GEOLOGICAL UNITS, AGES AND TECTONIC EVOLUTION OF THE NEOPROTEROZOIC DOM FELICIANO BELT, SOUTHERNMOST BRAZIL – A REVIEW

JOSÉ CARLOS FRANTZ, MARCUS VINICIUS DORNELES REMUS AND LÉO AFRANEO HARTMANN

ABSTRACT The Neoproterozoic Dom Feliciano Belt, southernmost Brazil, is divided in two the Western and Eastern Dom Feliciano Belts. The Western Belt consists of rock units related to juvenile accretion in a magmatic-arc while the Eastern Belt consists of rock units related to a continental collision. During the Brasiliano Cycle the evolution of these two different belts were integrated. The evolution of a juvenile magmatic arc/back-arc system in the Western Belt coincides with the closure of a passive platform-type basin with continental collision in the Eastern Belt. The collision between the juvenile magmatic arc and an older continental crust segment in the Western Belt can be the agent of a new compressive episode in the Eastern Belt with an intracontinental transpressive tectonics. These episodes were accomplished of an extensional tectonics in both belts.

Keywords: tectonic evolution, Neoproterozoic Dom Feliciano Belt, southernmost Brazil

INTRODUCTION The Neoproterozoic Dom Feliciano Belt consists of supracrustal rocks and granitic batholiths. The belt can be divided into a Western and an Easter Domain (Fig. 1) based on its rock associations and tectonic evolution (Frantz and Botelho 2000). The Western Belt consists mainly of rocks related to a juvenile accretion in a magmatic-arc (Babinski *et al.* 1996). The Eastern Belt consists of rock associations related to a continental collision with a Paleoproterozoic continental crust.

Archean/Paleoproterozoic associations of the Western and Eastern Dom Feliciano Belt are records of an older continental crust, preserved during the evolution of these belts. In the Western Belt, they comprise granulite ortogneisses of the Dom Pedrito-Bagé region (Hartmann 1998), mafic-ultramafic layered intrusions like Palma and Mata Grande, and quartzo-feldspatic orthogneisses of the Caçapava do Sul region (Remus *et al.* 1999). In the Eastern Belt, they consist of orthogneisses of the infrastructure of the Santana Dome (Jost 1981), meta-anortosites and paragneisses in the Capivarita and Encruzilhada do Sul regions, and paragneisses of the Torrinhas region (Frantz and Remus 1986). The Pre-Brasiliano associations are interpreted as part of the Rio de la Plata Craton in the Western Belt (Almeida *et al.* 1973). The Pre-Brasiliano associations in the Eastern Belt are interpreted as tangential tectonic slices from the basement, which is a Transamazonian-age continental crust (Frantz *et al.* 1999, Frantz and Botelho 2000).

THE WESTERN DOM FELICIANO BELT The Western Belt consists of supracrustal rocks and granitoids related to (1) the evolution of a juvenile magmatic arc and a back-arc basin, (2) the syn- to post-collisional phase of this magmatic arc, with tangential tectonics succeeded by transcurrent tectonics, and (3) the extensional tectonics (Fig. 2). The sequence of supracrustal rocks (Vacacaí Group) contains two units: the Bossoroca Complex, which is represented by volcanic and sedimentary rocks of a magmatic arc, and the Passo Feio Complex, represented by sedimentary and volcanic rocks of a back-arc basin. The Western Belt corresponds to the São Gabriel Block in the concept of Hartmann *et al.* (1999).

The low-K calc-alkaline diorites e granodiorites, related to the subduction of an oceanic slab, begun their emplacement at 879±14 Ma, according to a SHRIMP U-Pb age in zircon (Leite *et al.* 1998) and they represent the Passinho TTG association (Leite *et al.* 1998). This unit represents the first records of juvenile material with a magmatic arc signature.

