

APPLICATION OF ENVIRONMENTAL ISOTOPES IN WATER RESOURCES STUDIES IN LATIN AMERICA

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The development of urban centers and economical activities, such as agriculture and mining, in Latin America are intimately linked to the availability of water resources. The increasing demand for water and the risks associated to contamination have generated numerous studies related to the evaluation of water resources in this region. In the specific case of groundwater studies, environmental isotopes have played a significant role in these studies (^{18}O , ^2H , ^{14}C , ^{13}C). Groundwater provides about 50-60 % of the water resources used in Latin America. Large urban centers such as Lima (Peru), Managua (Nicaragua) and San Jose (Costa Rica) depend mainly on groundwater as a water supply for the population. The agriculture sector is also a major user of groundwater. The Isotope Hydrology Section of the International Atomic Energy Agency based in Vienna has mainly promoted the application of isotope techniques in Latin America. Most of these applications have focussed on the evaluation of the origin and residence time of the groundwater. The groundwater origin is intimately linked to recharge areas whose evaluation is key for the water balance of the aquifer. The evaluation of the groundwater residence time provides information that is relevant for the management of the groundwater system. This presentation will discuss the basic principles of the application of environmental isotopes in hydrology and it will review the current application of isotope techniques in Latin America. Case studies from different Latin American countries will be used to illustrate the main type of application of isotope techniques in groundwater studies in this region.

NEW PERSPECTIVES ON $^{40}\text{Ar}/^{39}\text{Ar}$ GEOCHRONOLOGY AND TIME SCALES FROM PLINIUS TO COPERNICUS

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Now well into its fourth decade of usage, the $^{40}\text{Ar}/^{39}\text{Ar}$ method has matured into a routine geochronological tool of unsurpassed geological scope. Its exceptional time range of applicability, high analytical precision, and relatively low cost are key factors in establishing the method's prominence. As a calibrant of the geologic time scale, $^{40}\text{Ar}/^{39}\text{Ar}$ is by far the dominant method for the Cenozoic and Mesozoic Eras, and with appropriate attention to detail, will be an increasingly important factor into the Paleozoic. Applicability to processes as diverse as Quaternary paleoclimate studies, thermal histories of crystalline basement, Proterozoic to Holocene volcanism, and early Solar System evolution illustrate the singular breadth of the method's utility. Creative new applications continue to expand the scope of the method at a rapid pace. It seems now appropriate to reflect on current limitations of the $^{40}\text{Ar}/^{39}\text{Ar}$ method. Clearly there is substantial room for improvement in ultimate calibration of the method, as uncertainties related to neutron fluence monitors and the ^{40}K decay constants currently limit accuracy (c.f. precision) to about $\pm 2\%$, i.e. about a factor of 10 worse than commonly achievable precision. These limitations are currently being addressed in several laboratories, and significant improvements will be made over the next few years. Improved measurement sensitivity would also be desirable, mainly for enabling analysis of smaller/younger/less potassic materials. Such progress, through improvements in ionization and detection efficiencies, are inevitable but must be accompanied by reductions in procedural blanks in order to be useful. Thus, vacuum technology must improve before ultrasensitive methods such as magneto-optical traps and/or time-of-flight techniques can be harnessed to their potential for $^{40}\text{Ar}/^{39}\text{Ar}$ dating. Further progress also remains to be made in circumventing the collateral effects of neutron irradiation on samples, especially the recoil of ^{39}Ar and ^{37}Ar , potentially through the use of monochromatic neutron sources. Process automation now enables rapid accumulation of large data sets, and their meaningful interpretation in some cases challenges existing conventions. Considerable improvement is needed in the sophistication with which data analysis is conducted. Progress in this area will become more critical as sensitivity enhancements inevitably reveal increasing complexities in the $^{40}\text{Ar}/^{39}\text{Ar}$ systematics of materials.

OXYGEN-ISOTOPE MAPPING AND EVALUATION OF PALEO-HYDROTHERMAL SYSTEMS ASSOCIATED WITH SYNVOLCANIC INTRUSIONS AND VMS DEPOSITS

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Oxygen isotope mapping of four syn-volcanic intrusive complexes in Canada and one in Sweden during a CAMIRO-GSC project (94E-07) was applied to delineate and quantitatively evaluate paleo-hydrothermal systems associated with volcanic-associated massive sulfide (VMS) deposits. The resulting oxygen isotope maps illustrate the paleo-distribution of heat and fluids, and offer a potential aid to exploration. Isotopic data may be contoured to reveal zones of ^{18}O depletion and enrichment, relative to unaltered rocks. Zones of $\delta^{18}\text{O} < 6.0\text{‰}$ comprise rocks that have reacted with seawater at high (e.g., $300\text{+}^{\circ}\text{C}$) temperatures, supplying many of the constituents of VMS deposits. The volume of footwall rocks isotopically depleted by such seawater/rock interaction is proportional to the amount of heat available from the syn-volcanic intrusive center. In contrast, rocks bearing evidence of isotopic enrichment (e.g., $\delta^{18}\text{O} > 9.0\text{‰}$) typically may be found in hanging wall sequences, having formed subsequent to most alteration and mineralization. Thus, terrane between high- and low- $\delta^{18}\text{O}$ zones is prospective. At the camp or district scale, discordant up-flow zones clearly indicated by isotopic mapping serve as local vectors for exploration.

Neither the grade of regional metamorphism, nor the accompanying deformation has diminished the value of isotopic mapping. Among the areas studied, the grade of regional metamorphism varied from prehnite-pumpellyite facies to lower-amphibolite facies. Regional metamorphism does not generally disturb the isotopic record of paleo-hydrothermal activity at the hand-specimen scale, although the shape of isotopically depleted and enriched zones typically reflects the strain pattern of the host rocks. Isotopic techniques can distinguish hydrothermally altered domains from regionally metamorphosed rocks with similar mineralogy, as well as the ages of intrusions relative to hydrothermal activity.

