DATING OF GRANULITES BY SHRIMP U-Pb SYSTEMATICS IN BRAZIL: CONSTRAINTS FOR THE AGE OF THE METAMORPHISM OF PROTEROZOIC OROGENIES.

Colombo C. G. Tassinari[1], Umberto G. Cordani[1], Ciro T. Correia[1], Allen Nutman[2], Peter Kinny[3], Coriolano de Marins and C.M. Dias Neto[1]

1 Centro de Pesquisas Geocronológicas do Instituto de Geociências da Universidade de São Paulo. Po. Box 11348, CEP 05422-970, São Paulo, Brazil. ccgtassi@usp.br
2 Research School of Earth Science, Australian National University. Canberra, ACT 2601.
3 Tectonics Special Research Centre, Curtin University Technology. GPO Box U 1987, Perth WA6001, Austrália.

Keywords: U-Pb Geochronology, Granulites, Proterozoic Orogenies

U-Pb zircon ages are commonly used to constrain primary crystallization ages of the protoliths of metamorphic rocks. In this work we have used U-Pb analyses of single zircons by SHRIMP (sensitive high-resolution ion microprobe) on granulites to date the metamorphic peak of major Proterozoic orogenic episodes in the South American Platform.

Considering that metamorphic zircon growth and/or overgrowth occurs during granulitic metamorphism, and the SHRIMP technique permits the choice of suitable zircon morphology and the best sites within single-crystals for spot analyses, this technique can provide precise constrains on crystallization and metamorphic ages of the granulites. As generally accepted, granulite facies metamorphism is usually related to subduction zones, and thus, the obtained metamorphic ages in this study are interpreted as related to the peak of metamorphism during orogenies.

To characterize the timing of metamorphism of the Paleo, Meso and Neoproterozoic major orogenic events in the South American Platform, we have dated granulites of both sedimentary and igneous derivation, from different tectonic units in Brazil using SHRIMP facilities (Figure 1) at The Australian National University and Curtin University of Technology in Australia. This technique is described in Compston *et. al* (1984)

The three Proterozoic orogenies investigated are the Transamazonian (Paleoproterozoic) in Itatins Massif, SE Brazil, the Rondonian (Mesoproterozoic) in the western portion of the Amazonian Craton, and the Brazilian (Neoproterozoic) in Central Goias area and Ribeira Fold Belt. To better understand the significance of SHRIMP U-Pb zircon ages in high grade metamorphic rocks, different types of granulites have been analyzed. The first example with a complex polycyclic metamorphic history, including overprint of medium grade metamorphism, (Itatins Massif), two others, correspond to a banded granulites, probably with metavolcano-sedimentary derivation and further younger felsic material formed under granulite conditions involving the presence of melt (Central Goias region). The last type consists of two granulites of sedimentary derivation (Ariquemes and São Sebastião kinzigites).

The Itatins Massif is a polycyclic high-grade complex, which is a possible extension of Luiz Alves Craton. It is composed of enderbites and charnoenderbites in association with granitic-migmatitic terranes. This complex was dated by Picanço *et. al.* (1998), using the U-Pb SHRIMP methodology as well as the Sm-Nd and Rb-Sr methods. The zircon grains in the charnoenderbite are clear, homogeneous and unzoned. The crystals are generally rounded, a feature often related to granulitic zircons. The analyses yielded a concordant $^{207}Pb/^{206}Pb$ age of 2173 ± 18 Ma (2σ). This age is interpreted as the high grade metamorphic episode, considered to be the metamorphic peak of the Transamazonian Orogeny in southeastern Brazil. It is important to note that these granulites were affected by a superposed amphibolite facies metamorphism, dated by Sm-Nd mineral isochron, at 610 Ma.

To date the Mesoproterozoic metamorphic episode, granulites of sedimentary origin were collected, composed mainly of high grade garnet-bearing gneisses, from south Ariquemes, Rondonia.

These rocks belong to the Rondonian-San- Ignácio Orogenic Belt, developed within the time period of 1.4 to 1.3 Ga (Tassinari *et. al.* 1997). The selection of zircons crystals was made with considerable care, to choose only zircons formed during the granulitic metamorphism. They are rounded, but with well defined crystallographic faces. The U contents for the analyzed zircons range from 651 to 1557 ppm, and Th/U ratios vary between from 0.012 to 0.023. The SHRIMP U-Pb values are concordant with $^{207}Pb/^{206}Pb$ mean age of 1331 ± 8 Ma (2σ). This age is interpreted to be the time of metamorphic peak of the Rondonian – San Ignácio Orogeny in the sampling area.

