DISCUSSÃO E RÉPLICA

REALEVAÇÃO DA EVOLUÇÃO GEOLÓGICA EM TERRENO E PRÉ-CAMBIANOS BRASILEIROS COM BASE EM NOVOS DADOS U-PB SHRIMP,
PARTE II: ORÔGENO ARAÇUAÍ, CINTURÃO MINEIRO E CRATON SÃO FRANCISCO MERIDIONAL de Luiz Carlos da Silva et al., Rev. Bras. Geoc.,
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CRISTINA DE CAMPOS¹, SILVIA REGINA DE MEDEIROS², JÚLIO CEZAR MENDES²
& ISABEL PEREIRA LUDKA¹

O artigo em questão apresenta novos dados isotôpicos, em amostras coletadas ao longo de uma extensa área (>400 000 km²), cuja complexidade geológica é conhecida. Só podemos parabenizar os autores, não só pela quantidade de novos dados, mas principalmente por sua qualidade.

A densidade do conhecimento geológico de detalhe, focalizando a faixa marginal leste ao Craton de São Francisco (faixa Araçuaí), entretanto, ainda não é diretamente proporcional a sua complexidade. Assim, dados analíticos, podem originar dúvidas quanto ao seu significado.

Como uma das áreas amostradas vem sendo por nós estudada, em maior detalhe, há mais de dez anos, (a região do Alto Caparão), talvez seja de interesse dos autores e da comunidade geológica, discutir um pouco mais a interpretação apresentada. Trata-se da região correspondente à amostra LC 32 (OPX-Bt granulito).

A idade obtida para os supracrescimentos nos zircões foi de 587 ± 9 Ma e 2195 ± 15 Ma, para o núcleo dos zircões. Essas idades são matematicamente coincidentes àquelas obtidas pelo chamado método tradicional (Soellner et al. 1991) ou seja: 586 ± 3 Ma para os supracrescimentos dos zircões e 2176 (e não 2170 Ma, como está no texto) ± 30 Ma, para o núcleo dos zircões. Resta esclarecer que, os dados deste último trabalho foram obtidos a partir das populações de zircões de mais de vinte amostras, onde duas populações de formas heterogêneas (A e D1), foram identificadas. Os zircões com supracrescimentos possuem núcleos arredondados, indicando um reabastecimento, por um processo de abrasão, que foi interpretado como gerado durante a sedimentação. Tal evento só pode ter sido posterior àquela da cristalização das rochas magmáticas que originaram os sedimentos. Apenas a idade da cristalização magmática é no ciclo Transamazonico. A idade de sedimentação só pode estar entre os dois limites.

O fato de parte do pacote sedimentar ser de origem fígeaa dificulta a sua interpretação. Só através de estudos de detalhe, novos aspectos podem ser considerados.

Além dos núcleos arredondados dos zircões, que ainda podiam ser interpretados como corrisão magmática (esta hipótese, por sua vez, indicaria um evento de fusão e produção de magma no Brasiliano) quais outras evidências indicam a origem sedimentar do pacote que compõe a Serra do Caparáo?

Para responder a esta pergunta, talvez fosse interessante relevar alguns trabalhos mais antigos sobre essa região. Seidensticker (1990), Seidensticker & Wiedemann (1992), Fritz (1991- focaliza Serra do Valentin e o lineamento de Guajuí), Soellner et al. (1991) e Soellner et al. (2000) apresentam os seguintes argumentos:

1) Além do opx-granulito granulado amostrado (LC 32), que certamente faz parte da sequência ortodivida bimodal, a região do Caparáo possui ainda granada-gnaisses leucocráticas, granulitos bandados com granada, cordiérita e sillimanita (gnaisses kinzigítico) e migmatitos estromáticos, tanto nas cotas mais altas, próximas ao pico da Bandeira, como na base. Níveis de grafita e de quartzo (típicos do Complexo Paruíba do Sul) concomitante ocorrem intercalados aos granulitos.

2) No campo, rochas da fácies granulito e anfibolito alto (Complexo Paruíba do Sul, tipicamente sedimentar), apresentam contatos gradativos a interdigitados com a Suíte Caparáo de Soellner et al. (1991).

3) Os padrões de distribuição de Elementos Ternas Raras da Suíte Cápbarao são semelhantes aos obtidos no Complexo Paruíba do Sul, nesta região. (Seidensticker & Wiedemann 1992)


Barbosa & Sad (1983) propuseram igualmente uma origem sedimentar, e como a mais provável, para o pacote de rochas aflorantes no Caparáo (Unidade Comendador Venâncio), baseados em dados geoquímicos e relações de campo.

Interpretações geológicas diferentes para dados, matematicamente coincidentes, fazem parte da própria dinâmica de evolução do conhecimento geológico. Nossa intenção é simplesmente abrir uma discussão. Já que a interpretação apresentada discorda daquela dos poucos trabalhos de detalhe realizados na região.