HETEROGENEOUS $^{40}\text{Ar}/^{39}\text{Ar}$ LASER PROBE APPARENT AGES IN LOW-GRADE MYLONITIC ROCKS: CONSTRAINING A MEANINGFUL GEOLOGICAL AGE

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Mylonitic rocks show very complex isotopic patterns at the sample scale. Very fine grained white-mica aggregates, genetically associated with low-grade mylonitic deformation, were studied in order to better understand isotopic distribution of argon in complex systems.

Heterogeneous $^{40}\text{Ar}/^{39}\text{Ar}$ laser probe apparent ages were obtained. The age distributions range from 100 to 200 Ma and define three age groups: younger ages (105-130 Ma), intermediate ages (145-175 Ma) and older ages (190-200 Ma). Although some intermediate and older ages are attributed to ablation of adjacent phases, inverse isochron analysis indicates that most of them contain excess argon, probably incorporated during mica formation. Therefore, only the younger ages group have a geological meaning. Microstructural studies suggest that deformation temperature lies in the vicinity of the argon closure temperature for white mica and that mica formation is coeval with the mylonitic deformation. Then, deformation events will be constrained by the younger age group (105-130 Ma).

Complex argon distribution in low-grade mylonites suggest the need of high spatial resolution studies to correctly interpret otherwise inconsistent apparent ages. By combining electron microscopy studies, electron microprobe analyses and *in situ* $^{40}\text{Ar}/^{39}\text{Ar}$ laser probe analyses it is possible to better understand the geological significance of argon isotopic variation at the sample scale.

K-Ar DATING IN CELADONITE: A CONTRIBUTION TO TIMING OF A VERY LOW-GRADE METAMORPHISM IN THE CENTRAL ANDES OF CHILE

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Mylonitic rocks are relevant to structural geologists because they are thought to be the last rocks to be deformed in a tectonic belt. A single K-Ar age determination was carried out on celadonite from a vug of a volcanoclastic rock. This celadonite crystallized at the rim of an amygdale followed by corrensite and chlorite. It yielded an age of 101.3 ± 2.9 Ma. About 100 m above the sample locality carbonates occur which are of Tithonian age based on the occurrence of several ammonites. This indicates that the crystallization of celadonite occurred at least 45 Ma after the deposition of the carbonates. Celadonite is a widespread alteration mineral on the ocean floor forming at surface temperatures. Since the age of the celadonite is considerably younger than the depositional age of the overlying carbonates, it is assumed that the radiometric age of celadonite may represent either formation during diagenesis or regional low-grade metamorphism.

The K-Ar age on celadonite of 101.3 ± 2.9 Ma determined in this study is similar to the age of a White Tuff of 104 Ma which lies stratigraphically above the calcarenites of the Baños del Flaco Formation in the study area. These two age values are unique compared with reported ages of intrusive and extrusive rocks, and no major magmatic event is known for this time within the study area. At this stage of the work the meaning of the celadonite age is not clear because the celadonite age may indicate its formation under diagenetic or very low-grade metamorphic conditions.

The two examples presented in this contribution confirm the great problems encountered when trying to determine the absolute timing of deformation in mylonitic rocks. Besides targeting those grains that are believed to have recrystallized or neofomed/deformed during mylonitic deformation, one has to take into account all the analytical isotopic data available in order to critically assess the actual meaning of ⁴⁰Ar-³⁹Ar apparent ages on high-strain rocks.

THIRTY-FIVE YEARS OF GEOCHRONOLOGY IN URUGUAY

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Geochronology of Uruguayan rocks and minerals obtained abroad has improved considerably the understanding of the geological relationships. Up to 1965, the Pre-Devonian rocks in Uruguay were divided into Archean and Algonquian, but no geochronology or fossil controls were available. In 1967 a first model was proposed, based mainly on the work of Hart, identifying the Antiguo and Moderno orogenic cycles.

A detailed description of the evolution of knowledge of the crystalline basement is presented. The updated model is based on detailed mapping and supported by U-Pb SHRIMP dating. It shows major advances in the understanding of Uruguayan geology, attained as a result of careful examination of each piece of radiometric information in its geological context.

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ABSOLUTE TIMING OF DEFORMATION IN MYLONITIC ROCKS: IS IT POSSIBLE TO OBTAIN?

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Mylonitic rocks are relevant to structural geologists because they are thought to record the kinematics and timing of deformation along ductile shear zones. While deformation paths are commonly interpreted directly from diagnostic microstructures such as asymmetric porphyroclasts systems and S/C fabrics, the absolute timing of deformation is less straightforward to obtain.

It has become widely accepted in recent years that mylonitic rocks are difficult to date by any method; specially meaningless are those dates produced from bulk mineral separates that contain no information on the structural position and kinematic significance of the analyzed minerals. Although great advancements have been recently made by using the laser probe to conduct *in situ* ⁴⁰Ar-³⁹Ar apparent age determinations in K-bearing deformed minerals, the problem remains when interpreting the actual meaning of those dates in terms of kinematic history.

This contribution presents and discusses two distinctive case studies. The first concerns the dating of a very young greenschist facies condition S-C mylonitic granodiorite. *In situ* ⁴⁰Ar-³⁹Ar apparent ages range from ~4 to 15 Ma and are interpreted in terms of absolute deformation ages and local excess Ar. A second sample is a sub-greenschist facies condition porphyroclastic tuffaceous mylonite. Total fusion *in situ* ⁴⁰Ar-³⁹Ar apparent ages on neocrystallized white mica range from 100 to 200 Ma and are interpreted as geologically meaningless ages with excess Ar, static cooling ages and absolute ages of deformation.

