

TIMING AND DURATION OF COLLISION IN THE NEOPROTEROZOIC SERGIPANO BELT, NE BRAZIL: AGE CONSTRAINTS FROM MAJOR SHEAR ZONES, OROGENIC GRANITES AND FORELAND BASIN FILLING

Elson P. Oliveira¹, Mario N. C. Araújo², Juliana F. Bueno¹, Marcelo J. Carvalho¹, Rosemary S. Nascimento¹, Neal Mcnaughton³, Wilson Teixeira⁴, Giorgio Basilici¹

¹Instituto de Geociências, UNICAMP (elson@ige.unicamp.br), ²CENPES, Petrobras, ³Centre for Global Metallogeny, UWA, Austrália, ⁴Instituto de Geociências, USP

ABSTRACT Ar-Ar ages of hornblende and muscovite from major shear zones are combined with U-Pb SHRIMP data on zircons from two syn-collisional granites and from non-deformed foreland basin sandstone to assess the minimum span of time that lasted the Brasiliano Orogeny in the Sergipano Belt. The older orogenic granitoids yielded ages between 634 ± 10 Ma and 628 ± 12 Ma. The latter was emplaced in micaschists between the first and the second regional deformation events. Amphiboles from amphibolites associated with the second deformation phase milonites of the Macururé and Belo Monte-Jeremoabo shear zones are dated respectively at 636 ± 7 Ma and 625 ± 3 Ma by the Ar-Ar step-heating technique. Muscovite from the São Miguel do Aleixo and Macururé shear zones yielded the ages 612 ± 7 Ma and 581 ± 2 Ma, respectively. On the other hand, detrital zircon grains from sandstone of the foreland basin Lagarto Formation at the southernmost margin of the Sergipano belt cluster about 565 Ma, 632 Ma and 956 Ma, the younger zircon grain being 540 Ma old. These numbers place the onset of collision at least about 635 Ma and the end after 540 Ma. Collision has lasted a minimum of 95 million years.

INTRODUCTION

The exact timing of continent-continent collision is hard to be established if not impossible. The collision between the Indian and Eurasian plate is possibly an exception because palaeomagnetic information on rocks from the Indian Ocean indicated that at about 40 Ma the Indian plate slowed its rate of northward movement from 14.9 ± 4.5 cm yr⁻¹ to the present velocity of ~ 5 cm yr⁻¹; the time of slowing corresponding to the time of India-Asia collision (Patriat & Achache, 1984). In general, the age of syn-collisional granites or of the peak of metamorphism (e.g. Guan et al. 2002; Tanner & Evans 2003) is often used as a minimum age for the beginning of collision. On the other hand, the minimum length of time that an orogeny lasts can be estimated by combining the ages of collisional igneous rocks and any orogeny-related feature, such as syn-deformation minerals and late-stage sediment deposition. In order to set age constraints on the collisional history of the Sergipano belt, here we discuss Ar-Ar data on hornblende and muscovite from major shear zones, U-Pb SHRIMP ages of early-collisional granites and detrital zircon grains from non-metamorphosed foreland basin sedimentary rocks.

THE SERGIPANO BELT

The Sergipano belt (Figure 1) is one of the most important Precambrian orogenic belts of Brazil, especially because it was considered as evidence for continental drift (e.g. Allard & Hurst, 1969) and because it contains several structural and lithologic domains that allow it to be compared to Phanerozoic orogens. The Sergipano belt was formed by the continental collision between the Congo-São Francisco Craton and the Pernambuco Alagoas Massif (PEAL) during the Brasiliano/Pan-African orogeny (e.g. Brito Neves et al., 1977). It has been previously interpreted as a typical geosynclinal (e.g. Humphrey & Allard, 1968; Silva Filho & Brito Neves, 1979), then as a collage of lithostratigraphic domains (Davison & Santos, 1989; Silva Filho, 1998), or as a Neoproterozoic fold-thrust belt produced by inversion of a passive margin basin located at the northeastern portion of the São Francisco craton (Santos et al. 1998, D'El-Rey Silva, 1999).