The supracrustal rocks unit that represents a juvenile magmatic arc is the Bossoroca Complex. The SHRIMP U-Pb ages of the volcanic rocks of this unit are about 757±17 Ma (Remus *et al.* 1999), U-Pb about 753±2 Ma (Machado *et al.* 1990) and ε_{Nd} values (750 Ma) of +6.6 (Babinski *et al.* 1996). The Bossoroca Complex consists of interlayered andesitic to rhyolitic tuffs and flows, conglomerates, sandstones, pelites and minor chert and iron formations, and some basalts. The volcanic rocks have low-K calc-alkaline signatures. They have younger than 900 Ma TDM ages (Babinski *et al.* 1996). This association was defined as the Bossoroca Volcanic Arc (Remus *et al.* 1999). The metamorphism is of low- to medium-grade, with a SHRIMP U-Pb age about 699±15 Ma (Remus *et al.* 1999).

The supracrustal rocks unit related with a back-arc basin is the Passo Feio Complex. This volcano-sedimentary unit consists of slates, phyllites and pelites, carbonaceous rocks, marbles, quartzites, conglomerates, calc-silicate rocks and amphibolites. Volcanoclastics, metabasalts and magnesian schists are subordinated (Bittencourt 1983). The metamorphism is of low- to medium-grade with a SHRIMP U-Pb age of about 685±12 Ma (Remus 1999, Remus *et al.* 2000).

The second TTG unit, the Cambaí Complex, with a U-Pb age of about 704±13 Ma (Babinski *et al.* 1996), is related to a tangential tectonic phase, possibly associated with the end of the evolution of the magmatic arc and associated with the beginning of a collisional phase. The ages of this unit are very close of the metamorphic peak, considered by Remus *et al.* (1999) at 699±15 Ma on the basis of SHRIMP data. The ε_{Nd} values (700 Ma) range from +2.8 to +4.5.

Granodiorites to sienogranites from Sanga do Jobin are a syn-transcurrent unit, related to a post-collisional tectonic phase. They have a Rb-Sr age of about 661±29 with a $^{87}Sr/^{86}Sr$ initial ratio of 0.704 (Remus 1990) and e_{Nd} of +5.2 (Babinski *et al.* 1996).

Some granitoids were intruded at the end of the tectonic evolution of the Western Dom Feliciano Belt. The Lavras Granitic Complex has the same U-Pb age of about 594±5 Ma and 594±4 Ma in the core and in the margin, respectively (Remus *et al.* 1999, 2000). The ε_{Nd} values of this unit range from -0.2 to -3.0, compatible with a mixed source (Babinski *et al.* 1996). The Caçapava Granitic Complex consists of leucogranites, monzogranites, and granodiorites, with minor tonalites and quartz-diorites (Bitencourt 1983). They are calc-alcaline granitoids with a large variation in their $^{87}Sr/^{86}Sr$ initial ratios from 0.703 to 0.707 (Sartori and Kawashita 1989), and ε_{Nd} values from -10 to -19 (Babinski *et al.* 1996). SHRIMP U-Pb age is about 562±8 Ma. The isotopic data suggest a source with crustal material of different nature and age (Remus *et al.* 2000). The São Sepé Granitic Complex consists of two facies (Sartori and Ruegg 1978): a monzogranite facies with a SHRIMP U-Pb age of about 558±8 Ma, and a microgranite facies with a SHRIMP U-Pb age of about 550±6 Ma (Remus *et al.* 1999). The ε_{Nd} values for the microgranite facies are about -10, with T_{DM} age of 2.3 Ga. The isotopic data indicate a derivation from an ancient crust (Remus *et al.* 1997), with lead isotopic data for K-feldspars from core and margin facies indicating they were derived from a very primitive source, possibly granulites, at 550 Ma (Remus *et al.* 1999).

The final evolution of the Western Dom Feliciano Belt is defined with the deposition of the sediments and with the volcanism of the Camaquã Basin. The lowest sequences of this unit is intruded by the Lavras and São Sepé granitic complexes (Remus *et al.* 1999, 2000). The extensional volcanism of the Rodeio Velho Member has a poorly defined U-Pb age of about 470 Ma (Hartmann *et al.* 1998, Remus *et al.* 1999).