Mesmo se tratando de uma região pequena, a área do Caparáo é de fundamental importância no contexto regional.
Referências


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RÉPLICA

LUIZ CARLOS DA SILVA¹, RICHARD ARMSTRONG, CARLOS MAURÍCIO NOCE, MAURÍCIO ANTÔNIO, CARNEIRO, MARCIO PIMENTEL, ANTONIO CARLOS PEDROSA SOARES, CARLOS AUGUSTO LEITE, VALTER SALINO VIEIRA, MÁRCIO ANTÔNIO DA SILVA, VINICIUS JOSÉ DE CASTRO & JOÃO MORAES CARDOSO FILHO


Como no presente fascículo foram veiculados comentários de conteúdo similar (Sölmer 2004), optamos por responder a Campos et al. (2004) juntamente com os desse último autor. Portanto, o leitor interessado poderá obter as respostas aos questionamentos levantados por Campos et al. (2004), nas respostas ao documento de Sölmer et al. (2004). Entretanto devido à importância para o entendimento da discussão proposta pelos autores comentaremos separadamente o principal argumento levantado por Campos et al. (2004), pelo qual os Os zírcons com 'supraercessivos' possuem núcleos arredondados, indicando um retrabalhamento, por um processo de abrasão, que foi interpretado como gerado durante a sedimentação. Infelizmente, ao contrário dessa principal conclusão de Campos et al. (2004), o estudo de dezenas de imagens panorâmicas de catodoluminescência por nós efetuado (Fig. 1) não revelou nenhum cristal ou núcleo arredondado por abrasão. A observação da figura 1 de Sölmer (2004), confirma a ausência de núcleos detríticos, ao contrário da interpretação do autor. Realmente existe uma abundante população de cristais e núcleos arredondados (globulares). São cristais metaigneos, com alta luminosidade (baixo-U) que adquiriram essas características devido ao avançado estágio de recristalizados na facies granulite. Ademais, nenhum núcleo ou cristal estudado mostra terminações abruptas (fraturadas), características de abrasão detritica, como demonstraremos na resposta aos comentários de Sölmer (2004).

Quanto à interpretação da amostra datada ser um ortognaisse como mencionado por Campos et al. (2004), estamos de acordo e a mesma foi tratada dessa forma por Silva et al. (2002a).

Finalmente, esclarecemos que nossa interpretação não pretende invalidar, nem invalidar, o quadro geológico da Serra do Caprao elaborado a partir dos trabalhos de Sölmer et al. (1991) e aceitos por Campos et al. (2004). Apenas demonstra a existência de remanescentes de ortognaisse intercalados no pacote metasedimentar por eles descrito, os quais podem representar restos do embasamento paleoproterozoico tecnicamente embutido. A presente discussão é mais um exemplo da necessidade de revisão geocronológica de amplas áreas do pré-cambriano brasileiro sob a sistemática SHRIMP, precedida por estudos detalhados de catodoluminescência e petrografia microscópica para a determinação consistente dos protólitos: mesmo em terras estudados em maior detalhe, há mais de 10 anos, como referem Campos et al. (2004).

¹ - Pesquisador do Serviço Geológico do Brasil, Brasília DF. Pesquisador do CNPq. Pesquisador Associado do Instituto de Geociências da UnB. Professor Participante do Curso de Pós-Graduação do I.G.C-UFGM. luizcarlos@df.cprm.gov.br

Frank Söllner

Da Silva et al. (2002) did a lot of work dating zircons from several kinds of rocks within the Ribeira mobile belt and the adjacent areas by the U-Pb SHRIMP method. Several of these rock series have been dated more than 10 years ago by conventional U-Pb dating methods (Söllner et al. 1991, Söllner et al. 2000) and by the SHRIMP-method, as well (Söllner & Nelson 1998).

One of the most amazing points are that, in each case SHRIMP U-Pb zircon data confirm the conventional U-Pb data without bringing significantly more to the zircons history. On the other hand, the limited amount of zircon crystals analyzed by the SHRIMP method may lead to misinterpretation.

At first, attention should be drawn to sample LC 32, a charnockitic granulite of the Serra do Caparaó (Alto Caparaó) that was analyzed by the above-mentioned authors. This reply focuses on the interpretation of the age results, which ascertain the upper intercept age of the discordia in the U-Pb Concordia diagram (Fig. 4b in Da Silva et al.) to represent the Transamazonian magmatic formation of the precursor rock of the charnockitic gneiss. This is contrary to the interpretation given in 1991 (Söllner et al.), which confirm the HP-HT-metamorphic rocks of the Suite Caparaó as a unit solely formed during post-Transamazonian times. The precursor rocks of charnockites, enderbites and granulites of the Suite Caparaó are of post-Transamazonian sedimentary origin and had been formed syn-genetically to the overin amphibolite facies rocks of the Paraiba do Sul complex sensu stricto (Söllner et al. 1991, 2000).

