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Tectono-magmatic cycles and the volcanic-plutonic evolution of the Campo Alegre-Corupá Basin – SC, Brazil

LUCAS MARTINS LINO AGUIAR DOS SANTOS

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Orientador: Prof. Dr. Miguel A. S. Basei

Coorientador: Prof. Dr. Silvio R. F. Vlach

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LUCAS MARTINS LINO AGUIAR DOS SANTOS

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Tese de Doutorado

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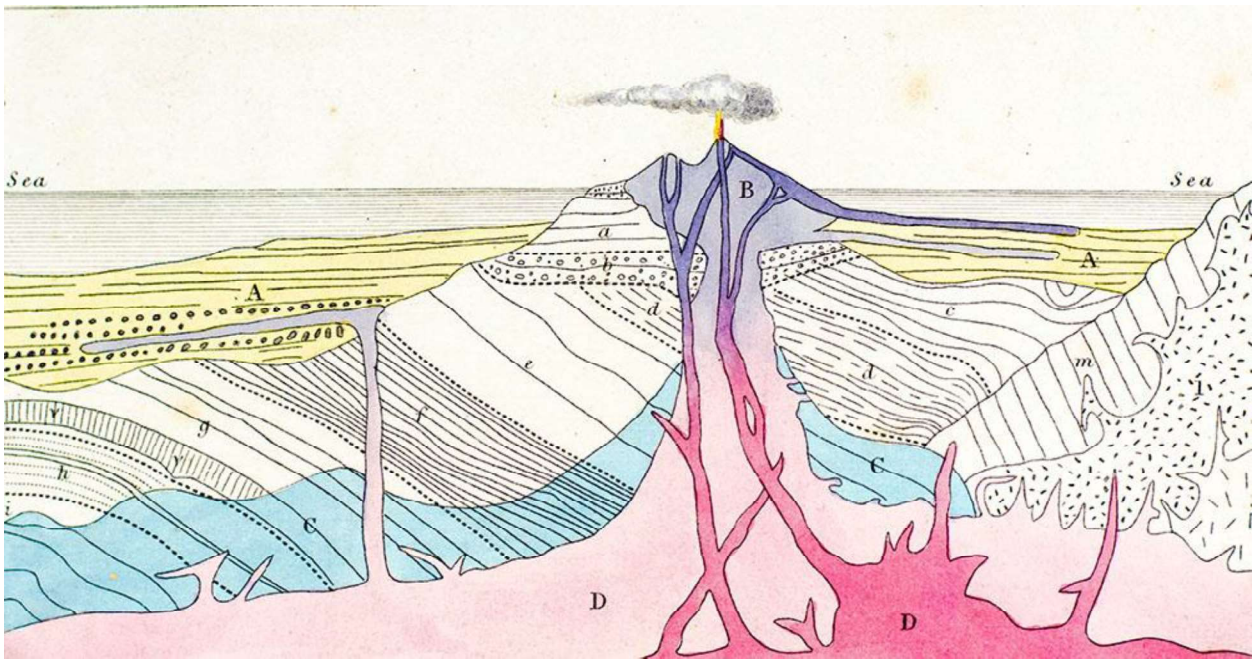
"If I have seen further, it is by standing
on the shoulders of Giants." Sir Isaac Newton



Para los que ya no están, para los que están y los que vienen

De la discussion jaillit la lumière

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"*Diante da vastidão do tempo e da imensidão do universo, é um imenso prazer para mim dividir um planeta e uma época com vocês" Carl Sagan*

Aquí estamos, siempre estamos
No nos fuimos, no nos vamos

Aquí estamos pa que te recuerde
Si quieres mi machete, él te muerde

RESUMO

Lino, L. M., 2022. Ciclos tectonomagmáticos e a evolução vulcânico-plutônica da Bacia de Campo Alegre-Corupá – SC, Brasil [Tese de Doutorado], São Paulo, Instituto de Geociências, Universidade de São Paulo, 174 p.