THE EASTERN DOM FELICIANO BELT The Eastern Belt (Frantz and Botelho 2000) consists of two supracrustal rocks units and some granitic suites (Fig. 2). The first unit, the Porongos Metamorphic Suite (Jost 1981), can be divided into two sub-units: a rift-type association with graywakes and conglomerades, and a passive margin-type association with sandstones, pelites and carbonaceous rocks. An interbedded alkali-rich tholeiitic basic volcanism (Marques *et al.* 1996)

* Instituto de Geociências, UFRGS – Av. Bento Gonçalves 9500, Porto Alegre, RS, CEP 91540-000. E-mails: frantz@if.ufrgs.br, mremus@ if.ufrgs.br, afraneo@if.ufrgs.br

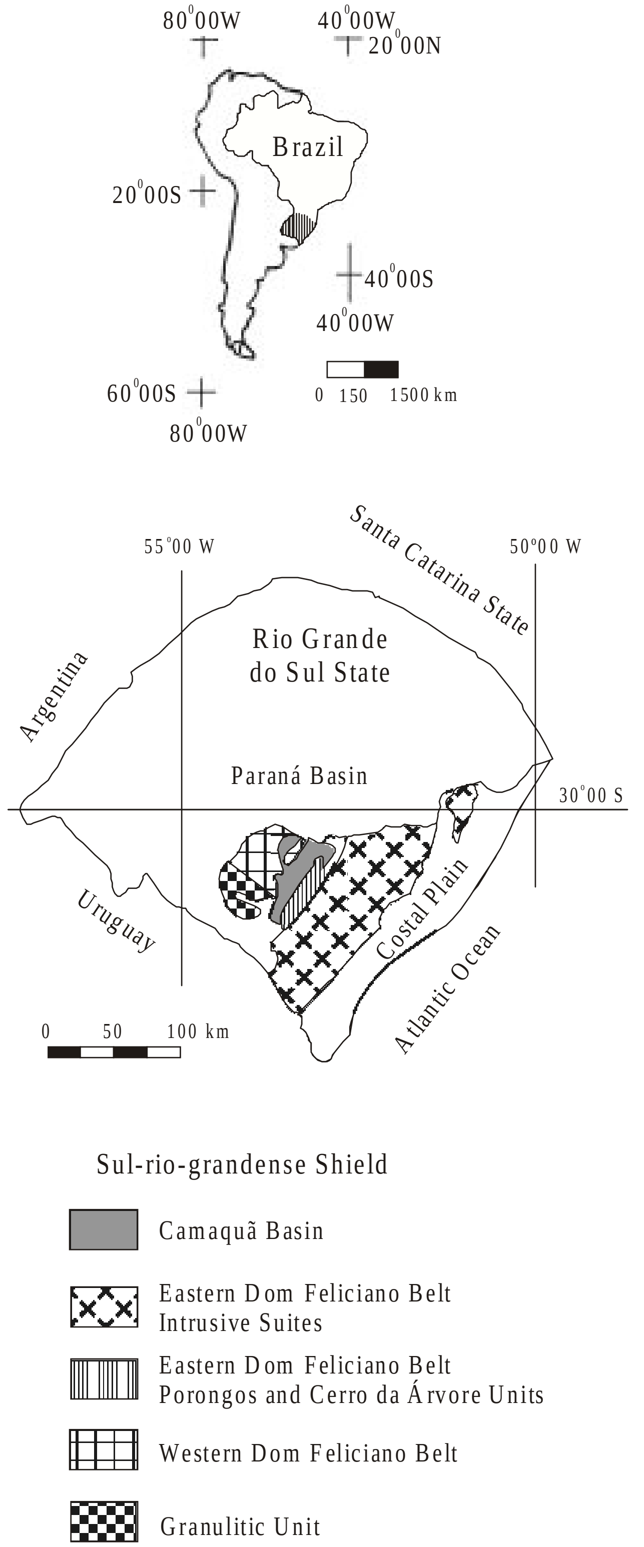

Figure 1 – Simplified sketch of the Sul-rio-grandense shield, showing the Western Dom Feliciano Belt and the Eastern Dom Feliciano Belt