The two examples presented in this contribution confirm the great problems encountered when trying to determine the absolute timing of deformation in mylonitic rocks. Besides targeting those grains that are believed to have recrystallized or neoformed/deformed during mylonitic deformation, one has to take into account all the analytical isotopic data available in order to critically assess the actual meaning of ⁴⁰Ar-³⁹Ar apparent ages on high-strain rocks.

NEW BATCH SYSTEM FOR ^{14}C ACCELERATOR MASS SPECTROMETRY (AMS): GRAPHITE TARGETS PREPARATION AT THE INGEIS LABORATORIES, ARGENTINA

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At present a new batch system for the production of graphite from CO_2 is functioning at the INGEIS- ^{14}C laboratory. The main goal of the system is to do specific targets by catalytic reduction for a new AMS system which is being installed in the building of the Autoridad Regulatoria Nuclear.

There are two methods for determining very low concentrations of radionuclides: measuring the radiation emitted by their radioactive decay or measuring the particular atoms themselves.

In one mg of carbon there are 5×10^{19} stable ^{12}C atoms. Since the global atmospheric ratio $^{14}\text{C}/^{12}\text{C} = ca 1.2 \times 10^{-12}$, it contains 6×10^7 atoms of ^{14}C and only one of these atoms decays in one hour. Conversely, this one mg used up in the ion source of an AMS can collect 6×10^5 ^{14}C atoms. This example clearly shows the enormous gain in detection efficiency of atom collection by AMS over decay-measuring techniques.

The main field of application of this line will be radiocarbon dating and environmental studies, using materials like hair, microfossils, atmospheric CO_2 , *foraminifera*, pictures and all those materials containing small quantities of carbon that make impossible their dating by traditional β -counting.

THE COMPLEX SYSTEMATICS OF ZIRCONS IN MIGMATITIC GNEISS: AN EXAMPLE FROM AN ARCHEAN MIGMATITE ALONG THE PATOS SHEAR ZONE, BORBOREMA PROVINCE, NE BRAZIL

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The Patos Shear Zone represents a first-order subdivision into the Northern and Southern Tectonic domains of the Borborema Province. The basement complex of the Northern Tectonic Domain is composed primarily of juvenile and enriched Paleoproterozoic gneisses and migmatites, and smaller enclaves of polyphase Archean crust, whereas the Southern Tectonic Domain is dominated by Meso- to Neoproterozoic granite-gneiss complexes and volcanosedimentary associations. Both tectonic domains are intruded by ca. 600 Ma granitoids that are associated with Brasiliano/Pan-African orogenesis. U-Pb systematics of zircons from a migmatitic gneiss just north of the Patos Shear Zone provide an excellent example of the difficulties encountered using conventional single-grain U/Pb zircon geochronology in polydeformed gneiss terranes. Our conventional single grain zircon analyses of a migmatite yielded Archean ages between ca. 3.3 and 2.8 Ga, as well as some highly discordant Paleoproterozoic ages. U/Pb zircon analyses from the migmatitic gneisses with the older $T_{(DM)}$ model ages indicate that they represent Archean lithologies, but their polyphase histories make it difficult to determine the protolith crystallization ages. Cathodoluminescence imagery of the zircons shows that some of the grains experienced at least 4 phases of growth. Ten single crystal zircon analyses from a gneiss having a $T_{(DM)}$ of 2.83 Ga yield $^{207}\text{Pb}/^{206}\text{Pb}$ ages between 3294 and 2816 Ma and analyses of 3 fractions of very small grains yield $^{207}\text{Pb}/^{206}\text{Pb}$ ages around 1800 Ma. Because the $T_{(DM)}$ age of the gneiss is 2.83 Ga, the grains with older ages are interpreted to be xenocrystic components incorporated into the protolith during its formation. On the other hand, the small grains with ages around 1800 Ma probably represent either new zircon growth or recrystallization. To unravel the complex growth history of these zircons, it will be necessary to perform additional studies using a SHRIMP.

THE Rb-Sr ISOCHRON METHOD APPLIED TO LOW-GRADE METAMORPHIC ROCKS: THE CASE OF THE PUNCOVISCANA FORMATION, NW ARGENTINA

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The feasibility of the Rb-Sr isochron method for dating clastic rocks affected by low-grade metamorphism is discussed taking into account evidence obtained by the TEM study of such rocks. Samples chosen for isotopic analyses are metapelites of the Puncoviscana Formation. Analyses performed on fine fractions do not permit to construct an isochron, because they show a very narrow spread in $^{87}\text{Rb}/^{86}\text{Sr}$ ratios. For the other group of fine-grained rocks the analyses were performed on whole rock, and four samples from Sierra de Mojotoro determine an apparent isochron with an age of 486 ± 17 Ma (Early Ordovician), an initial $^{87}\text{Sr}/^{86}\text{Sr}$ ratio of 0.7147 ± 0.0008 and a MSWD equal to 1.15. This age is noticeably lower than previous K-Ar dates obtained on fine fractions, this discrepancy could be due to the opening of the Rb-Sr isotopic system in post-metamorphic processes. Numerous mineralogical evidences of retrograde reactions were found in samples from Sierra de Mojotoro. Therefore, the Rb-Sr date of 486 Ma could be considered evidence that uplift occurred in the Lower to Middle Ordovician.

One of the premises of the Rb-Sr isochron method is that at time zero all samples had the same initial $^{87}\text{Sr}/^{86}\text{Sr}$ ratio. Evidence of chemical heterogeneity in phyllosilicates of single Puncoviscana metapelites was clearly manifested by analysis at the TEM scale of these rocks. Similar heterogeneity has been reported in other TEM studies of minerals formed in the course of low-temperature metamorphism. These differences require that such minerals had not precipitated at the same time from a pervasive aqueous fluid of uniform composition or that they had precipitated, at the same time, from a fluid inhomogeneous at millimetre scale. In both cases, although the samples were taken from a single crosscut, they could not satisfy the premises of the Rb-Sr isochron method. Therefore, the Rb-Sr isochron method is not always suitable for anchizonal slates.