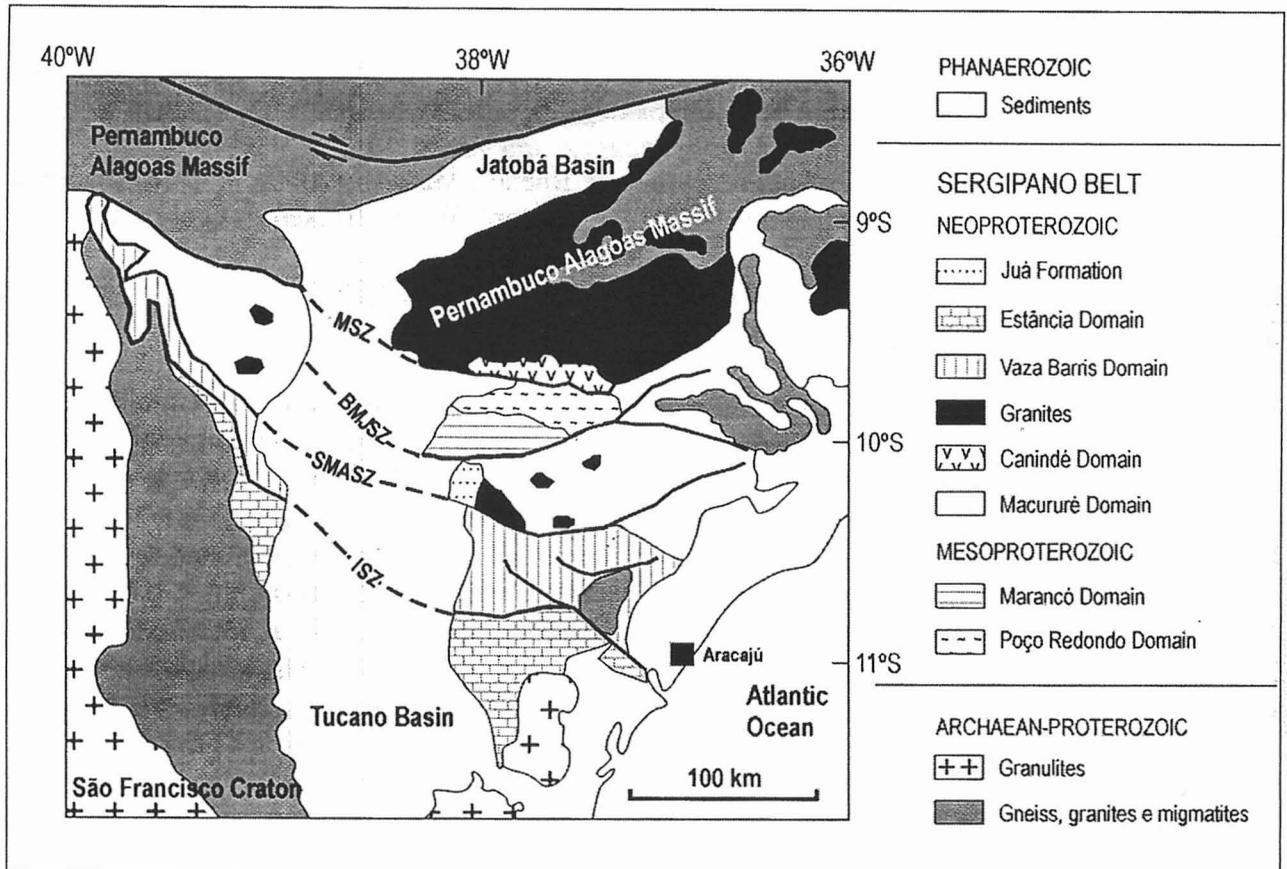


Figure 1: The Sergipano belt and its main domains. MSZ, BMJSZ, SMASZ and ISZ are, respectively, the Macururé-, Belo Monte-Jeremoabo-, São Miguel do Aleixo-, and Itaporanga shear zones. Modified after D'el-Rey Silva (1999).

There is a general consensus about its subdivision into six lithostratigraphic domains from north to south: Canindé, Poço Redondo, Marancó, Macururé, Vaza Barris and Estância, each separated from the other by major shear zones (Santos et al., 1988; Davison & Santos, 1989; Silva Filho, 1998). Silva Filho & Torres (2002) have suggested three additional domains: Rio Coruripe, Viçosa and Pernambuco-Alagoas. Clastic sedimentary rocks are more abundant in the Macururé, Vaza Barris and Estância domains, which show decrease of metamorphic grade from the former to the latter. Granitic intrusions are not observed in the Vaza Barris and Estância domains. Recently, on the basis of detrital zircon geochronology, Oliveira et al. (2005) proposed that most clastic sedimentary rocks of the Vaza Barris and Estância domains were deposited on foreland basins.

The Sergipano belt underwent three main deformation episodes (D1, D2 and D3, cf. Araújo et al. 2005). These deformation events are recognized in the supracrustal sequences of the Estância, Vaza Barris and Macururé domains, as well as in the basement rocks exposed in the Itabaiana and Simão Dias domes. The collisional event reworks previous gneiss-migmatitic fabrics (Dn) that can be either remnants of a pre-Braziliano deformation event or a precocious structure related to the very beginning of the collision. The continued collision compressed the lithotectonic units of the belt, initially by D1 south verging nappes and thrust zones that transported the metasedimentary rocks of the Macururé and Estância domains over large distances above the São Francisco Craton. The D2 deformation is marked by the extensive reactivation of the D1 compressive event, associated with the transpressive regime that affected the entire belt. D3 was the last deformation event that probably took place when the entire belt experienced a high amount of uplift during which the rock units had a brittle to ductile-brittle behavior.

