(\text{DM})$, of 1.78 to 1.64 Ga. Sm-Nd data for the metavolcanic rocks are similar, with $\epsilon(\text{Nd})$ (1.0 Ga) from -5.0 to 0.0 and $T(\text{DM})$ between 1.77 to 1.56 Ga. $\epsilon(\text{Nd})$ (600 Ma) values for the ca. 750 Ma metavolcanic units are comparable to those for the 1000 Ma metavolcanic units and gneisses; however, the $T(\text{DM})$ for the 750 Ma rocks are a little younger, between 1.51 and 1.34 Ga. The isotopic data for the granitoid rocks are quite different from either the gneisses or metavolcanic units. At ca. 600 Ma $\epsilon(\text{Nd})$ values are very negative, between -14.2 and -15.5, and the $T(\text{DM})$ ages are about 2.15 Ga.

Discussion

The close age agreement between the basement gneisses, or their protoliths, and some of the metavolcanic deposits in SPAB and SPP strongly suggests that these rocks formed during the same magmatic cycle, during the latest Mesoproterozoic and earliest Neoproterozoic. This theory is supported by Nd data for these rocks, wherein all share mildly negative $\epsilon(\text{Nd})$ values at the time of their formation. The negative $\epsilon(\text{Nd})$ values may be due either to derivation from an enriched lithospheric mantle source or to derivation from a mixture of depleted mantle and enriched crustal sources. $T(\text{DM})$

for these rocks indicate that the second option may be correct, since there is no evidence in Borborema Province for any event occurring 1.78 to 1.34 Ga, and the isotopic data could be explained by a 1.0 ± 0.1 Ga continental margin magmatic arc developed on older crust. The older crustal source may be Transamazonian basement (approximately 2.15 Ga), and the younger source may be mafic roots of the 1.0 Ga arc that were melted during latter stages of the 1.0 Ga cycle.

Subsequent magmatic activity about 750 Ma was probably unrelated to the 1.0 Ga event, although it may have been related to coeval volcanism and sedimentation in the Seridó fold belt, north of the Patos shear zone⁵. Epsilon(Nd) (600 Ma) (about -3.3) for these middle Neoproterozoic rocks are similar to $\epsilon(\text{Nd})$ (600 Ma) values for late Mesoproterozoic to early Neoproterozoic activity in the ZT, indicating that 750 Ma magmatism may have been due to partial melting of the 1.0 Ga rocks. The presence of ca. 1.05 Ma inheritance in the 750 Ma Baixa Grande rhyolite supports this interpretation.

Petrogenetic environments that produced magmatism at 1000 Ma and 750 Ma are not well constrained at this time. It has been proposed that the 1000 Ma event is related, at least in part, to rifting², while others suggest that convergence and arc formation are responsible for most of the magmatism in the ZT^{3,6,7}. Research is currently being conducted that will bring the 1000 Ma petrogenesis into focus through further precise U-Pb geochronology, Sm-Nd isotopic studies, and trace element geochemical analyses.

Table 1. Summary of Sm-Nd results for ZT rocks.

Sample Locality Lat. & Long.	Rock	Age (Ga)	$\epsilon(\text{Nd})$ 0.6 Ga	$\epsilon(\text{Nd})$ 1.0 Ga	T(DM) (Ga)
Ambó 7:23.52S, 37:16.24W	gneiss	1.00	-4.8	-1.1	1.78
Fazenda Arroz 7:27.52S, 37:34.43W	gneiss	0.96	-4.3	-0.3	1.67
Palmeira 7:23.86S, 37:36.78W	gneiss	0.96	-5.8	-1.0	1.64
Serra Talhada 7:58.52S, 38:16.82W	gneiss	0.98	-3.5	1.7	1.40
Piaus 7:36.07S, 38:02.51W	felsic volc.	0.93	-10.1	-5.0	1.77
Serra do Pinheiro 7:39.36S, 38:12.30W	felsic volc.	0.98	nd		
Manaira 7:40.39S, 38:11.47W	felsic volc.	1.06	-5.0	0.0	1.56
Fazenda Mocambo 7:31.58S, 37:56.94W	felsic volc.	0.73	-3.2	--	1.34
Baixa Grande 7:52.66S, 37:29.61W	felsic tuff	0.72	-3.4	--	1.51
Solidão 7:43.36S, 37:45.45W	granitoid	0.57	-15.5	--	2.14
Palmeira 7:22.79S, 37:37.50W	granitoid	0.50	-14.2	--	2.17

nd = not determined; for latitude and longitude, NN:nn.nn = degrees and decimal minutes. Data from this work and reference 2.

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**Extended
Abstracts**

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