Another constraint for the age of the Puncoviscana Formation is the $^{87}\text{Sr}/^{86}\text{Sr}$ ratio obtained for a limestone from the Volcán locality (0.70873). This value agrees with the seawater Sr isotope value estimated for the Vendian-Lower Cambrian limit.

LATE CENOZOIC MAGMATISM IN THE SOUTH PATAGONIAN BATHOLITH: SHRIMP U-Pb ZIRCON AGE EVIDENCE

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The Patagonian Batholith is a belt of plutonic rocks forming a curvilinear outcrop more than 1000 km long and 50 to 120 km wide. The North Patagonian Batholith (NPB), the part of the PB that lies north of the Golfo de Penas, has a well-established zonal pattern of ages with Early Cretaceous margins and Cenozoic central portions. In the Southern Patagonian Batholith, this age pattern has been suggested by previous authors but is less well defined, owing to less detailed knowledge of the age of its constituents. Within a large collection of samples of the SPB and its surrounding rocks, two samples were selected for SHRIMP U-Pb zircon dating as being likely on geological grounds to yield young ages. The analyzed samples correspond to a columnar dacite at Isla del Medio, in the intersection of Fiords Peel and Calvo, and to a hornblende-biotite granodiorite at Bahía Inservible, Chatham Island. The dacite yielded a 4.93 ± 0.09 Ma crystallization age, with additional populations of zircons at 5.44 ± 0.12 Ma and 10 to 10.5 Ma. The granodiorite crystallization age is 19.8 ± 0.2 Ma. These data show that young (Miocene) plutonic bodies do exist within the limits of the SPB, and not only in the eastern satellite bodies as the Torres del Paine granite. The late Miocene to Pliocene volcanic activity indicated by the dacite is reported for the first time here, and is coeval with basaltic volcanism in the extra-Andean Patagonia.

has been shown to be useful in modeling lateral retreat of escarpments and flexural response, and can provide important insights regarding marginal isostatic uplift and the evolution of offshore sedimentary basins.

CONVERGENT STRATEGY TO DATE METAMORPHIC MINERALS IN SUB-GREENSCHIST FACIES METABASITES BY THE $^{40}\text{Ar}/^{39}\text{Ar}$ METHOD

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The time interval between volcanism and metamorphism in a subsiding basin has been obtained in rocks of the Veta Negra Formation affected by very low-grade metamorphism exposed at the Cordón de Chacana, c. 100 km NNW of Santiago, applying a new convergent geochronological method. This consisted in the $^{40}\text{Ar}/^{39}\text{Ar}$ dating of crystals of transparent and wholly sericitized plagioclase and of adularia. The transparent plagioclases gave an age close to 119 Ma whereas the sericitized plagioclase crystals yielded values between 98 and 104 Ma. The adularia crystals were dated in the range 97-100 Ma. These results show a close agreement between the metamorphic ages of sericitized plagioclase and adularia confirming their belonging to the main metamorphic paragenesis. They also permit to quantify the time elapsed between the volcanic and metamorphic events as being 19 to 22 Ma and to obtain preliminary basin subsidence rates of c. 0.19 mm/year. The convergence in ages of adularia and of wholly sericitized plagioclase affords a novel method for $^{40}\text{Ar}/^{39}\text{Ar}$ dating of low-grade metamorphism. Additionally, the methodology employed offers the unique possibility to date both, the volcanic and the metamorphic events, using primary and secondary mineral phases from the same rock sample.

Another constraint for the age of the Puncoviscana Formation is the $^{87}\text{Sr}/^{86}\text{Sr}$ ratio obtained for a limestone from the Volcán locality (0.70873). This value agrees with the seawater Sr isotope value estimated for the Vendian-Lower Cambrian limit.

EXHUMATION AND DENUDATION OF THE SOUTHEASTERN BRAZILIAN COAST: APATITE FISSION TRACK ANALYSES FROM A TRANSECT IN THE SERRA DO MAR AND MANTIQUEIRA MOUNTAIN RANGES

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The origin of the Serra do Mar and Mantiqueira mountain ranges is related to Cretaceous tectonics, but its denudational history has not been well defined. Apatite Fission Track Analysis (AFTA) of 30 samples along a NW/SE profile of the Serra do Mar and Mantiqueira mountain ranges of southeastern Brazil now provide a better understanding of the region's uplift/denudation history. Two different groups of fission track ages obtained from these samples are related to distinct episodes of epirogenesis and denudation. The analyses indicate that the area close to the coast in the Serra do Mar Mountains suffered lateral erosional processes causing long-term scarp retreat, as previously proposed by many authors, combined with one intense progressive denudation to the continent. This is evidenced through the fission track ages with a progressive younging observed towards the coast.

For the interpretation of the denudation rate a simple relationship is accomplished by plotting the sample elevations versus fission track ages and sample distances from the coast versus fission track ages. These results show 4 km of denudation for the Mantiqueira and Serra do Mar mountain ranges.

The progressive denudation started a direct relation with the isostatic rebound of all the coast region, causing a flexural uplift of the Mantiqueira Mountain Range, that already existed since the beginning of the rifting phase.

This method has been shown to be useful in modeling lateral retreat of escarpments and flexural response, and can provide important insights regarding marginal isostatic uplift and the evolution of offshore sedimentary basins.