U-Pb SHRIMP analyses of zircon sample LC 32 (Fig. 4a; Da Silva et al.) display 9 points, which form an upper intersection age with the Concordia of 2195 ± 15 Ma. Three of the points are discordant, pointing towards mixing with a younger zircon phase, perhaps of Brasiliano age. Two of them are reverse discordant with higher 207Pb/206Pb ages. Two further data points are discordant, but at a significantly lower age, less than about 2100 Ma. This implies, regarding the limited number of analyses, that at most 50% of the analyses displays discordant 207Pb/206Pb ages at about 2195 Ma. Despite the two significantly younger data points, Da Silva et al. interpreted the upper intercept age as the time of the magmatic crystallization of the precursor rock of the charnockitic gneiss. The authors argue that the upper intercept may represent magmatic rock formation based on cathodoluminescence images. If the rock already crystallized from a melt 100 Ma before, where do these younger zircons come from? If more detailed work would have been done, like analyzing variable core structures from zircons of the charnockitic gneiss, the authors could no longer believe in this interpretation.

We performed cathodoluminescence (CL) investigations, on the same zircon fractions analyzed in 1991. In addition, we included analyses on the charnockite sample TUI from the real Juiz de Fora complex in order to highlight the difference between these two equally looking and, genetically deviating rock types.

Chronology of zircon growth of the charnockite (EF 3), as well as of the granulite (EF 2) from Serra do Caparaó can be described as following. The highest common factor of all the zircons is the immense variability in growth structures. Therefore, the presented description focuses generally on some fundamental aspects.

The inner core (volume 1 – 3%) is often formed as a small, globular, dim and detrital debris disposed off the center of the zircon crystal (zircon 1 in Fig. 1). It is dark in CL, standing for high abundance in foreign element concentrations, which normally lead to metamictisation.

The inner core is surrounded by an outer core domain (volume up to 80%, still higher in globular zircons; zircons 1 to 6), which in every case, is composed either of anhedral detrital remnants or fragments of a former zircon phase. Often, CL investigations of the outer core domain displays a weak, diffusive luminescence without oscillatory or sector zoning (zircons 1, 2 and 6) and therefore, discards a simple magmatic zircon growth. Moreover, the diversity of this zircon phase, which includes dim to opac, metamict domains (zircon 4) is incompatible with a simultaneous, syngenetic magmatic growth. If magmatic zonation of the core domain is clearly visible (zircon 5), the fragmentary rudiment unequivocally contradicts an in-situ crystallization.

Both core areas are overgrown by one or two rim generations. The first rim generation (volume commonly 20 – 50%; zircons 1 to 3 and 5) can be characterized as the main in-situ zircon crystallization phase. CL investigations reveal regularly alternating domains of dark and medium luminescence. This type of inconsistent luminescence can clearly be related to the zircon growth under HT/HP-metamorphic conditions.

A second rim generation (best developed in zircon 4) is restricted to some of the investigated zircons and is normally limited to about 10 µm. It is predominantly identified, if its luminescence exceeds that of the first rim generation. Zircon growth may be attributed to a retrograde stage with influx of a CO2-rich fluid phase.

In summary, zircon growth history in the HT/HP-metamorphic rocks of the Suite Caparaó, identified by detailed CL investigations, discards an in-situ magmatic zircon growth within the precursor rocks, due to the presence of detrital zircon core structures and the diversity of the main crystallization phase. The lack of reliable indications for magmatic conditions within these HP-HT-metamorphic rocks is demonstrated by detailed geoch, as well as by regional geological investigations cited in the reply of De Campos et al. (this volume). The rocks of the Suite Caparaó

Department of Earth and Environmental Sciences, Section Geology, University of Munich, Germany – frank.sollner@lrz.uni.de

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Figure 1 - Cathodoluminescence images from prismatic, rounded and globular zircons of the charnockite EF 3 and the granulite EF 2 from Suite Caparaó (Parába do Sul complex; zircons 1 to 6) and of the charnockite TU1 from Juiz de Fora complex (zircons 7 and 8), reflecting different growth histories. Zircons 1 to 6: The depicted core domains of the zircons from HP/HT-metamorphic rocks of the Suite Caparaó (up to 70% in volume) are of variable luminescence, diverse inner structures (zircon 1 - transparent, zircon 4 - metamict) and partly fragmentary outline (zircons 2 and 5) and therefore, discard a common magmatic growth within the present rock type. The HP/HT-metamorphism lead to in-situ zircon overgrowth, predominantly at pyramidal apices. Zircons 7 and 8: The main growth phase within zircons of the charnockite TU1 from Juiz de Fora complex, encasing detrital inner cores of variable size is always developed and shows oscillatory and/or sector zoning with an euhedral outline. This clearly reflects zircon growth under magmatic conditions within the present rock type. As well as in the above mentioned zircons 1 to 6, the outer rim, displaying two growth stages of dark and bright luminescence can be explained best by different phases of metamorphic zircon overgrowth.