Pelo menos dois estágios principais de preenchimento e subsidência foram identificados na Bacia de Campo Alegre-Corupá (CACB), que são os estágios de *Bacia* e *Caldeira*. No *Estágio de Bacia*, a tectônica colisional regional desencadeou uma extensão local em ~605 ± 5 Ma através da reativação de estruturas NNW-SSE herdadas, presentes no embasamento. A deposição da bacia sedimentar termina com a Atividade Vulcânica Inicial, correspondendo a um vulcanismo bimodal levemente alcalino, predominantemente máfico e efusivo. As rochas basálticas exibem padrões de enriquecimento de elementos traços similares a OIBs, no entanto, com depleção em Nb e Ta, e assinaturas isotópicas de Sr-Nd semelhantes à crosta, sugerindo que elas foram derivadas de baixos graus (~ 5%) de fusão parcial de uma fonte litosférica enriquecida. As rochas silícicas são traquidacitos levemente alcalinos, associados a riolitos subordinados, com composições de elementos traços típicos de granitóides do tipo-A_2, produzidos por cristalização fracionada dos basaltos contemporâneos na descontinuidade *Moho*. Após a transição para um cenário pós-colisional, provavelmente em *ca.* 595 Ma, a extensão regional levou ao *Estágio de Caldeira* da bacia, que teve seu pico vulcânico em *ca.* 583-580 Ma, contemporâneo ao magmatismo intrusivo tipo-A da Província da Graciosa. A Atividade Vulcânica Principal, correspondente às rochas vulcânicas do *Estágio de Caldeira*, é constituída por traquitos e riolitos alcalinos, ocorrendo principalmente como sequências piroclásticas e exibindo concentrações de elementos traços típicos de granitóides do tipo-A_2, associados a basaltos transicionais a levemente alcalinos, exibindo assinaturas de elementos traços similares a IABs. Os basaltos do *Estágio de Caldeira* resultam de aproximadamente 15% da fusão parcial de fontes enriquecidas do manto litosférico, durante o colapso da raiz litosférica de um terreno cratônico, e as rochas silícicas são derivadas de sua cristalização fracionada na *Moho*. No entanto, um estágio adicional de diferenciação na crosta superior é necessário para explicar suas composições enriquecidas em sílica. Os produtos vulcânicos de ambas as atividades chegam à superfície através de condutos orientados NNW-SSE e ENE-WSW, respectivamente reativados e neoformados durante o processo colisional. As descontinuidades de escala crustal associadas ao desenvolvimento da bacia sedimentar controlaram ainda mais a subsidência da estrutura da caldeira, que pode ser o principal mecanismo de preservação dessas sequências vulcano-sedimentares. Isótopos de Lu-Hf de zircões detríticos sugerem um cenário tectônico do tipo arco Andino durante a história do Paleoproterozóico (~2.185 Ma) do embasamento do Terreno Luis Alves (TLA). Essa configuração tectônica foi responsável pelas assinaturas de arco das rochas derivadas da litosfera em ambiente intraplaca de ambas as sequências vulcânicas bimodais. As características isotópicas de Sr-Nd-Hf com assinaturas "crustais" resultam de uma evolução isotópica prolongada de suas fontes de manto, e cada estágio tectonomagmático resulta de uma configuração extensional diferente, que tem implicações para a metacratonização do TLA. Finalmente, a CACB consiste em uma exposição rara e excelente de rochas piroclásticas e seus plútons subjacentes cogenéticos. Elementos traços em zircões das rochas vulcânicas de todos os estágios da CACB indicam que as composições silícicas do *Estágio de Caldeira* representam líquidos altamente evoluídos extraídos de um *mush* cristalino, solidificado como uma intrusão sienítica (o plúton Corupá). Durante a evolução do sistema vulcânico-plutônico, os cristais de zircão foram capazes de rastrear as mudanças de composição associadas à extração de líquidos silícicos residuais das massas de cristais e a formação de cumulatos silícicos intermediários. Tal conexão é revelada pelo comportamento complementar das razões Eu/Eu*, Zr/Hf e Th/U entre rochas vulcânicas e plutônicas, e interpretadas como resultado de processos de segregação entre cristais e líquidos residuais.