For the Neoproterozoic orogenies we selected two different granulite types from the Central Goias region and one high grade kinzigite from Ribeira Fold Belt.

From the Goias area we have dated a banded granulite, collected in Interlandia Quarry, near Anapolis region, Goiás. It comprises a basic band including orthopyroxene, clinopyroxene, hornblende, plagioclase and garnet, interbanded with quartzofeldspathic material with or without pyroxene. This rock is partially remobilized, forming felsic material by partial melting under high grade metamorphic conditions with a main mineralogy composed by orthopyroxene, clinopyroxene, quartz, plagioclase and K feldspar. The analyzed zircons are rounded but with well defined crystallographic faces. Most grains are clear and their morphology suggests a metamorphic origin. U contents in the zircons range from 46 to 84 ppm and the Th/U ratios range from 0.21 to 0.33. The U/Pb analyses yielded a weighted mean $^{206}Pb/^{238}U$ age of 634 ± 15 Ma (2σ).

The zircons from the younger felsic remobilized material are similar in morphology, but have relatively higher U contents (ranging from 100 to 767 ppm) when compared with those from the banded granulites, indicating U-enrichment processes during the zircon crystallization. Most grains present fractures, which may be a response to decompression during uplift processes, and exhibit some internal zoning. The most concordant analyses yielded a weighted mean $^{206}Pb/^{238}U$ age of 640 ± 13 Ma (2σ), which can be interpreted as the age of the partial melting event. Some analyses, obtained from the core of the crystals exhibit evidence of an older zircon generation, of uncertain age. The ages obtained for the banded granulites and for the younger remobilized felsic material are very similar, implying that the phase of exhumation to high-medium pressure levels (partial melting episode) occured around 630-640 Ma, and the age obtained for the banded granulites should not be assumed as the time of peak metamorphism, which can be estimated based on previous work, at about 780 Ma (Correia *et. al.* 1997), but likely date the partial melting event superimposed on these rocks.

High grade kinzigitic gneisses from the Ribeira Fold Belt, collected near São Sebastião, southeastern São Paulo State, contain two morphological groups of zircons, the first one including elongated and prismatic grains and the second composed of rounded crystals. All zircons commonly display overgrowth features. U contents of the analyzed sites are between 789 and 1118 ppm, and Th/U ratios have a wide range from 0.005 to 0.04. To date the high grade metamorphic episode the spots were selected only within the overgrowth zones. Their isotopic analyses are concordant and yielded a well-defined weighted mean $^{206}Pb/^{238}U$ age of 571 ± 10 Ma (2σ), which is considered to be close to the age of the metamorphic event in the studied Ribeira Fold Belt area.

In conclusion, in all of our cases a metamorphic age for zircon crystals was obtained, for different Proterozoic systems. In our opinion, this confirms previous evidence (Kröner *et. al.* 1987), that zircons can be strongly reset during episodes of high-grade P-T conditions, leading, in some cases, to completely newly formed material.

ACKNOWLEDGEMENTS

Thanks are given to the Brazilian Agency FAPESP for the financial support to this research, Thematic Projects numbers: 95/4652-2 and 97/00640-5.

REFERENCES

Compston, W., Williams, I.S. and Meyer, C., 1984. U-Pb Geochronology of zircons from lunar breccia 73217 using a sensitive high mass-resolution ion microprobe. Journal Geophysical Research. 89 (Suppl.) B534.

Correia, C.T., Tassinari, C.C.G., Lambert, D.D., Kinny,P. and Girardi, V. V., 1997. U-Pb (SHRIMP), Sm-Nd and Re-Os systematics of the Cana Brava, Niquelandia and Barro Alto layered Intrusions in Central Brazil, and constrains on the tectonic evolution. South American Symposium on Isotope Geology, Campos de Jordao, S. Paulo, Brasil. Extended Abstracts: 88-89.

Kröner, A., Stern,R.J., Dawoud,ªS., Compston, W., Reischmann, T., 1987. The Pan-African continental margin in northeastern Africa: Evidence from a geochronological study of granulites at Sabaloka, Sudan. Earth & Planetary Science Letters. 85: 91-104.

Picanço, J.L., Tassinari, C.C.G., Cordani, U.G., Nutman, A. P., 1998. Idades U-Pb (SHRIMP), Sm-Nd e Rb-Sr em Rochas do Maciço de Itatins (SP): Evidências de Evolução Policçilica. Na. Academia Brasileira Ciencias. 70 (1): 35-47.