hence, should be regarded as Brasiliano HT/HP-metamorphic rocks of post-Transamazonico sedimentary origin. Sedimentary detritus of these rocks are mainly restricted to Transamazonico provenance ages and this way; they form the bottom of the Parába do Sul complex.

In contrast, cathodoluminescence investigations of zircons from the charnockite TU1, sampled at the very western border of the Juiz de Fora complex to the adjacent Piedade complex, display a deviating growth history, which is recorded in the zircon pattern:

The zircon core domain is commonly composed of at least two growth phases. The inner core is a dark detrital debris comparable in size and shape to that in the above mentioned charnockitic rocks of the Suite Caparaó (zircons 7 and 8 in Fig. 1). The outer core (volume up to 20%) is quite variable in structure, luminescence and outline. The main magmatic crystallization phase (volume about 50%), subsequently developed in all investigated zircon crystals, shows oscillatory and/or sector zoning and a perfectly shaped euhedral outline. The euhedral outline of the main zircon domain, developed in any case emphasizes a magmatic zircon growth within the present rock type. Commonly, the magmatic zircon domain is overgrown by at least two rim generations with dark and bright luminescence (5-100μm thick; volume 30-50%), prevalently generated at pyramidal apices. It may be indicative of zircon growth under different metamorphic conditions. Bay-like structures point towards a corrosion event between these two metamorphic crystallization phases (zircon 7).

The depicted growth history in zircons of the charnockite TU1 from the Juiz de Fora complex fits very well with the U-Pb data previously presented in Stöllner et al. (1991). The lower intercept age of the discordia at 577 ± 18 Ma corresponds perfectly to that determined on the garnet-rich charnockite from Manhuaçu (LC 31; 584 ± 5 Ma; Da Silva et al., Fig. 4f) and thus, confirms the Brasiliano rim generation. Wildly scattering data points in the
Concordia diagram (Figs. 4.4 and 4.5 in Söllner et al. 1991) are best explained by varying quantities of large detrital and magmatic zircon domains of different Proterozoic and/or Archean ages, impossible to keep apart in conventional U-Pb analyses. Nevertheless, concentration of data points adjacent to a discordia with intercepts at 2220 ± 27 Ma and 577 ± 18 Ma (Söllner et al. 1991; Fig. 4.4) unambiguously defines the main zircon crystallization event to be of Transamazonic age. This is supported by numerous Rb-Sr whole rock analyses on HT/HP-metamorphic rocks of the Juiz de Fora complex (see e.g. Cordani et al. 1973).

At first glance, U-Pb SHRIMP analyses on zircons of an endebiteric granite from the Juiz de Fora complex (LC 17; Da Silva et al., Fig. 2b) are not in agreement with these results. Several stages of magmatic and metamorphic zircon growth, mentioned in CL investigations are well documented by discordant data points expecting formation ages between 3 and 2.85 Ga. Surprisingly, none of the U-Pb SHRIMP data points is concordant. This implies, that the analyses site incorporates zircon material of different growth zones and hence, of different ages. CL investigations depict various growth zones of so far unknown age, which may account for these complicated data configuration in the Concordia diagram.

A much more reasonable result is reached, if all available age data are used to compile a reliable model for the geological history of the Juiz de Fora complex. The geological evolution of the granite facies rock types of the Juiz de Fora complex may have started with accumulating of Archean detritus, derived from the nearby Barbacena complex (rock forming event at 3130 ± 7 Ma; Söllner & Nelson 1998), that underwent magmatic and HP/HT-metamorphic overprinting during Transamazonic orogenesis. The final stage of zircon growth within these rocks occurred during Brasilian HP/HT(?)-metamorphism. More analytical work has to be done to verify this evolutionary model.

Comparison of zircon data from HT/HP-metamorphic rocks of the Suite Caparaó (Paraiba do Sul complex) and the Juiz de Fora complex clearly demonstrates deviating provenance ages and a completely different rock forming history. This is well documented by conventional U-Pb data (Söllner et al. 1991, Söllner et al. 2000) as well as, by SHRIMP U-Pb data (Da Silva et al.).