ABSTRACT

Lino, L. M., 2022. Tectono-magmatic cycles and the volcanic-plutonic evolution of the Campo Alegre-Corupá Basin – SC, Brazil [Ph.D. Dissertation], São Paulo, Institute of Geosciences, University of São Paulo, 174 p.

At least two main stages of filling and subsidence have been identified in the Campo Alegre-Corupá Basin (CACB), namely the *Basin* and the *Caldera Stages*. In the *Basin Stage*, the regional collisional tectonics triggered the far-field stress resulting in a local extension at ~605 ± 5 Ma through the reactivation of NNW-SSE inherited basement structures. The deposition of the sedimentary basin finishes with the Initial Volcanic Activity, corresponding to a bimodal mildly alkaline, predominantly mafic and effusive volcanism. The basaltic rocks are transitional to mildly alkaline, exhibiting OIB-like trace element enrichment patterns, with depletion in Nb and Ta, however, and crustal-like Sr-Nd isotopic signatures, suggesting that they were derived from low degrees (~5%) of partial melting of an enriched lithospheric mantle source. The silicic rocks are transitional to mildly alkaline trachydacites and minor rhyolites, with trace element compositions typical of A_2-type granitoids, produced by fractional crystallization of the coeval basalts at the Moho. After the transition to a post-collisional setting, probably at *ca.* 595 Ma, regional extension led to the *Caldera Stage* of the basin, which had its volcanic peak at *ca.* 583-580 Ma, contemporaneous with the intrusive A-type magmatism of the nearby Graciosa Province. The Main Volcanic Activity, corresponding to the volcanic rocks from the *Caldera Stage*, is constituted by alkaline trachytes and rhyolites, occurring primarily as pyroclastic sequences with minor effusive lava flows, also exhibiting trace element compositions typical of A_2-type granitoids. They are associated with minor transitional to mildly alkaline basalts exhibiting IAB-like trace element signatures. The basalts from the *Caldera Stage* result from the partial melting of ~15% of enriched lithospheric-mantle sources during the lithospheric root collapse of a cratonic terrane, and the silicic rocks are derived from their fractional crystallization at the Moho. However, an additional stage of differentiation in the upper crust is required to explain their silica-enriched compositions. The products from both volcanic activities were raised to the surface mainly through NNW-SSE and ENE-WSW oriented conduits, respectively reactivated and neo-formed during the collisional process. The crustal-scaled discontinuities associated with the development of the sedimentary basin have further controlled the subsidence of the caldera structure, which might be the main mechanism of preservation for these ancient volcano-sedimentary sequences. Lu-Hf isotopes from detrital zircon suggest an Andean arc-type tectonic setting during the Paleoproterozoic (~2,185 Ma) history of the Luis Alves Terrane (LAT) basement. This tectonic setting was responsible for the arc-like signatures of the intraplate lithospheric-derived rocks of both bimodal volcanic sequences. Crustal-like Sr-Nd-Hf isotopic characteristics result from a protracted isotope evolution of their mantle sources, and each tectono-magmatic stage results from a different extensional setting, which has implications for the metacratonization of the LAT. Finally, the CACB consists of a rare and excellent exposure of both caldera-forming pyroclastic rocks and their cogenetic underlaying plutons. Zircon trace element data for the volcanic rocks from all stages of the CACB indicate that the silicic volcanic rocks from the *Caldera Stage* represent highly evolved compositions extracted from a crystal-mush solidified as a syenitic intrusion (the Corupá pluton). During the evolution of the volcanic-plutonic system, zircon crystals were able to track compositional changes associated with the extraction of residual silicic liquids from crystal mushes and the formation of intermediate-silicic cumulates. Such a connection is revealed by the complementary behavior of Eu/Eu*, Zr/Hf, and Th/U ratios between volcanic and plutonic rocks, and interpreted to result from crystal-melt segregation processes.

