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EDITORIAL

50 years of Isotope Geology in South America – Scientific Highlights from the 9th South American Symposium on Isotope Geology

50 anos da Geologia Isotópica na América do Sul – Destaques do 9º Simpósio-Sul Americano de Geologia Isotópica

On April 2014, over 250 members of the South America Earth Sciences community gathered at the Universidade de São Paulo, Brazil, for the 9th South American Symposium on Isotope Geology – 9th SSAGI. The symposium is a traditional scientific meeting in South America and it has been organized since 1997 in different countries of our continent, including Brazil, Argentina, Chile, Uruguay and Colombia. The motivation to hold the 9th SSAGI in São Paulo was to celebrate the 50th anniversary of the Geochronological Research Center (CPGeo). The establishment of the first K-Ar laboratory in South America at the Universidade de São Paulo (USP) was only possible due to Professor John Reynolds' effort (University of California at Berkeley) and a USA National Science Foundation grant that permitted the acquisition of a mass spectrometer. The center was operated since 1964 by Umberto Cordani, Koji Kawashita, and Gilberto Amaral. Professor Reynolds came to the Universidade de São Paulo for a sabbatical leave and helped to set up the laboratory facilities, obtaining the first K-Ar ages on basalts from the Paraná Basin. Further work permitted the Brazilian team to contribute to the tests of the Continental Drift hypothesis, providing ages to show the fitting of the African and Brazilian continents before the opening of the Atlantic Ocean.

A reconnaissance geochronological study was done in the entire Brazilian territory during the 1970's and 1980's, especially when the Rb-Sr radiometric method was implemented at the CPGeo. Improvements were possible after the acquisition of two VG-354 and a Finnigan Mat multicollector mass spectrometers in the late 1980's and during the 1990's which allowed to implement new methods, such as Sm-Nd, Pb-Pb, U-Pb, and Re-Os. Improvements in these methods were possible with the acquisition of the Triton, in 2005, and Thermo Fisher Neptune Plus in 2013. The latest allowed CPGeo researchers to carry out non-traditional isotopes analysis, such as Zn and Cu, expanding the applications of isotope geochemistry to environmental sciences research.

New facilities for stable isotope analysis were set up at the CPGeo around 2000, allowing to perform C, O and D isotope analysis in carbonates and water samples. In 2003, Ar-Ar dating was also implemented at the CPGeo. Professor Paulo Vasconcelos, from University of Queensland, was crucial to implement that methodology, which is now being optimized after the acquisition of a new Argus VI Mass Spectrometer in 2013.

Thanks to major acquisitions in 2010, researchers at CPGeo can now carry out in situ isotopic measurements (e.g., U-Pb and Lu-Hf). Uranium rich minerals can now be analyzed for U-Pb isotopic ratios using a LA-ICP-MS Neptune or a Sensitive High Resolution Ion MicroProbe (SHRIMP IIe). The SHRIMP, a multicollector ion microprobe, installed at the CPGeo, still is the first equipment available in South America, making the CPGeo one of the few laboratories in the world with such a large isotope facility complex.

During the past 50 years, CPGeo has had a very satisfactory trajectory, becoming an important center of isotope geology research in South America. The center has welcomed more than three hundred students and researchers from other states of Brazil, as well as from international institutions, including not only South American partners but also researchers from North America, Europe, India, and so many others.

To celebrate the CPGeo achievements, we invited 12 keynote speakers and other 12 researchers to present state-of-the-art themes in different fields of isotope geology at the 9th SSAGI. In addition, a total of 250 attendees communicated their research as conference posters. The SSAGI participants were invited to submit their scientific contributions for a special

volume of the Brazilian Journal of Geology. In this issue we have 12 papers showing the contribution of the isotope geology to the understanding of geological processes.

Crustal evolution has been described by four papers. **Cordani *et al.*** presented new SHRIMP and LA-ICP-MS U-Pb results for the NW corner of the Amazon craton, covering a large area of the Amazonas territory in Brazil, Colombia and Venezuela. This is an important contribution helping to build and integrate the history of the Rio Negro-Juruena tectonic province. The new U-Pb data, with previous isotopic information, indicate that the formation of this province is dominated by rock series of essentially juvenile magmatic arcs, that are closely related with subduction. Sm-Nd analyses indicate that all samples, regardless of their zircon ages, yielded T_{DM} model ages roughly between 1.9 and 2.2 Ga, suggesting the absence of a much older source material.