References


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REPLY TO FRANK SÖLLNER

LUÍZ CARLOS DA SILVA, RICHARD ARMSTRONG, CARLOS MAUPLÍCO NOCE, MAURÍCIO ANTÔNIO, CARNEIRO, MARCIO PIMENTEL, ANTONIO CARLOS PEDROSA SOARES, CARLOS AUGUSTO LEITE, VALTER SALINO VIEIRA, MÁRCIO ANTÔNIO DA SILVA, VINICIUS JOSÉ DE CASTRO & JOÃO MORAES CARDOSO FILHO

INTRODUCTION The main controversial issue raised by Söllner (2004) is related to the origin and interpretation of the ages of sample LC 32, a charnockitic granulite, dated by zircon SHRIMP U-Pb systems (Silva et al. 2002a). Söllner et al. (1991) collected a “composite sample” in distinct outcrops, (supposedly corresponding to sample LC 32) and dated it using zircon ID-TIMS U-Pb systems. The results from this mixed population, corroborated by Söllner (2004) and Campos et al. (2004), define an eight points discordia, with an upper intercept at 2176 ± 30 Ma and a lower at de 586 ± 3 Ma. All the Paleoproterozoic results are strongly discordant, indicating important Pb-loss during the Neoproterozoic. The protholit of the granulite charnockitic was interpreted as a metagraywacke and accordingly, the upper intercept apparent age was interpreted as the age of the sources of the sediment, whereas the lower intercept was ascribed the Brasiliano metamorphism.

The fact that all zircons plot on a single discordia line, with an upper intercept at ca. 2170 Ma, called much attention because the analyses were obtained on mixed zircon populations from distinct, supposedly metasedimentary samples. This is an unusual feature for metasedimentary rocks, which commonly show a large spread of detrital zircon ages, corresponding to variable ages of the source(s)-area(s). In addition to this intriguing fact, recent field and microscopic studies on charnockites of the same unit, carried out by the mapping team of the Geological Survey of Brazil (SGB), suggested a distinct interpretation for the charnockite protholit, favouring a metasigneous origin. Silva et al. (2002a) explored these
interpretative ambiguities, targeting one typical sample of the charnockite granulite to be studied by means of zircon U-Pb SHRIMP systematics, preceded by detailed cathodoluminescence imagery studies. The results demonstrated the metasomagen origin for the analysed zircons and furnished a Paleoproterozoic crystallisation age for the magmatic cores and a Neoproterozoic age for the high-grade metamorphic overgrowths.

**METHODOLOGICAL CONSIDERATIONS** Despite the strong concerns expressed by Söllner (2004) and Campos et al. (2004) - relatively to the comparison of the results from the mixed samples analyzed by (Söllner et al. 1991) with those from sample LC 32 (Silva et al. 2002a), there are serious problems hindering a consistent debate. The major hindrances are of methodological order. First, the data from sample LC 32 were performed under high spatial resolution of the ion microprobe down to intra-crystalline scale. Hence, it was possible to discriminate and date separately the multi-components isotopic systems of the polyphase charnockite gneiss sample. Since Söllner et al. (2001) have not used the same systematics, it seems evident that igneous and metamorphic zircons domains may have been mixed and may have been analysed together. Accordingly, the data provided by Söllner et al. (1991) do not seem to date specific events and can not be compared directly with the new SHRIMP data, because of high-grade morphologically complex zircons, the higher precision of ID-TIMS data becomes useless as the they may represent average composition of mixtures (e.g. Williams 1998).

According to the usual geochronological procedures adopted by the Brazilian Geological Survey, each sample to be analyzed by U-Pb systematics must be collected from one single outcrop and from a homogeneous site/domain. This routine aims preventing risks of sampling mixed populations from distinct outcrops, or even from distinct compositional bands and domains of a same outcrop. Only with this caution it is possible to prevent unavoidable (and undesirable) risks of treating zircons from different rocks as a single population, resulting in gross errors. As Söllner et al. (1991) did not adopt these precautions, we are afraid that the proposed discussion has not the significance expected by Söllner (2004) and Campos et al. (2004).

Finally, another methodological difference of procedures between both studies also does not encourage a detailed comparison of the results. In special, the lack of CL imagery studies previously to the data acquisition by Söllner et al. (1991), makes the discussion an unbalanced exercise. Despite these barriers, we decided to reply Söllner’s criticisms, in order to give to journal’s readers an opportunity to have a detailed picture of the ongoing progress of the geochronological evolution of these polyphase terranes. In so doing, we will demonstrate that comments of Söllner (2004) that “in each case SHRIMP U-Pb zircon data confirm the conventional U-Pb data without bringing significantly more to the zircons history” were, at least, economic with the truth.