SUMMARY

"However, there is a pleasure in recognizing old things from a new point of view" Feynman, 1948

1. INTRODUCTION

1.1. Research motivation

During the Neoproterozoic latest stages (~610-580 Ma), the syn- to post-collisional tectonic settings in Southern Brazil plays an important role in the development of the so-called transitional basins, and the magmatism related to the establishment of Western Gondwana (*e.g.*, Basei *et al*., 1998a; Brito Neves, 2002; Teixeira *et al*., 2004). At the Santa Catarina and Paraná states, these igneous manifestations result in scattered, oval-shaped granitic bodies constituting the Graciosa Province, aligned along the Brazilian coast, as well as in the extensive bimodal volcanism covering the sedimentary units from the transitional volcano-sedimentary basins (*e.g.*, Guaratubinha, Campo Alegre, and Corupá) (Kaul, 1984; Basei *et al*., 1998a; Basei *et al*., 2009; Gualda & Vlach, 2007a; Citroni *et al*., 2001; Passarelli *et al*., 2018). Several studies, concerning especially geochronological, petrographic, and petrological aspects of these igneous rocks were done in the last decades (Basei *et al.,* 1998b; Waichel *et al.,* 2000; Citroni *et al*., 2001; Gualda & Vlach, 2007a; Vlach *et al*., 2011), indicating the possible co-genetic relationship between the plutonic and volcanic occurrences based on their similar ages, compositional aspects, and the emplacement of the A-type granitoids at shallow crustal levels. However, there are still few attempts to correlate these contrasting igneous manifestations, especially in the context of their plumbing systems and tectonic settings.

Magmatic manifestations are a clear sign of tectonism, and several igneous bodies are responsible to shape and modulate the processes of the Earth's crust creation and evolution. In the case of intrusive occurrences, they might represent remnant storages of the ancient igneous plumbing system before magma reaches the surface. For a long time, it was considered that these igneous intrusions, especially granitic occurrences, were formed by instantaneous events through the inflation of a single or a few magma pulses (*e.g.,* Menand, 2011). However, several pieces of evidence suggest that most small to large intrusions might be formed by the amalgamation of several magma batches, under varying accretion-rates (Hawkes & Hawkes, 1933; Cruden, 1998; Coleman *et al*., 2004; Glazner *et al*., 2004; Horsman *et al*., 2005; Miller *et al*., 2011, Lino & Vlach, 2021). Thus, volcanic activities represent the superficial igneous manifestations that might result from many events, in which magma transport and replenishment within deep chambers, and/or transitional storages in the crust, represent the most important ones (*e.g.*, Gonnermann & Manga, 2007). Additionally, their crystal cargo under crystallization throughout the crust can possibly record some processes underneath the surface, reflecting their

formation conditions and their entire path until reaching the surface (Davidson *et al.*, 2007a; Morgan *et al.,* 2007; Jerram & Martin, 2008).

The origin of magmas and their path throughout the Earth's crust, which might include storage and differentiation, plays a fundamental role in igneous petrology and volcanology. In this sense, a hidden puzzle piece essential to understand the behavior of volcanic manifestations comprises the Volcanic and Igneous Plumbing System (VIPS), including channels and chambers for magma production, storage, and transportation (*cf.* Burchardt, 2018). To unveil their influence in the generation of igneous bodies and in the dynamics of volcanism, a great diversity of models emerged, based mostly on textural and *in situ* analysis of single mineral phases (*e.g.,* Higgins, 1996; Morgan *et al.*, 2007; Salisbury *et al.,* 2008). On the other hand, the acting processes within the VIPS can also trigger changes in the eruptive style and the rates of physicochemical processes of the ascending magmas (Dingwell, 1996; Giordano *et al.*, 2008; Tramontano *et al*., 2017). Based on the viscosity of silicate melts and their eruptive styles, the understanding of the products during an eruption might somehow reveal important mechanisms, such as possible recharges within the chamber, variations in the local stress that might influence the dissolution of volatiles, and/or the mixing of contrasting magmas (Druitt *et al.,* 2002; Spieler *et al.,* 2004; Caricchi *et al.,* 2007; Gonnermann & Manga, 2007).