An up-to date reinterpretation of the structural framework and role of the Cabo Frio Tectonic Domain (**CFTD**) in the SE Brazilian margin is presented by **Schmitt *et al.*** The basement of the **CFTD** is considered as part of the Angola Block of the Congo craton that was involved in a major continental collision with the Neoproterozoic Oriental Terrane of the Ribeira Orogen during the Cambrian Búzios Orogeny. As geophysical evidence suggests the Mesozoic breakup of the central segment of the South Atlantic occurred within the ancient continental margin of the Angola block, the Cambrian collisional orogeny represents a major belt that is mostly submerged today. Taking into account that the Early Cambrian is also the time of a major continental collision event all along SW Gondwana, the importance of this episode during the final Gondwana amalgamation has been so far probably underestimated.

The tectonic evolution of the Brasília Belt on the light of ID-TIMS, ion microprobe and LA-ICP-MS U-Pb geochronological data published mostly over the last ten years have been discussed by **Pimentel**. Formed during the complex 900 – 600 Ma convergence of the Amazonian, São Francisco-Congo, Paranapanema, and West African paleocontinents, the Brasília belt is larger than envisaged previously. Sedimentary sequences of the belt mainly represent either older passive margin sequences derived from the erosion of the São Francisco craton or sequences dominated by Neoproterozoic detrital zircon populations, as young as 0.65 Ga, suggesting derivation from the Goiás Magmatic Arc (GMA). In turn, the GMA represents a composite arc terrain, formed by the accretion of older (ca.0.9-0.8 Ga) intraoceanic island arcs, followed by more evolved continental arcs.

A large set of ages determined by different radiometric methods on igneous, metamorphic and sedimentary rocks, allowed **Philipp *et al.*** to present the evolution of the Dom Feliciano Belt in southern Brazil and Uruguay, which has evolved during three orogenic events named: Passinho (0.89 – 0.86 Ga), São Gabriel (0.77 – 0.68 Ga), and Dom Feliciano (0.65 – 0.55 Ga). The paper shows that the Dom Feliciano Belt had a long-lived evolution of ca. 450 M.y. starting with the opening of the Charrua ocean in the southwestern part of the Gondwana at ca. 0.95 Ga. The closure of this ocean, generating an intraoceanic arc, took place during the Passinho orogeny, followed by the formation of a continental arc during the São Gabriel orogeny. The collision of the Nico Perez Microplate/Rio de la Plata Craton and Kalahari and Congo cratons occurred at ca. 650 Ma due to the closure of the Adamastor ocean. These tectonic processes culminated with the formation of the Pelotas batholith. The orogenic collapse is represented by the late magmatism of the Pelotas batholith and deposition of the upper section of the Camaquã basin.

The **mantle sources** involved on the genesis of the Mesozoic tholeiite dykes from the Southern Espinhaço, São Francisco Craton, have been investigated by **Marques *et al.*** This study presents the first Pb isotope data of the high-Titholeiite dykes. A detailed investigation about the risks of Pb contamination during sample preparation is presented. The Pb data, combined with published geochemical and Sr-Nd isotope results, rule out crustal contamination processes in the genesis of the dykes, requiring magma generation in a metasomatized subcontinental lithospheric mantle with the involvement of HIMU-type and carbonatite mantle components.

Provenance studies, based on U-Pb data on detrital zircons and Sm-Nd whole rock data from metasedimentary rocks of the Piriá basin, and implications for the evolution of the Gurupi Belt, represent the contribution of **Lopes *et al.*** The U-Pb data indicate that sources with ages ranging from Archean to Neoproterozoic fed the basin. Possible additional sources have not been identified in the area. The data suggest that proximal felsic to intermediate rocks, as well as recycled sedimentary sources, provided the detrital material. The youngest zircon dated at 590 Ma set the maximum depositional age of the Piriá basin, which has been interpreted as a post-orogenic basin related to the final stages of the Brasiliano orogeny in the Gurupi belt.