**CATHODOLUMINESCENCE AND U-Th-Pb RESULTS AND INTERPRETATIONS FROM SAMPLE LC 32** The sample was carefully selected and collected from one single, petrographically homogenous domain of one charnockitic gneiss outcrop. The zircon population consists of large (300-500 μm), euhedral, prismatic crystals, with a length:width ratio of 3:1, typical of felsic plutonic rocks (Fig. 1A). Most crystals show internal sharp discrimination between voluminous magmatic-textured, oscillatory- or sector-zoned cores, and metamorphic rims (Figs. 1A). Two sub-groups can be discriminated on the basis of their morphology and measured ages. Sub-group 1 comprises a major population of magmatic textured core-dominated crystals, with the core forming up to 95% of some grains. No detrital cores or mechanical abrasion evidence as fracture-truncated terminations usually shown by detrital-core were registered. The cores are overgrown by thin (<5-10 μm), high-luminescent (low-U), metamorphic rims (Fig. 1A). These rims show irregular contacts with the cores and their external shapes are isometric, giving rise to multifaceted, sub-rounded grains, typical of high-grade metamorphic zircons.

Eleven spots were sputtered on eleven magmatic-textured core domains. Two of the eleven results yielded discordant apparent ages of ca. 90 m.y. younger than the main cluster age of ca. 2190 Ma, as pointed out by Söllner (2004). They were discarded because of the morphological evidence of mixed nature and that they underwent ancient Pb-loss some ca. 90 m.y. after the magmatic crystallization peak, a common feature observed in SHRIMP analytical data. The remaining nine analysed on magmatic domains form a discordia line with an upper intercept at 2195±15 Ma (Fig. 4b; Silva et al. 2002). Three of the nine pooled ages are highly discordant (>10%), but present the same morphological pattern and are perfectly fitted to the well-defined discordance line and present no detectable scatter of geological origin (MSWD 0.62). In addition to the magmatic textures, the analysed core-domains also present U-Th chemistry typical of felsic magmatic rocks. Accordingly, the upper intercept age was interpreted as reflecting crystallisation of the orogeanic protolith. The discordance pattern was, in turn, attributed to significant Pb-loss during an event that is poorly defined by a lower intercept (599±79 Ma), but is within the range of the peak of high-grade metamorphism in the belt and confirmed by the measured age of the metamorphic overgrowths, dated at 587±9 Ma (see below).

Sub-group 2 is characterized by large external rims in grains with advanced metamorphic overprinting and almost complete recrystallisation of the former core/crystal, resulting in annealed, sub-rounded (Fig. 1B) and globular crystals (Fig. 1C). The latter, represents the final morphological stage of an originally magmatic grains. Owing to the glaborular habit, in the absence of previous CL studies, this deceivingly simple zircon population, could had been mistakenly interpreted as detrital crystals by Söllner et al. (1991), Campos et al. (2004) and Söllner (2004). Eleven spots were sputtered in 10 metamorphic domains from sub-Group 2. The U (and Th) concentrations in the analyzed domains are up to five times lower than that of the magmatic core population. Consequently, the results had to be treated separately from the cores’ results, in a Tera-Wasserburg diagram (Fig. 4C in Silva et al. 2002a). The linear regression of the U analyses are perfectly fitted to a discordance line with a concordia intersection age of 587±9 Ma, and without detectable scatter of geological origin (MSWD 0.89). The 238U/235U value of the intercepcion was interpreted the age of the granite grade metamorphic peak on this domain of the Araçuaí Orogen (Silva et al. 2002a).

**Conclusion 1** The morphological evolution observed in the zircon population is typical of high-grade orogeanitic zircons worldwide (e.g. Friend & Kinny 1995, Vavra et al. 1999), and was also recognized in other orogeanic (TTGs) from granulitic belts in Brazil, as in the HP/HT Itabuna-Salvador-Curacã Belt (Silva et al. 1997, Silva et al. 2002b). In this similar orogeanises, the zircon populations also underwent high grade metamorphism and show
remnants of magmatic-textured crystals (Figs. 1D and 1E) partially overprinted by lower-U, external overgrowth, some 400 m.y younger (Fig. 1E). They also show a globular (meta)igneous granulite zircon with sector zoned textures (Fig. 1F). Similarly to the globular zircons from sample LC 32, they are characterized by an almost complete erasing of their prior isotopic memory during the high-grade event, and their apparent ages mark the spanning of P and T metamorphic peak.