In this regard, in this doctoral research it will be introduced some possible scientific approaches to reveal the tectono-magmatic cycles, plumbing system evolution, and eruptive styles of the main volcanic rocks at Campo Alegre-Corupá Basin, correlating the genesis, storage, and chemical differentiation of magmas with their plumbing systems and tectonic settings. The mechanisms associated with the main compositional and eruptive style variations might disclose essential information about the magmatic evolution of their VIPS, probably constituted by the nearby A-type intrusions, and the tectonic setting in this area during the late stages of Western Gondwana establishment. Additionally, the structural architecture and the topography of this basin possibly results from caldera subsidence, a typical feature of silicic volcanoes in association with A-type intrusions (*cf.,* Bonin, 2007), which might explain the current configuration in this region.

1.2. Objectives and implications

The purpose of the present doctoral research is to understand the tectono-magmatic cycles/settings and mechanisms responsible to result in the extensive and well-preserved Neoproterozoic volcano-sedimentary association recorded in the Campo Alegre-Corupá Basin (CACB). The specific aims include to:

1. Characterize the structural architecture of the CACB, using structural data obtained during field works for both the basement rocks and the volcano-sedimentary sequences present in the basin. Available geophysical data will be also integrated with the structural data to draw a fear model of installation and evolution for the Campo Alegre-Corupá Basin;
2. Constrain the main episodes of development of these volcano-sedimentary sequences, based on the stratigraphy, compositional features of the volcanic rocks, and U-Pb zircon geochronology and Lu-Hf isotopy;
3. Characterize the chemical variations of whole-rock, for major, minor, and trace elements for each eruptive event to be analyzed, comparing with the available data presented for the plutonic occurrences, also including zircon trace element signatures aiming to track their possible complementary compositional paths;
4. Characterization of the nature and possible source areas of these lava flows, based on trace elements abundance and Sr-Nd-isotope signatures in the volcanic sequences, and also considering the ongoing geochronological and Hf-isotope characterization;
5. Correlate, based on compositional (major and trace elements) and isotopic signatures, the nature of the A-type granites and the associated volcanic rocks, the former possibly extracted from the granitoid magma chambers, which might result in their internal heterogeneities and architecture of chambers (Garin, 2002; Gualda & Vlach, 2007a, b; Vlach & Gualda, 2007; Vilalva & Vlach, 2014), for example;
6. Determine, employing petrogenetic and thermodynamic modeling, the magmatic mechanisms acting during the crystallization process of each magmatic unit in the Campo Alegre-Corupá Basin, and their influence on the explosive events and in the composition of the supposed associated intrusive bodies, interpreting granitic compositions and fabrics in terms of melt segregation and mineral accumulation.

In this sense, the present research has significant implications concerning the tectonic settings at the late stages of Western Gondwana consolidation, certainly the main mechanisms responsible for these igneous manifestations. Through the detailed characterization of the volcanic

manifestations and their relationship with the closest A-type intrusions, we expected to reconstruct the tectonic settings and detail the volcanic activities based on models of translithospheric magmatism, and possibly the plutonic-volcanic connection between these igneous occurrences.