has a Rb-Sr age of 884±19 Ma with a $^{87}Sr/^{86}Sr$ initial ratio of 0.702 (Soliani Júnior 1986). The Porongos Metamorphic Suite was submitted to a medium- to high-grade metamorphism. The second unit, the Cerro da Árvore Complex (Jost 1981), consists of high-K calc-alkaline dacitic- to rhyolitic-tuffs and flows submitted to a low- to medium-grade metamorphism. This unit was controlled by the tangential deformation and can be correlated with the syn-tangential granitoids of the Arroio Solidão Intrusive Suite, according to their structural controls, petrological data and ages. The SHRIMP U-Pb age of the Cerro da Árvore Complex is about 783 Ma (Porcher *et al.* 1999).

Granitoids associated with the evolution of the Eastern Belt begun their emplacement with the Arroio Solidão Intrusive Suite, controlled by the tangential tectonics, associated to the closure of the platform-type basin (Porongos Metamorphic Suite), which occurred during the continental collision. The Arroio Solidão Intrusive Suite consists of syn-tangential high-K calc-alkaline tonalites/granodiorites to monzogranites (Frantz and Remus 1986, Frantz and Nardi 1992). The Rb-Sr age of 800±32 Ma, with a $^{87}Sr/^{86}Sr$ initial ratio of 0.705 (Frantz *et al.* 1999) and the SHRIMP U-Pb age of about 780 Ma (Hartmann *et al.* 1998), indicate the beginning of the tangential tectonics and the continental collision. The T_{DM} age between 1.6 and 2 Ga and ε_{Nd} from -2 to -6 indicate crustal reworking with an interaction between mantle and older continental crust, with low degree of homogenization (Frantz *et al.* 1999, Frantz and Botelho 2000).

The transcurrent tectonics begun about 100 Ma later and controlled the intrusion of several syn- to post-transcurrence calc-alkaline granitoids, syn- to late-transcurrence peraluminous granites, post-transcurrence alkaline granitoids, and syn- to post-transcurrence basic dykes (Frantz and Remus 1986). The Arroio Moinho Intrusive Suite consists of syn- to late-transcurrence high-K calc-alkaline granodiorites and monzogranites. The Rb-Sr age about 672±22 Ma with a $^{87}Sr/^{86}Sr$ initial ratio of 0.716 (Koester *et al.* 1994) indicate the beginning of the transcurrent tectonics and the beginning of the granitic magmatism of this suite. The U-Pb age of 630 Ma (Babinski *et al.* 1996) indicates the end of the transpressive phase of the transcurrent tectonics, and the emplacement of the latest granitic bodies of the Arroio Moinho Intrusive Suite. The T_{DM} age from 1.98 to 2.06 Ga (Frantz *et al.* 1999) and -7.2 to -7.4 ε_{Nd} values, indicate a strong involvement of continental crust in their genesis but with a higher degree of homogenization of their sources than in the syn-tangential granitoids.

The Cordilheira Intrusive Suite consists of syn- to late-transcurrent crustal melting peraluminous granites (Frantz and Nardi 1992). These granites are benchmarkers of the progressive relaxation of the transcurrence tectonics. Their Rb-Sr ages are 630±22 Ma with a $^{87}Sr/^{86}Sr$ initial ratio of 0.732 and 617±48 Ma with a $^{87}Sr/^{86}Sr$ initial ratio of 0.741(Koester *et al.* 1994). The ε_{Nd} values are variable from -5.4 to -19.3 and may represent different crustal sources to the melts (Frantz *et al.* 1999, Frantz and Botelho 2000).