RELATIONSHIP BETWEEN THERMOTECTONIC EVOLUTION OF SERRA DO MAR MOUNTAIN RANGE AND SANTOS BASIN, SP, BRAZIL, ACCESSED THROUGH FISSION TRACK ANALYSIS IN APATITE

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The goal of this work is to present the methodology of fission tracks in apatite and some thermal histories obtained in Serra do Mar indicating its influence on Santos Basin, SP, Brazil. The methodology, based on the annealing model of fission tracks in apatite, was employed to obtain a thermal history that is common for a group of samples with the same geological characteristics, i.e. collected in the same tectonic unit. The thermal history obtained for Serra do Mar makes plausible to connect its formation with the reactivation of the Santos fault through several tectonic pulses. The first one took place in the Late Cretaceous (~80 Ma), the second in the Paleocene (~60 Ma), the third in the Oligocene (~40 Ma) and the last one in the Neogene (~25 Ma). These reactivations find support in unconformities clearly observed in the stratigraphic profile of the Santos Basin. The first unconformity reflects a pulsing uplift correlated with the beginning of Serra do Mar formation; the unconformities observed in the Paleocene, Oligocene and Neogene are probably associated with reactivations that built the morphology it presents nowadays.

PRELIMINARY CALCULATIONS ON THE COOLING RATE OF THE RENCA BATHOLITH, SIERRA DE SAN LUIS, ARGENTINA

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The first results on the calculation of the cooling rate of the Renca batholith on the basis of the combination of both thermometric calculations and available crystallization and cooling ages are reported.

The Devonian Renca Batholith belongs to a group of post-collisional plutons that are well exposed in the Sierra de San Luis, Sierras Pampeanas. Zonal ellipsoidal batholiths, *i.e.* Batolito de Renca, Batolito de Las Chacras-Potrerrillos, Granito La Totorá, and San José del Morro pluton, that cover the compositional span from granodiorite to monzogranite with minor syenogranites are the representatives of this magmatism. Zr thermometry is used to estimate a medium temperature that was assumed as representative of the temperature of the magma when zircon grew, therefore available U-Pb calculation on zircon was used as the time constraint for this magmatic temperature. Mean K/Ar mineral ages on biotite were used as the time constraint for the closure temperature of $280^{\circ}\text{C} \pm 40^{\circ}\text{C}$ that is currently accepted for biotite.

Temperatures obtained from seven representative samples of the porphyroid unit of the batholith, located close to the area from which the published U/Pb age was obtained, yielded a medium temperature of 795°C . If this temperature is assumed as similar to the closure temperature for the U/Pb system in zircon, a time constraint for the cooling path of the batholith using the U/Pb zircon age of 393 ± 5 Ma is obtained. Mean K/Ar ages on biotite yielded 382 ± 17 Ma. Closure temperature has been assumed as $280 \pm 40^{\circ}\text{C}$ for biotite.

A cooling rate of $47^{\circ}\text{C}/\text{Ma}$ was calculated. This value would indicate a non-tectonically assisted cooling that might be associated with the unroofing of a stabilizing crust.

DATING QUARTZ: Ar/Ar ANALYSES OF COEXISTING MUSCOVITE AND FLUID INCLUSION - RICH QUARTZ FROM A PALEOCENE METAMORPHIC AUREOLE

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Ar/Ar analyses were carried out on coexisting muscovite and quartz from the contact metasomatic aureole of the 61-63 Ma La Copiapina Pluton, 6 km S of Inca de Oro, III Region, Chile. A 1 cm muscovite cleavage flake was cut up into 11 pieces, 10 of which were analysed by total fusion, giving a distribution of apparent ages between 62 and 65 Ma, with the older ages concentrated in the centre and on one side of the crystal, and a surrounding envelope of younger ages. A step-heating experiment carried out on 0.5-1 mm muscovite concentrate yielded a plateau age of 63 Ma, indicating partial homogenization of gas from different sectors of the crystals. Three individual quartz crystals, rich in high-salinity primary fluid inclusions, were analysed by total fusion, with a low-temperature cleaning step. The argon degassed during cleaning steps was essentially atmospheric, but fusion ages yielded 13-30% radiogenic ⁴⁰Ar, which is interpreted to have originated in the primary fluid inclusions. Concordant total fusion ages of 62.5 ± 3 Ma, 67 ± 11 Ma and 60 ± 18 Ma were obtained. A weighted mean age of 63 ± 3 Ma was obtained using all quartz analyses. An inverse isochron of all quartz analyses yielded an essentially atmospheric ⁴⁰Ar/³⁶Ar intercept and a rather less precise age of 61 ± 6 Ma. The range of ages obtained from the muscovite may be ascribed to a possible older muscovite component, or a change in fluid composition during muscovite growth, from an early component with excess ⁴⁰Ar, to a late fluid with an atmospheric ⁴⁰Ar/³⁶Ar ratio. In this case, the quartz analyses provide a more realistic estimate of the real age of alteration than the muscovite data.

SIMULATED SAMARIUM-NEODYMIUM THERMOCHRONOLOGY OF GARNET- CLINOPYROXENE-PLAGIOCLASE GRANULITES

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The fast grain boundary diffusion model is used to simulate the influence of variable conditions on radiometric ages that would be obtained from $^{147}\text{Sm}/^{144}\text{Nd}$ – $^{143}\text{Nd}/^{144}\text{Nd}$ systematics of garnet-clinopyroxene-plagioclase during cooling of granulitic rocks. Mineral-pair Sm-Nd apparent closure temperatures (T_{iso}) are predicted to depend on the factors involved in the formulation of Dodson's classical model, being ordered (for most rock compositions) according to the following sequence: $T_{\text{iso}}(\text{gt/cpx}) > T_{\text{iso}}(\text{gt/pl}) > T_{\text{iso}}(\text{cpx/pl})$. T_{iso} usually differ from individual closure temperatures predicted by Dodson's model, and large thermal offsets between T_{iso} values imply that isotope equilibrium will not be commonly achieved during slow cooling of granulitic rocks. In addition, T_{iso} values were also found to be dependent on the amount of Sm/Nd fractionation and, most significantly, on rock modal composition. An important implication is that Sm - Nd cooling ages from rocks having the same cooling history, but different modes, should differ. At slow cooling rates age differences could be very large, and might be misinterpreted as implying different temperature – time cooling paths for rock units that shared the same tectonothermal evolution. However, if properly recognized, such effects could be helpful in estimating the true cooling rates.