1.3. Hypotheses and questions

Based on recent data suggesting a coeval volcanic manifestation during the late depositional stages of the sedimentary sequences (Quiroz-Valle *et al.*, 2019), the occurrence of a basal bimodal association of lava flows and the overlaying thick silicic alkaline, pyroclastic volcanics (Citroni *et al.*, 2001), the formation and evolution of Campo Alegre-Corupá Basin certainly result from a singular tectono-magmatic evolution. At normal conditions, arc-related basins might present some early bi-modal and incipient igneous manifestations (Ingersoll, 2001). On the other hand, late-stage igneous activities with bimodal characteristics and transitional to alkaline compositions are common in intracontinental rifts and typical of passive rifts (*cf.,* Merle, 2011). Additionally, the presence of peralkaline to peraluminous A-type granites, syenites and recently mapped porphyry dikes, emplaced at relatively shallow crustal levels, can suggest a contemporaneous and/or co-genetic origin for these rocks and the predominant silicic volcanic sequences in the CACB. In this sense, the present research project is based on the following hypotheses:

1. The Campo Alegre-Corupá Basin possibly represents a passive rift-like basin, associated with the assembling of the Gondwana Supercontinent and induced by the collisional tectonics, and the early bimodal activity results from a passive mantle-upwelling and partial melting during such tectonic setting;
2. Conversely, the bimodal and predominantly silicic, alkaline to peraluminous volcanic activity that recovers these previous volcano-sedimentary sequences results from the post-collisional tectonics;
3. The A-type granites and syenites close to CACB might represent the magma reservoirs for the volcanic rocks generated during the development of a caldera volcano. Is this association the deeply eroded remnant of a possible ring complex?
4. The geometry and internal distribution of rock types in the Corupá pluton (architecture of this magma reservoir), and the presence of radial porphyry dikes, probably suggest its connection with the volcanic rocks from main silicic volcanic activity, in which the presence of mela-syenites with cumulate-like texture (Garin, 2002) and coarse-grained syenites might represent residues generated from crystal-liquid segregation processes;
5. The composition and textures of both volcanic and plutonic occurrences suggest a connection between them, in which the architecture of the nearby magma chambers are responsible for the contrasting eruptive styles and compositional stratigraphy

registered in each stage of development of these sequences;

6. The extensional post-collisional tectonic setting plays a fundamental role in the generation, emplacement, and evolution of the volcanic rocks and the plutonic igneous manifestation in this region. Finally, the caldera collapse was responsible for the approximation between the volcanic and plutonic realms represented by the volcanic sequences at the CACB and their cogenetic magma reservoirs.

1.4. Dissertation outline

This doctoral dissertation has been organized into three main chapters, and the results obtained during the research were organized and included in three manuscripts. The current ***Chapter 1*** introduces the motivation, objectives and implications, and the hypothesis and questions that were the guide for this research. The main results raised from the present research were included in ***Chapter 2***, in which each subtopic represents a published scientific paper, a manuscript revised and recommended for publication under Minor Reviews, and another manuscript being prepared for submission in a peer-revised scientific journal.

In the first paper (***Section 2.1***), entitled "*Structural architecture and the episodic evolution of the Ediacaran Campo Alegre basin (southern Brazil): implications for the development of a synorogenic foreland rift and a post-collisional caldera-volcano*", and published by the Journal of South American Earth Sciences as part of the Special Issue "*The Precambrian to Paleozoic crustal growth of South America: From collisional to accretionary tectonics*", the structural architecture and main tectono-magmatic cycles registered in the CACB have been firstly described. To achieve such results, the structural aspects of the basement rocks have been detailed through field and aero-geophysical data, coupled with the U-Pb geochronology of the main volcanic stages recorded.

The second contribution (***Section 2.2***), entitled "*Petrogenesis and tectonic significance of two bimodal volcanic stages from the Ediacaran Campo Alegre-Corupá basin (Brazil): Record of metacratonization during the consolidation of western Gondwana*", was recommended for publication after Minor Revisions in the journal Precambrian Research. In this contribution, the petrogenesis and tectonic significance of two bimodal volcanic sequences have been detailed, each of which occurs at a different evolutionary stage of the CACB. The results presented in this contribution allowed us to constrain the tectonic settings of each tectono-magmatic stage and identify their potential magma sources. The magmatic evolutive paths of both bimodal suites constitute two contrasting plumbing systems, which demand a connection between the silicic rocks derived from shallow plutons during the caldera collapse with the nearby A-type granitoids form the Graciosa Province. Sophisticated geochemical and isotopic tools usually have a more restricted application to petrogenesis, without taking into account the tectonic implications. This contribution gives an example of how these results can be useful in answering tectonic questions.