The high-K calc-alkaline granitic magmatism associated to the end of the transcurrent tectonic phase (post-transcurrence) consists of two suites between 600 Ma and 580 Ma (Frantz *et al.* 1999). The Campinas intrusive Suite represents a transition between the transpressive and extensive structures about 600 Ma. This suite presents granitoids with a strong involvement of an older continental crust and a heterogeneous source (Frantz and Botelho 2000). The ε_{Nd} values are variable from -8.4 to -13.2 with T_{DM} ages ranging from 1.85 to 2.2 Ga (Frantz *et al.* 1999). The Canguçu Intrusive Suite presents highly-evolved high-K calc-alkaline granitoids emplaced under an extensional regime. The Rb-Sr age is 585±13 with a $^{87}Sr/^{86}Sr$ initial ratio of 0.708. Their ε_{Nd} values range from -5.8 to -6.1 with T_{DM} ages from 1.53 to 2.27 Ga (Frantz *et al.* 1999).

The end of the granitic magmatism in the Eastern Dom Feliciano Belt consists of isolated paralkaline granitic bodies and alkaline metaluminous granitoids of the Encruzilhada Intrusive Suite.

DISCUSSION AND CONCLUSIONS

The evolution of the Dom Feliciano Belt during the Brasiliano Cycle indicates the existence of two different but integrated belts. The Western Belt resulted from the evolution of a juvenile magmatic arc/back-arc system with their initial records about 880 Ma. At this time, the records of the Eastern Belt show the existence of a spread sedimentation under a rift/passive margin regime with alkali-rich tholeiitic basalts. The relation suggests the existence of a initial subduction zone, starting the evolution of the Western Belt meanwhile the Eastern Belt was a passive margin-type basin.

The evolution of the juvenile magmatic arc/back-arc system has its most significant record in the volcanic activity between 760 Ma and 750 Ma. Its rolls the consolidation of the Neoproterozoic Juvenile Western Belt. This coincides with the closure of the passive platform-type basin with continental collision and granitic magmatism, with an older continental crust signature, at the beginning of the Eastern Belt.

The existence of a syn-tangential TTG association about 700 Ma in the Western Belt can represent the beginning of a collisional episode between the juvenile magmatic arc and an older continental crust segment. This collision can be the agent to the new compressive episode in the Eastern Belt, starting an intracontinental transpressive tectonics. The 670 Ma age syn-transcurrent granitoids are the initial records of this deformational phase.