Tassinari, C.C.G., Mellito, K.M., Rodrigues,L.V., 1997. The geochronological map of the Amazonian craton in Brazil. South American Symposium on Isotope Geology, Campos do Jordao, S.Paulo, Brasil. Extended Abstracts: 312-313.

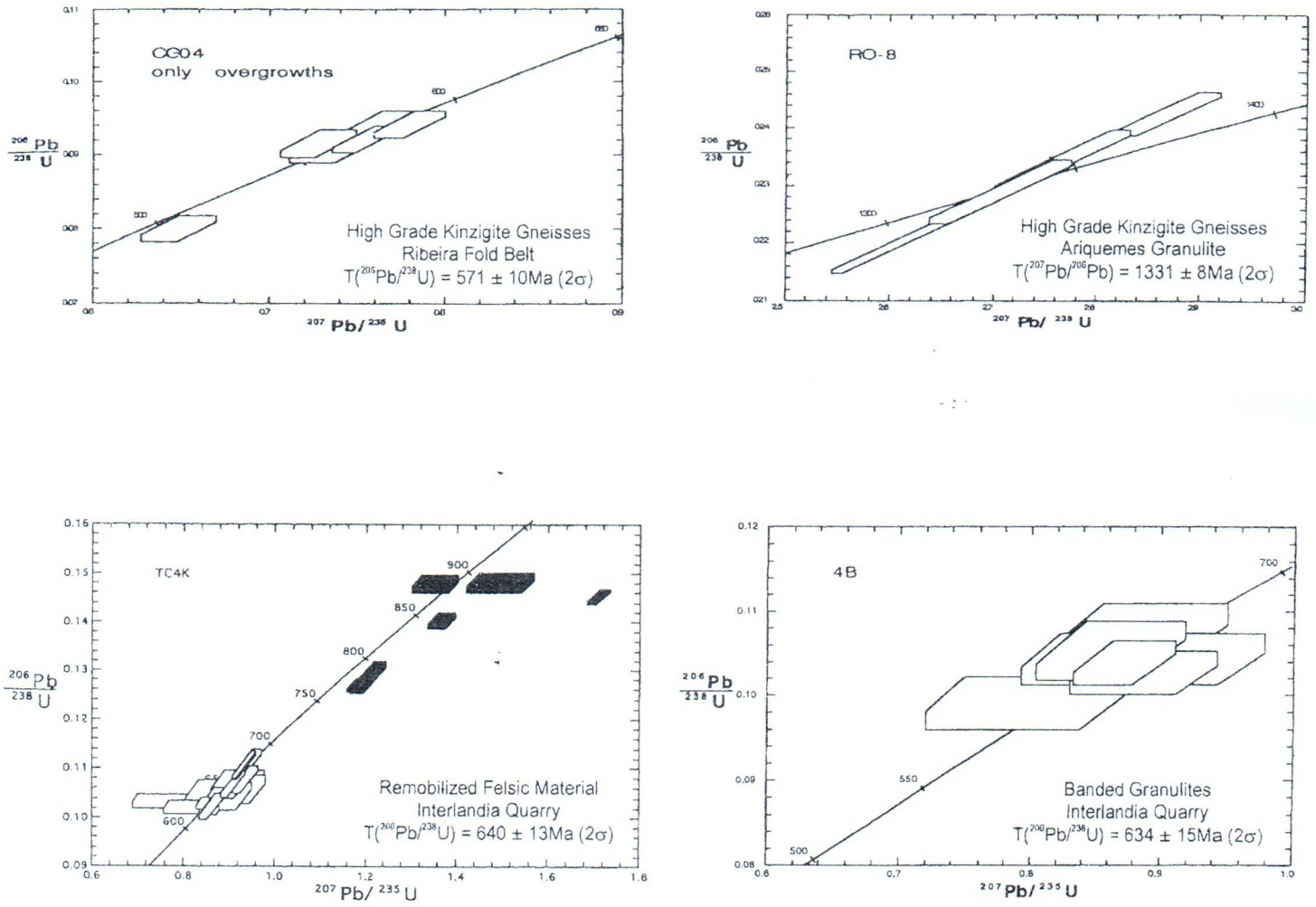

Figure 1: U-Pb SHRIMP Zircon analyses for granulites Geological units given on each figure. Error boxes represent 2σ mean.