The results confirmed the cosmogenic origin of the He excess and yielded an age of 850 ± 120 a, calculated from the magnetic separate of the surface sample when assuming a MORB-like composition of trapped He. Under the more likely assumption of an atmospheric trapped He composition, the age increases to 1230 ± 120 a, which may still be a lower limit since He retention increases to 1230 ± 120 a, which may still be a lower limit since He retention may not have been complete even in the magnetic separate. A derivation of the use of the He retention in a magnetic separate can be used to corroborate stratigraphic and paleogeographic data obtained in foreland areas near the São Francisco Craton: during the infilling of the Andrelândia basin, the main available source rocks were the Archaean to Palaeoproterozoic plutonites of the nearby cratonic areas. These source areas are recognized nowadays in the São Francisco Craton or in the tectonically exposed basement rocks of the Andrelândia basin.

A MINIMUM AGE FOR LLULLAILLACO SOUTH FLOW FROM COSMOGENIC ^3He : MUCH OLDER THAN 19th CENTURY

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We present minimum surface exposure ages based on cosmogenic ^3He for three andesitic to dacitic lava flows from the Central Volcanic Zone (CVZ) in northern Chile. As expected, no cosmogenic ^3He was found within error limits for the 1993 Láscar flow. However, samples from Cerro Overo and Lastarria yielded distinct ^3He excesses even if a MORB-like magmatic He component is assumed in these rocks, corresponding to minimum exposure ages of ~ 8000 a and ~ 1400 a, respectively. A surprising result was obtained for a sample from the south flow of Llullaillaco, which contained substantial amounts of excess ^3He . Llullaillaco south flow has earlier been attributed to a series of eruptions in the years 1854-1877, which were observed from the surroundings of Arica and Antofagasta. Based on our first He data, however, a minimum age of ~ 400 a was suggested.

To check whether the observed ^3He excess was indeed cosmogenic and to obtain a better estimate of the age of Llullaillaco south flow, we studied several well-documented samples from variable shielding depths within a large lava block. A magnetic Frantz separator was used to split the He-retentive minerals, such as pyroxene, from less retentive constituents (e.g. plagioclase and quartz). The results confirmed the cosmogenic origin of the ^3He excess and yielded an age of 890 ± 120 a, as calculated from the magnetic separate of the surface sample when assuming a MORB-like composition of trapped He. Under the more likely assumption of an atmospheric trapped He composition, the age increases to 1230 ± 120 a, which may still be a lower limit since He retention may not have been complete even in the magnetic separate. A derivation of Llullaillaco south flow from eruptions recorded in the 19th century can therefore safely be excluded.

THE USE OF Nd ISOTOPES TO ESTABLISH SEDIMENTARY PROVENANCE AT INVERTED PASSIVE MARGINS: THE CASE OF THE ANDRELÂNDIA DEPOSITIONAL CYCLE AT THE RIBEIRA BELT, BRAZIL

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The Ribeira Belt, in southeastern Brazil, is a Brasiliano/Pan-African belt that resulted from the agglutination of the Gondwana Supercontinent (750-500 Ma). The tectonic organization in its central segment can be defined by several tectono-stratigraphic domains. In general terms, each tectonic domain comprises: a) pre-1.8 Ga basement rocks; b) post-1.8 Ga metasedimentary cover including metabasic rocks of continental to MORB geochemical affinity; and c) Brasiliano-Pan African granitoids.

The Andrelândia basin was described at the limits of the São Francisco Craton as an intraplate basin. In spite of increasing metamorphic grade and tectonic deformation, the metasedimentary rocks of the Andrelândia Depositional Cycle (ADC) can still be identified in the Occidental terrane (reworked margin of the São Francisco Craton) of the Ribeira belt.

The Juiz de Fora domain (JFD) is the hinterland of this belt and represents a Proterozoic passive margin that was inverted during the agglutination of the Gondwana supercontinent. Representative samples of metapsammopelites of the ADC in the JFD were selected for analyses.

The analytical results were compared to a previously published dataset and possible source rocks on $\epsilon_{Nd}(0)$ versus $^{147}\text{Sm}/^{144}\text{Nd}$ isochronic plot. In general terms, the isotopic composition of ADC samples plot between reference lines and compositional fields of basement rocks. Consequently, possible source rocks for these samples could be their own Archaean to Palaeoproterozoic basement rocks.

The use of the Nd isotopic system, even in a hinterland area of a mobile belt (Juiz de Fora Domain), can corroborate stratigraphic and paleogeographic data obtained in foreland areas near the São Francisco Craton: during the infilling of the Andrelândia basin, the main available source rocks were the Archaean to Palaeoproterozoic plutonites of the nearby cratonic areas. These source areas are recognized nowadays in the São Francisco Craton or in the tectonically exposed basement rocks of the Andrelândia basin.