SAMPLING SITES

For this account, we have selected the following rocks: (i) two granitic bodies representative of syn-collisional igneous intrusions; one is a pre-D3, possibly syn-D2 enclave-rich granodiorite from the Canindé domain (sample CRN-109b; Nascimento et al. 2005) collected at the right margin of the São Francisco river close to the Xingó dam, and the other (sample JUMS-35; Bueno et al. 2005) is a tonalite sheet emplaced into micaschists of the Macururé domain between D1 and D2; (ii) one sandstone (sample FS-F) of the weakly deformed, non-metamorphic Lagarto Formation of the Estância domain, which is interpreted as a foreland basin owing to its south-verging thrust-related structures and Neoproterozoic detrital zircon grains that are unlikely to have been eroded from rocks of the São Francisco Craton (Oliveira et al. 2005); (iii) milonitized amphibolites or muscovite-schists from major shear zones: amphibole CPD-28A and muscovite SBE-122 are from the Macururé shear zone that limits the Canindé and Marancó domains; amphibole SBE-38A is from the Belo Monte-Jeremoabo shear zone that separates the Marancó and Macururé domains; and muscovite SB-33M is from the São Miguel do Aleixo shear zone that bounds the Macururé and Vaza Barris domains.

RESULTS AND DISCUSSION

SHRIMP U-Pb data for the two syn-collisional granitic rocks give an estimate of the beginning of collision between the Pernambuco-Alagoas massif and the São Francisco Craton. Fourteen zircon grains from granodiorite CRN-109b of the Canindé domain define a $^{207}\text{Pb}/^{206}\text{Pb}$ age of 634 ± 10 Ma, whereas ten zircon grains from the pre-D2 tonalite JUMS-35 of the Macururé domain yield a $^{207}\text{Pb}/^{206}\text{Pb}$ age of 628 ± 12 Ma. Within error limits these ages are similar, and we interpret these ages as representative of the minimum age for the onset of the collision. A maximum age for the collision can be constrained by the 684 ± 7 Ma-old Curralinho rapakivi granite of the Canindé domain, which has its origin related to magma mixing during the rift event that pre-date basin inversion in the Canindé domain (Nascimento et al. 2005). The $^{39}\text{Ar}-^{40}\text{Ar}$ ages presented here for shear zone minerals aimed at having an estimate of the span of time during which the orogen remained active. $^{39}\text{Ar}-^{40}\text{Ar}$ closure temperatures for hornblende is higher than that of muscovite, thus providing a nice time spread. Six $^{39}\text{Ar}-^{40}\text{Ar}$ plateaus for hornblendes from the Belo Monte-Jeremoabo and Macururé shear zones indicate ages between 636 ± 7 Ma and 623 ± 2 Ma. This age span is interpreted as associated with an early, high-temperature regional uplift. Muscovite $^{39}\text{Ar}-^{40}\text{Ar}$ ages between 615 ± 4 Ma and 611 ± 4 Ma mark a progression of terrane uplift along the São Miguel do Aleixo shear zone. A third, sin-D3 muscovite age group cluster about 581 ± 2 Ma and indicate further terrane uplift along the Macururé shear zone. SHRIMP U-Pb ages of detrital zircon grains from the Lagarto sandstone agree nicely with the suggested tectonic setting for the Estancia domain as a foreland basin. Thirty-seven zircon grains indicate $^{206}\text{Pb}/^{238}\text{U}$ age clusters about 565 Ma, 632 Ma and 956 Ma, the younger zircon population constrains a maximum age for the original sediment deposition. Interestingly, two zircon grains give ages of 540 Ma and 552 Ma, and they probably indicate that deposition occurred after 540 Ma, at the same time as the orogenic belt was still active. Finally, our age data on the Sergipano orogenic belt support the suggestion that collision between the São Francisco Craton and the Pernambuco-Alagoas Massif started after 680 Ma, the age of extension-related granite of the Canindé domain (Nascimento et al. 2005), but most likely shortly before 640 Ma if an analogy with the Himalayas is drawn. In the Himalayas, India and Asia collided between 50-40 Ma and the first two-mica granite was emplaced at about 37 Ma (Windley 1995), thus at least a 3-13 Ma lapse of time between collision and the first granite intrusion. Collision went on until perhaps after 540 Ma when a source bed with zircons of this age supplied detritus to form the Lagarto sandstone. Hornblende and muscovite Ar-Ar ages between 635 Ma and 580 Ma along the main shear zones concur with the suggested minimum duration of collision in the Sergipano belt, i.e. at least 95-100 million of years.

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