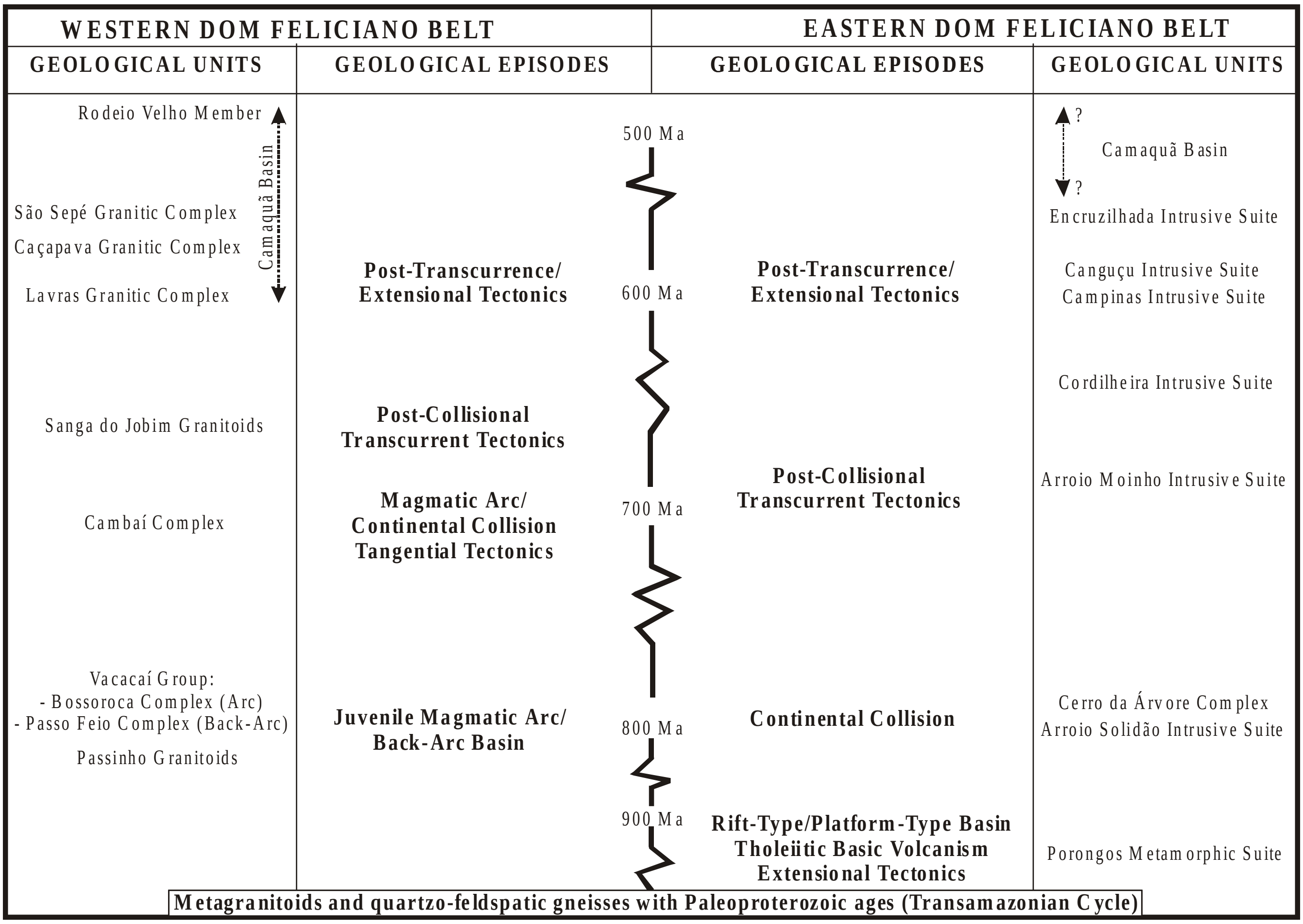

Figure 2 – Comparative sketch showing the geological episodes and associated geological units in the Western and in the Eastern Dom Feliciano Belt, southernmost Brazil.

While active, the transcurrent tectonics in the Western Belt hosted granitic intrusions between 660 Ma, as indicated by the Sanga do Jobim granitoids, and 560 Ma, by the Caçapava Granitic Complex. In the Eastern Belt, records of a transpressive tectonics can be identifying up to about 600 Ma, when a change from transtensive to an extensive tectonics took place.

The relationships between the petrotectonic associations, ages and chemistry indicate the existence of two belts with different, but related, evolutions during the Brasiliano Cycle.

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References

Almeida F.F.M., Amaral G., Cordani U.G., Kawashita K. 1973. The Precambrian evolution of the South American Craton. In: A. E. Nairn and F. G. Stehli (eds.) *The Ocean Basin and Margins*. New York, Plenum, 1411-1446.

Babinski M., Chemale Jr F., Hartmann L.A., Van Schmus W.R., Silva L.C. 1996. Juvenile accretion at 750-700 Ma in southern Brazil. *Geology*, 24: 439-442.

Bitencourt M.F. 1983. *Geologia, petrologia e estrutura dos metamorfitos da região de Caçapava do Sul, RS.* Instituto de Geociências, Universidade Federal do Rio Grande do Sul, Porto Alegre, Dissertação de Mestrado, 161p.

Frantz J.C. and Botelho N.F. 2000. Neoproterozoic Granitic Magmatism and Evolution of the Eastern Dom Feliciano Belt in Southernmost Brazil: A Tectonic Model. *Gond. Res.*, 3: 7-19.

Frantz J.C., Botelho N.F., Pimentel M.M., Potrel A., Koester E., Teixeira R.S. 1999. Relações isotópicas Rb-Sr e Sm-Nd e idades do magmatismo granítico brasiliano da região leste do Cinturão Dom Feliciano no Rio Grande do Sul: evidências de retrabalhamento de crosta continental paleoproterozóica. *Rev. Bras. Geoc.*, 29: (in press).