CONVENTIONAL LEACHING TECHNIQUE AND PARTIAL DIGESTION IN MICROWAVE OVEN: TREATMENT PROCEDURES FOR U-Pb DATING OF OVERGROWN ZIRCON RIMS BY THERMAL IONIZATION MASS SPECTROMETRY (TIMS)

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This article presents the results of U-Pb dating of overgrown zircon rims, using conventional leaching techniques and partial digestion in microwave oven as sample preparation methods. The ages obtained cluster around 2300 Ma and are close to those obtained by other techniques such as Evaporation and SHRIMP. For metamictic and microfractured zircons the ages obtained are interpreted as resulting from mixtures between rim and core leachates. The ages of the final fractions (around 3000 Ma) indicate the age of the cores of the crystals and in this case are close to those obtained for grains that did not undergo any type of abrasion. This age is interpreted as an average age, as the ages obtained by SHRIMP indicate multiple events occurring during the Archean between 3080 and 2900 Ma. It was observed that the $^{207}\text{Pb}/^{235}\text{U}$ and $^{206}\text{Pb}/^{238}\text{U}$ ratios in a general way show for the first leached fractions a reverse discordance that soon after becomes a normal discordance for the final portions. This reverse discordance was also verified for some zircons using SHRIMP.

LATE CENOZOIC TECTONIC AND GEOMORPHIC EVOLUTION OF THE PATAGONIAN ANDES BETWEEN 42°S AND 52°S, SOUTHERN CHILE ASSESSED USING FISSION-TRACK THERMOCHRONOLOGY

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Fission-track (FT) analysis has been applied in the Patagonian Andes of southern Chile to assess the late Cenozoic geomorphic and tectonic response of the overriding plate to subduction of the Chile rise active oceanic spreading centre and the timing and nature of uplift and denudation along the major transpressional intra-arc Liquiñe-Ofqui fault (LOF). 130 apatite and zircon FT ages and 39 apatite track length measurements reveal initiation of rapid cooling and denudation at ca. 30 Ma at the western margin of southern continental South America. This was followed by a ca. 200 km eastward migration of the locus of maximum denudation that ceased at ca. 12 to 8 Ma at the position of the present day main topographic divide. East of the divide less than 3 km of denudation has occurred since the Late Cretaceous. Initiation of enhanced denudation is coeval with a large increase in plate convergence rates at ca. 28 to 26 Ma. Along the southern parts of the LOF increased cooling and denudation related to transpression induced rock uplift and erosion has occurred largely since ca. 10 Ma. Several fault blocks are revealed, separated by major oblique-slip faults that appear to form part of a dextral transpressional flower structure. The fastest rates of cooling along the LOF occurred between ca. 7 and 2 Ma, contemporaneous with collision of the Chile rise with the margin of continental South America near the southern termination of the LOF.

EPMA DATING OF MONAZITES FROM SOUTHERN BRAZILIAN SHIELD

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The first results obtained in rocks from Rio Grande do Sul State (Brazil) and Uruguay, by EPMA dating of monazite, are reported. Two geological units were selected for this investigation because the age of the zircons from the same units were known from U-Pb SHRIMP dating. These are the Santa Maria Chico Granulitic Complex, southern Brazil, ca. 2.6 Ga, magmatic age, ca. 2.02 Ga, metamorphic age, and the Rocha Syenogranite - ca. 760 Ma, magmatic age. Two populations of rounded, normal to oscillatory zoned monazites included in garnet from a metapelite were dated. Those monazites situated in rims yield a chemical age of 1926 ± 141 Ma, while the age in a grain located in the core is 2325 ± 64 Ma. A single population of euhedral, normally zoned monazites from the Rocha Syenogranite yield a chemical age of 696 ± 76 Ma. The chemical Th-U-Pb dating by EPMA is undergoing further development at Universidade Federal do Rio Grande do Sul, Porto Alegre, Brazil; but the results obtained are already comparable with previous SHRIMP ages in zircon. The technique shows its potential to date complex metamorphic events and can be used in exploration work. The advantages over other dating techniques are the spatial resolution of 1-2 mm of the EPMA beam, the low cost, speed of analyses, large availability of electron microprobes and the capability of analyzing monazites directly on the thin section as done here.

$^{40}\text{Ar}/^{39}\text{Ar}$ GEOCHRONOLOGY AT THE INSTITUTO DE GEOCIÊNCIAS, USP

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Laser heating $^{40}\text{Ar}/^{39}\text{Ar}$ geochronology provides high analytical precision and accuracy, μm -scale spatial resolution, and statistically significant data sets for the study of geological and planetary processes. A newly commissioned $^{40}\text{Ar}/^{39}\text{Ar}$ laboratory at CPGeo/USP, São Paulo, Brazil, equips the South American scientific community with a new powerful tool applicable to the study of geological and cosmochemical processes.

Detailed information about laboratory layout, environmental conditions, and instrumentation provides the necessary parameters for the evaluation of the CPGeo/USP $^{40}\text{Ar}/^{39}\text{Ar}$ laboratory suitability to a diverse range of applications. Details about analytical procedures, including mineral separation, irradiation at the IPEN/CNEN IEA-R1 reactor at USP, and mass spectrometric analysis enable potential researchers to design the necessary sampling and sample preparation program suitable to the objectives of their study.

The results of calibration tests using synthetic CaSi_2 glass and K_2SO_4 salt crystals, international mineral standards, and in-house mineral standards show that the accuracy and precision obtained at the $^{40}\text{Ar}/^{39}\text{Ar}$ laboratory at the CPGeo/USP facility is comparable to results obtained in the most respected international laboratories. Total fusion results for grains of Alder Creek sanidine (1.189 ± 0.005 Ma), Bern 4B biotite (17.3 ± 0.2 Ma), Bern 4M muscovite (18.53 ± 0.17 Ma), GA-1550 biotite (99.08 ± 0.15), USGS P-207 muscovite (82.0 ± 0.5 Ma), and HB3gr hornblende (1076 ± 2 Ma) are consistent with the accepted ages for these standards. Several irradiations of Fish Canyon sanidine fluence monitors yield values of $0.00016 \text{ J}\cdot\text{hour}^{-1}$, a maximum horizontal variation of $0.0000026 \text{ J units}\cdot\text{mm}^{-1}$, and a vertical variation of $0.000004 \text{ J units}\cdot\text{mm}^{-1}$, results entirely suitable for high precision $^{40}\text{Ar}/^{39}\text{Ar}$ analyses.