Chemostratigraphy studies have been presented by three papers carried out in sedimentary successions of different ages. **Kuchenbecker *et al.*** present high resolution C, O and Sr isotope, as well as lithochemistry data on carbonate rocks from the lower Bambuí Group, recovered from drill cores from the southwestern São Francisco basin. In the section, a diamictite layer is covered by impure carbonates with aragonite pseudomorph fans, followed by limestones and stromatolitic dolomites. The $\delta^{13}C$ data show negative values (-4‰) at the base, followed by values around 1‰ for most of the section and a sharp change to positive values (up to 8‰) in the top. The Sr isotope ratios for most of the samples range from 0.7075

to 0.7077. The data allowed the authors to interpret a diamictite/cap carbonate pair assigned to one of the Neoproterozoic glaciations, and to discuss the tectonic, climatic and paleogeographic framework of the Gondwana assemblage.

Isotope stratigraphy along with sedimentological and petrographic data have been used by **Silva-Tamayo *et al.*** to show that the Kesima Member of the Palanz Formation represents the first record of Cretaceous marine deposits along the Baja Guajira basin in the northern Colombia. The Sr isotope ratios of 0.70735 and 0.70740 suggest a Valanginian (136 – 132 Ma) depositional age of these carbonates. In addition, a carbon positive anomaly recorded in the carbonates, showing $\delta^{13}C$ values of 2.5‰, could represent an oceanic anoxic event known as Weissert event. The authors use the data to reconstruct the evolution of the sedimentary environment, correlate the section at global scale, and revise the paleotectonic evolution of the area through the Jurassic and the Cretaceous.

Chemostratigraphic data combined with mud gas carbon isotope analysis from two wells from the Neuquén basin, Argentina, are discussed by **Ostera *et al.*** The Neuquén basin is located in west-central Argentina, on the eastern side of the Andes, and it is one of the most promising basins for oil and shale gas exploration in South America. Particularly, the black shales of Los Molles, Vaca Muerta, and Agrio formations are very prolific source rocks for oil, condensate, and gas throughout the basin. Carbon isotope analysis suggest that the gas composition of shales and conventional plays have been affected by complex processes, such as addition of microbial methane, biodegradation of ethane-propane, and mixing of gases.

The applicability of isotopes to discriminate pollution sources in **environmental studies** has been the subject developed by **Oliveira *et al.*** In this contribution the authors use stable Pb isotopes and Pb concentrations to demonstrate the anthropogenic effects in the estuarine environment of Belém, Pará state of Brazil. Isotopic data was obtained on bottom sediments from the western margin of the Guajará bay and the Carnipijó river, and the results show that the river has not been affected by contaminants, since the isotopic signatures are the same of the background area. However, the Guajará bay sediments show less radiogenic isotope ratios demonstrating that the domestic and industrial wastewater from Belém affected the western margin of the bay.

The last two papers of this special issue deal with **new developments and applications** on optically stimulated luminescence (OSL) dating and in situ Sr isotope analyses by LA-MC-ICP-MS. **Sawakuchi *et al.*** present the basic principles of OSL dating, along with examples of OSL dating of Late Holocene to Late Pleistocene sediments from coastal and continental settings in Brazil. OSL dating of detrital quartz grains is a promising method to determine depositional ages of carbonate fluvial sediments. Investigation of the potential of isothermal thermoluminescence (ITL) signal in dating older Brazilian sediments from the Xingu River is also discussed. Moreover, the authors call for further development to determine the reliability of ITL dating of Brazilian quartz. **Munoz *et al.*** describe the successful implementation of in situ Sr isotope analyses by LA-MC-ICP-MS at the CPGeo-USP. The paper provides detail information about analytical conditions, data reduction, and petrogenetic applications of in situ Sr isotope measurements. Measurements of Sr isotopes carried out invariable matrices (e.g., plagioclase, apatite, carbonates, and clinopyroxene) from different geological scenarios, reveal the high potential of the technique to unravel complex igneous processes such as magma mixing, source-inherited isotope heterogeneity, and contamination processes.

The 12 papers included in this special volume provide an interesting snapshot of the current research developments in isotope geology and related areas. These papers also provide clear evidence that, despite of the new developments, there are still advances to be made in isotope geochemistry and its application to a range of scientific issues. As editors, we would like to thank all authors for preparing and submitting their contributions. We also like to thank the many colleagues who reviewed the papers and, in the process, provided constructive comments that enabled the authors to improve the content and clarity of the papers presented in the present issue. Finally, we would like to thank Professor Umberto Cordani for his efforts in helping create and further develop the Geochronological Research Center at Universidade de São Paulo, and also for inviting us to edit this special issue for the Brazilian Journal of Geology to celebrate the 50 years of isotope geology research in South America.

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