In the third manuscript (***Section 2.3***), entitled "*Deciphering the parent-daughter relationship between high-silica ignimbrites and their complementary silicic cumulates in the upper crust*", zircon trace element and whole-rock compositions were allied to explore the temperatures and fO_2 conditions acting during the generation of the silicic volcanic rocks, and the possible relationship between the nearby plutonic occurrences and the caldera-forming ignimbrites

constituting the main volcanic occurrences in the CACB. It was possible to recognize that minor pyroclastic activities associated with Plinian-type eruptions were derived from the primary fragmentation of highly evolved silicic melts, whereas the caldera-forming eruption(s) demand large volumes of silicic melts extracted from crystal mushes at the upper crust associated with a complementary cumulate. Zircon trace element and whole-rock compositions from both the silicic ignimbrites and the Corupá pluton suggest that they represent a single plutonic-volcanic system.

Finally, ***Chapter 3*** synthesizes the results and discussions developed in the former chapter, providing an integrative summary of conclusions based on the main achievements from the studies of our research group in the CACB so far. Furthermore, two other complementary contributions were developed during the period of this doctoral dissertation. Both have been included in the master and doctoral dissertations of their first author, but they represent significant achievements in our understanding of the CACB development. The first contribution is a scientific paper entitled "*Petrography and detrital zircon U-Pb geochronology of sedimentary rocks of the Campo Alegre Basin, Southern Brazil: Implications for Gondwana assembly*", published by the Brazilian Journal of Geology (Quiroz-Valle *et al*., 2019). In this contribution, the provenance of the sedimentary rocks from the basal units in the CACB reveals their derivation from the Luis Alves Terrane, associated with other source areas such as the Curitiba Terrane and the Piên Magmatic arc. The recognition of volcanogenic fragments and the youngest zircon crystals in the uppermost sequences of the sedimentary units also suggest that the volcanic activities were initiated during the final stages of sedimentary deposition.

The second contribution (Quiroz-Valle *et al*., in review) is a manuscript recently recommended for publication under Minor Reviews in the journal Gondwana Research, entitled "*Paleovolcanology, geochemistry, and zircon U-Pb-Hf isotopes of the volcano-sedimentary sequences from the Ediacaran Campo Alegre-Corupá Basin, southern Brazil: linking volcanism and tectonics during Western Gondwana consolidation*". In this contribution, a detailed lithofacies characterization coupled with zircon U-Pb geochronology and Lu-Hf-isotopic signature of both the volcanic and sedimentary units from the CACB, and whole-rock compositional aspects are presented, suggesting the occurrence of contrasted volcanic activities that are archetypal of intra-plate settings. The conclusions drawn in both manuscripts will be considered in the results and final chapter of this doctoral dissertation.

3. SYNTHESIS, CONCLUDING REMARKS, AND FUTURE RESEARCH

Based on the results and discussions synthesized by our research group in the three manuscripts that constitute this doctoral dissertation, as well as two other contributions produced in the last four years (*e.g.*, Quiroz-Valle *et al*., 2019, 2023), a geological, geochronological, and tectono-magmatic model for the evolution of the Campo Alegre-Corupá has been proposed. Considering such achievements arising from a wide diversity of methods and lines of investigation, the conclusions are the following:

- The internal and surrounding structural architecture, and the geochronological register of several volcanic activities in the Campo Alegre-Corupá Basin, allow interpreting this volcano-sedimentary sequence as resulting from contrasting episodes of extensional tectonics. It was probably initiated by the collisional setting through the reactivation of inherited basement anisotropies and the extension might increase before the break-off of the Luis Alves Microplate slab. In this sense, two stages of extensional tectonics and volcanism have been defined, namely the *Basin Stage* (605-590 Ma) and the *Caldera Stage* (583-577 Ma). The *Basin Stage* results in the installation of an *impactogene* (synorogenic passive rift), whereas the same structures that gave rise to the rift also modulate the caldera collapse in the form of a "graben-caldera" (*e.g.*, Quiroz-Valle *et al*., 2019, 2023; Lino *et al*., 2021, 2023);
- The stages of extensional tectonics results initially in a passive upwelling of the asthenospheric mantle followed by the erosion/root-collapse of the lithospheric mantle, respectively. Both result in relatively low degrees of partial melting of enriched regions of a heterogeneous cratonic lithospheric mantle, producing OIB-like and IAB-like basalts that intrude in the Moho discontinuity being subsequently submitted to extensive fractional crystallization. Each extensional stage has been associated with the destruction of the cratonic lithosphere from the Luis Alves Terrane, further influencing its metacratonization (*e.g.*, Lino *et al*., 2023);
- The silicic magmas generated during each stage were able to reach the surface and result in the trachydacitic lava flows and the diluted pyroclastic sequences from the Initial Volcanic Activity, whereas large silicic magma reservoirs were emplaced at shallow crustal levels and fed the voluminous trachytic to rhyolitic eruptions from the Main Volcanic Activity as lava flows, domes, and extensive pyroclastic sequences. Based on the complementary whole-rock and zircon trace element compositions, the volcanic silicic

rocks from the *Caldera Stage* and the Corupá pluton were interpreted as a single volcanic-plutonic system (*e.g.*, Quiroz-Valle *et al*., 2023; Lino *et al*., in prep.).

Supported by the fractional crystallization models conducted in **Section 2.3** using the rhyolite-MELTS algorithm, a significant interplay between the thermodynamic behavior of crystallizing magmas and the crustal thermic state has been suggested to explain the prevalence of intermediate volcanic compositions at the Guaratubinha Basin and the bimodal compositional spectra recorded in the Campo Alegre-Corupá. Both volcanic activities might result from a passive upwelling of the asthenosphere and partial melting of the cratonic lithospheric mantle induced by collisional tectonics (*cf.* Lino *et al*., 2023). However, the northern sector of the Luis Alves Terrane has been submitted to relatively high warming (Siga-Jr *et al*., 1993), which might be the conditions that modulated the preferential extrusion of the transitional, intermediate volcanic compositions. To test such a hypothesis, we have computed numerical thermic models simulating basaltic magma chambers at contrasting geothermic conditions. Hitherto, our preliminary results support the role of the lithospheric thermic state over the erupted compositions. For models conducted under constant geothermal gradients smaller than 20°/km, we were able to reproduce a bimodal compositional spectrum in which the basic compositions are predominant during the initial stages, being further substituted for trachydacites-rhyolites in the late evolution. On the other hand, for models conducted under warmer conditions (geotherm > 20°C/km) there is a predominance of intermediate compositions over the entire time of computing (300 ka).

Additionally, textural and compositional patterns from both the Campo Alegre-Corupá volcanic sequences and the Corupá pluton are suggestive of crystal-liquid segregation processes within shallow, zoned magma reservoirs. Such a connection can explain the sienites from the Corupá pluton as a residual/cumulate crystal mush, whereas the silicic volcanic rocks that constitute the caldera-forming eruptions in the CACB represent the complementary extracted melts. From both parameters, we were able to predict that the crystal-liquid segregation process initiated at relatively low crystal contents (between 10-30 vol.%), for high volumes of extracted residual liquids (46-80 vol.%). Our results confirm the hypothesis of a connection between both occurrences while providing a quantitative estimation for the rate between crystals and silicic liquids segregated in the upper crust before the caldera-forming eruption(s). Although both the numerical thermodynamic and the textural models already have preliminary results confirming the discussions present in the main manuscripts exposed in this doctoral dissertation, they are still being prepared and represent future contributions also derived from this research.

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