DISCUSSION ON SÖLMNER’S (2004) POST-ANALYTICAL CL IMAGERY INTERPRETATIONS  In figure 1 of Sölner (2004), zircons 1 to 5 clearly represent a homogeneous population of large (> 200 μm), euhedral to subhedral prismatic crystals, with length:width ratio of 3:1, typical of felsic plutonic rocks. The internal morphology is characterized by sharp discrimination between voluminous core, overgrown by metamorphic rims. In addition to the magmatic habit, some cores show fine oscillatory-zoned magmatic textures (5) or larger, regular alternating shells distributed over the crystal representing primary growth structure (3). Other crystal are unzoned (zircon 1 and 27). Zircon 3 shows an U-enriched (dark gray in CL) metamict large core with original, probably magmatic texture, obliterated by the metamictisation. Zircon 1 presents a more complex structure, with an internal, U-rich (dark gray) “inner core” (core within core morphology), of unknown origin, that could be ascribed to: i) the onset of the metamictisation of the original magmatic crystal; ii) inherited core of detrital? origin, or iii) inherited magmatic core, assimilated during the ascent of the charnockitic magma. In addition to the inner core, the ion probe
should also sputter the oscillatory-zoned magmatic domains of the crystals and the larger metamorphic rims, in order to determine the ages of crystallization and metamorphism. As all these domains are wide enough to be accessible to the ion probe, they should be dated by means of the SHRIMP systematics by Dr. Söllner to provide an improvement on the discussion proposed by him and his co-authors, allowing an appropriate comparison with sample LC 32’s results.

On the other hand, the globular high grade metamorphic zircon showed in Fig. 1G (Söllner 2004) matches well the morphological pattern of the ca. 387 Ma metamorphic population Sub-group 2 of Silva et al. (2002a) as shown in figures 1B,C (This study) and should also have been assessed by the ion microprobe for further comparisons.

Conclusion 2 In contrast to the interpretation of Söllner et al. (1991), Söllner (2004) and Campos et al. (2004) on the Caparáдержанes zircons: ("...which in every case, is composed either of anhedral detrital remnants or fragments of a former zircon phase"), no proved detrital cores and crystals or even mechanical abrasion evidences are seen neither in the images of figure 1 of Söllner (2004), nor in the images studied by Silva et al. (2004). As long recognized, evidence of mechanical fracturing (fracture-truncated crystals) of detrital origin are very persistent features, even in zircons that underwent high grade metamorphism and even advanced partial melting. This is illustrated by the detrital inherited Mesoproterozoic core within a S-type Neoproterozoic granite (Fig. 1G, this study). Evidently, the absence of these features in such a small number of CL images as presented by Söllner (2004) does not permit to deny the possible presence of detrital cores of metasedimentary origin. To support this interpretation it is necessary a detailed ion probe study, preceded by the acquisition of a larger number of CL images. Additionally, the population to be analysed must be collected from a single homogeneous site (sample), preventing the risks of sampling mixed populations from distinct outcrops, or distinct compositional bands.

Our interpretation did not aim to challenge the geological picture by Söllner et al. (1991) and Söllner (2004) for the Serra do Capará région. It just indicates the occurrence of orthogneiss remnants, interleaved with metasedimentary rocks, representing inliers of the Paleoproterozoic basement (rock unit of sample LC 32). Similar situation is described in the Ubá Sheet, south of the studied area, where charno-endobititic orthogneisses from the Paleoproterozoic basement (Juiz de Fora Complex) occur as thin tectonic intercalations into biotite-garnet-sillimanite gneisses of the Andrelândia Group (Noce et al. 2003). One U-Pb SHRIMP analysis, recently obtained on this charnockitic granite, yielded U-Pb isotopic evolution similar to that of sample LC 32. It is characterized by a discordia with intercepts at 2084±13 and 594±37 Ma, interpreted as the ages of crystallization and granulate grade metamorphism, respectively (C.M.Noce, Unpublished).

THE JUIZ DE FORA COMPLEX RESULTS (SAMPLE LC 17)
Zircons from a charnokitic orthogneiss from the vicinities of the Juiz de Fora town, previously included in the Juiz de Fora Complex was dated by Silva et al. (2002, sample LC 17). The populations revealed a much more intricate internal morphology when compared to zircons from the Capará and Juiz de Fora orthogneisses (stricto sensu). The main morphologic sub-group is represented by homogeneous crystals with magmatic-textured cores (Fig. 1H, This study), which form a discordant but homogeneous population, without apparent scatter of geological nature (MSWD 0.68), yielding an apparent age of 2985±17 Ma, interpreted as the crystallization age of the rock (see also Fig. 2B, Silva et al., 2002a). The same discordia shows an imprecise lower intercept (808±369 Ma), with no geological significance, but suggests metamorphic reworking during Brasiliano times. Additionally to this statistical evidence of Neoproterozoic overprinting, an older important Pb-loss episode could be dated on the external, thin, U-depleted (high-luminescent) metamorphic rims. They yielded an apparent age of 2856±44 Ma, interpreted as the age of the granulitic metamorphism (Fig. 11, This study). Curiously, even without access to the CL images and with absolute no information on the sputtered sites analysed by Silva et al. (2002a), Söllner (2004) reached the conclusion: "This implies, that the analysing site incorporates material of difference growth zones and hence, of different ages. CL investigations depict various growth zones of so far unknown age, which may account for these complicated data configuration on the concordia diagram". A more careful analysis of the concordia diagram (Fig. 2B, Silva et al. 2002a) clearly shows that the ellipses errors are coloured according to their specific sputtered site domains, i.e. dark grey = overgrowth and light grey = magmatic core/crystal. No mixed sputtered domain is indicated in the figure. Additionally, discordant SHRIMP U-Pb data does not necessarily imply that distinct zones within the zircon were analysed together in a single spot, meaning that a mistake was made during data acquisition. Discordant U-Pb data is paradigmatically ascribed to a process of Pb-loss that can be episodic and/or secular. This is certainly the case for sample LC 17 that was affected by at least by more two metamorphic events (Paleoproterozoic and Brasiliano) besides the one dated in metamorphic rims at 2856±44 Ma. This is the explanation for the complex discordant pattern of the Concordia and not the sputtering of material of different growth zones within a single spot, as deduced by Söllner (2004).