Frantz J.C. and Nardi L.V.S. 1992. O Magmatismo Granítico da Região Oriental do Escudo Sul-rio-grandense. Uma Revisão. *Pesquisas*, 19: 183-189.

Frantz J.C. and Remus M.V.D. 1986. Geologia da Região de Canguçu-Torrinhas,RS-Caracterização Petrográfica, Estrutural e Estratigráfica. In: SBG, Cong. Bras. Geol., 34, Goiânia, *Anais*, 2: 931-948.

Hartmann L.A. 1998. Deepest Exposed Crust of Brazil-Geochemistry of Paleoproterozoic Depleted Santa Maria Chico Granulites. *Gond. Res*., 1: 331-341.

Hartmann L.A., Nardi L.V.S., Formoso M.L.L., Remus M.V.D., Lima E.F., Mexias A.S. 1999. Magmatism and metallogeny in the crustal evolution of Rio Grande do Sul Shiel, Brazil. *Pesquisas*, (in press).

Jost H. 1981. *Geology and metallogeny of the Santana da Boa Vista Region, Southern Brazil*. University of Georgia, Athens, PhD Thesis, 208 p.

Koester E., Kraemer G., Tommasi A., Soliani Jr. E., Fernandes L.A.D. 1994. Evolução Geocronológica do Magmatismo Sintectônico à Zona de Cisalhamento Dorsal de Canguçu (RS): Dados Rb/Sr. In: SBG, Cong. Bras. Geol., 38, Camboriu, *Boletim de Resumos Expandidos*, 2: 383-384.

Machado N., Koppe J.C., Hartmann L.A. 1990. A late Proterozoic U-Pb age for the Bossoroca Belt, Rio Grande do Sul, Brasil. *Journal of South American Earth Sciences*, 3: 87-90.

Marques J.C., Roisenberg A., Jost H. 1996. Cromoespinélio como indicador petrogenético, Suíte Ultramáfica Cerro da Mineração (SUCM)-Antiforme Capané, Cachoeira do Sul-RS. In: SBG, Cong. Bras. Geol., 39, Salvador, *Boletim de Resumos Expandidos*, 6: 221-223.

Porcher C.C., McNaughton N.J., Leite J.A.D., Hartmann L.A., Fernandes L.A.D. 1999. Idade SHRIMP em zircão: vulcanismo ácido do Complexo Metamórfico Porongos. In: SBG/ Núcleo RS, I Simpósio sobre Vulcanismo e Ambientes Associados, *Boletim de Resumos*, 110.

Remus M.V.D. 1990. *Geologia e geoquímica do Complexo Cambaizinho, São Gabriel-RS.* Instituto de Geociências, Universidade Federal do Rio Grande do Sul, Porto Alegre, Dissertação de Mestrado, 267p.

Remus M.V.D., McNaughton N.J., Hartmann L.A., Koppe J.C., Fletcher I.R., Groves D.I., Pinto V.M. 1999. Gold in the Neoproterozoic juvenile Bossoroca Volcanic Arc of southernmost Brazil: isotopic constraints on timing and sources. *J. South Am. Earth Sc.*, 12: 349-366.

Remus M.V.D., Hartmann L.A., McNaughton N.J., Groves D.I., Reischl J.L. 2000. Distal magmatic-hydrothermal origin for the Camaquã Cu (Au-Ag) and Santa Maria Pb, Zn (Cu-Ag) Deposits, southern Brazil. *Gond. Res.*, 3: (in press).

Sartori P.L.P. and Kawashita K. 1985. Petrologia e geocronologia do batólito granítico de Caçapava do Sul - RS. In: SBG/ Núcleo SC, II Simpósio Sul-Brasileiro de Geologia, *Atas*, 102-115.

Soliani Jr E. 1986. *Os dados geocronológicos do Escudo Sul-Riograndense e suas implicações de ordem geotectônica.* Instituto de Geociências, Universidade de São Paulo, São Paulo, Tese de Doutoramento, 239 p.

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