Conclusion 3 Owing to the well constrained crystallization age of ca. 2900 Ma and the metamorphic overprinting at ca. 2850 Ma, the unit could not be ascribed to the ca. 2200 Ma Juiz de Fora Complex (Silva et al. 2002a). Hence, it was characterized as "domínios alótetos" (i.e. "allochthonous domains") of the complex. Considering that similar ages of Archean igneous and metamorphic events were obtained for the gneiss complex from the São Francisco Craton basement in the Quadrilátero Ferrifero (Noce et al. 1998), we may well have dated a fragment of the Archean cratonic basement within the Juiz de Fora complex and not the that complex as supposed by Söllner (2004).

THE MANHAUÇU GARNET CHARNOKITE RESULTS (SAMPLE LC 31)
The rock is an intrusive garnet charnockite with supracrustal xenoliths and textures that indicate a magmatic origin. The presence of garnet, in addition to field relations with the paragneiss country-rock, indicates that this charnockite is related to the extensive late-collisional, S-type magmatism widespread within the Araçuaí Orogen. This collisional magmatism has isotopically well-constrained U-Pb crystallization ages from ca. 580 to ca. 560 Ma (Silva et al. 2002a). The younger (ca. 560 Ma) plutons are the Governor Valadares granites I and II (samples LC 38 and 39). Two other plutons (Pão de Açúcar and Corcovado garnet granites) ascribed to this late collisional ca. 560 magmatic stage were also dated (Silva et al., 2003). The older collisional
phases accreted at ca. 580 Ma and are represented by the Nauquen garnet granite and the Manhuaçu garnet charnockite (samples 48 and 31, respectively from Silva et al. 2002a).

Despite all the regional reproducibility of the obtained age, once again, even without access to CL image and with absolute no information about the morphology of the sputtered sites analysed by Silva et al. (2002a), Söllner (2004) concluded that “The lower intercept age of the discordia (from the JF charnockite, dated by the author, elsewhere at 577 ± 18 Ma), corresponds perfectly to that (lower intercept) determined on the garnet-charnockite from Manhuaçu (LC 31; 584 ± 5 Ma, Silva et al., Fig. 4f) and thus, confirming the Brasiliano rim generation”. The Manhuaçu charnockite is characterized by a simple and homogeneous population of euhedral magmatic zircon crystals (Fig. 1J, this study), which yielded a very precise crystallization concordia age of 554 ± 5 Ma. This conclusion is obvious not only by the observation of the simple magmatic morphology of the zircons, but also easily deduced from the concordia diagram of Fig. 4f (Silva et al. 2002a). All the dated spots form a single concordant cluster (n = 10), with no detectable scatter of geological origin (MSWD 0.88), permitting the calculation of a very precise concordia age of 584 ± 5 Ma, interpreted as the crystallization age of the pluton. Accordingly, contrary to Söllner’s conclusion, it does not make sense to mention “lower intercept”, as well as “Brasiliano rim generation”. The garnet charnockite is not a reworked Paleoproterozoic rock ascribed to the Juiz de Fora Complex as interpreted by Söllner (2004), and hence its analytical data do not show “lower intercept”, “Brasiliano rim generation” or rim of any age, because it simply is a Brasiliano-aged magmatic rock.

**FINAL OBSERVATIONS** All the interpretative discrepancies and age variation here discussed indicate that the studied geologic terranes cannot be correlated over large distances. Consequently, the available regional geologic maps need to be continuous and significantly improved to correctly reflect both the rock record and unravel the correct protolith and the geotectonic evolution of the mapped units. Hence, the disaggregated use of SHRIMP systematics preceded by careful sampling, preventing mixed samples, and preceded by SEM imagery studies, must become a routine and play a major role in the future regional and local studies.

**References**


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