A COMPARISON BETWEEN CHEMICAL AND ISOTOPIC MICROBEAM DATING METHODS: Th-U-TOTAL Pb (MONAZITE, MICROPROBE) AND U-Pb (ZIRCON, SHRIMP)

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Microbeam dating techniques are the most powerful tools available for geochronology, as they can unravel small-scale intra-grain chemical and isotopic contrasts, a critical point in the study and dating of polygenetic rocks. The simplest is the chemical method based on the Th-U-total Pb contents determined with the microprobe (EPMA), in minerals which accumulate measurable quantities of Pb over time, such as monazite and xenotime. Microprobe dating is being routinely performed at the Institute of Geoscience of the University of São Paulo. Attempting to optimize this technique and improve age standards, several comparisons between chemical and isotopic results were made. This report presents age results obtained for monazite with EPMA and zircon with SHRIMP for a metapelite in the amphibolite grade of metamorphism.

A garnet-biotite schist (Juscelândia sequence, Central Brazil) with SHRIMP data already available was studied. Both monazite and zircon crystallized mostly together with the main metamorphic phases. WDS analyses were obtained for three monazite grains, an isolated bigger one and two small inclusions in garnet. Chemical isochron and weighted average monazite ages are as follows: 789 (± 26) Ma (normal isochron), 793 (± 15) Ma (isochron drawn to origin) and 792 (± 8) Ma, respectively. These results are in close agreement with U-Pb SHRIMP in zircon, which gave averages of 794 (± 14) Ma ($^{207}\text{Pb}/^{206}\text{Pb}$) and 782 (± 16) Ma ($^{206}\text{Pb}/^{238}\text{U}$). Some zircon crystals have inherited nuclei up to 2.0 Ga, an event not recorded in monazite; on the other hand, the isolated monazite crystal has late rims with *ca.* 740 Ma, probably related to a late regional shear affecting the area.

This comparison shows that microprobe dating is a very reliable one and can, under favorable conditions, give very accurate results. In fact, EPMA and SHRIMP should furnish complementary information on the evolution of polygenetic rocks.

POLYGENETIC MONAZITE FROM THE SÃO JOSÉ DO CAMPESTRE MASSIF, BORBOREMA PROVINCE, NE BRAZIL: INSIGHTS FROM EPMA CHEMICAL AND DATING STUDIES

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Conventional isotopic U-Pb systematics in monazite from garnet-bearing leucosome veins within host trondhjemitic rocks of the São José do Campestre older nuclei, Borborema Province, NE Brazil, yields a discordia line with Archean (*ca.* 3.0 Ga) upper and Brasiliano lower (*ca.* 0.60 Ga) intercepts. A systematic EPMA study and dating were made in order to understand such a pattern. Three isolated monazite grains and another three inclusions in garnet were studied. Over 45 complete WDS analyses and some X-ray dot maps were obtained for Th, U, Y, and Pb.

Elemental x-ray maps for isolated grains show that the main monazite is partially substituted along irregular in-fillings by a new monazite with lower Th and higher U and Y contents. These in-fillings present contrasting REE patterns, being poorer in Th and some LREEs and richer in HREEs, Y, and U. WDS quantitative data reveal ages averaging 3.0 Ga for the main monazite and similar values for inclusions within garnet. The in-fillings are much younger, averaging 0.58 Ga, a mean value also found in a small isolated grain. These results match well with the isotopic ones. Some discrete ages suggest also a partial resetting of the monazite clock around *ca.* 2.7 and 1.7 Ga. Isotope discordance is due to mixing of at least two contrasting monazite types. A superimposed Neoproterozoic thermal event opened way to fluid percolation and development of a new monazite, which appeared as discrete small grains and partially substituted the main monazite. Such fluids had high LREE (Pr-Sm) and low HREE, Y, and U solubilities.

Our results demonstrate that EPMA can provide useful insights concerning monazite behavior in polygenetic rocks, depicting the main features of inter- and intra-grain domains. This allows a better comprehensive view of geological processes and should be taken into account in geochronological studies in such terranes.

Our results allow us to conclude that the Borborema region did not record any Mesoproterozoic event. The Pb-Pb and Rb-Sr isochron ages (1.3-1.4 Ga) were calculated from pseudoisochrons formed due to the interposing of two different isochrons generated for two melt components of Paleo- and Neoproterozoic ages.



TIME CONSTRAINT BASED ON ZIRCON DATING FOR THE JACAREACANGA GROUP (TAPAJÓS PROVINCE, AMAZON CRATON, BRAZIL)

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The Cuiu-Cuiu Complex (2.00-2.03 Ga) and Creporizão granitoids (1.99-1.96 Ga), as well as the Jacareacanga Group, are considered the oldest rocks in Tapajós Province (Amazonian Craton, Brazil). The Jacareacanga Group is represented by quartz-mica schists, quartzites (including ferruginous quartzite and metachert), and minor talc-tremolite-chlorite schist, actinolite-epidote schist, hornfels, metargillites and metawackes metamorphosed in low to medium-grade conditions. The aim of the paper is to establish the maximum age of Jacareacanga sedimentation and identify probable sources for the Espírito Santo muscovite-biotite schist, in the Espírito Santo region. For a long time the Jacareacanga meta-volcanosedimentary sequence has been interpreted as an Archean greenstone belt terrane, however most recent data have demonstrated lower ages around 2.1 Ga (U-Pb conventional ages). In this research, similar and new results are obtained by the zircon evaporation method. Three main zircon populations with different ages and provenances were obtained: 2,189±4 Ma, 2,136±2 Ma and 2,034±6 Ma. Only one zircon grain yielded 1.97 Ga, which is similar to the age of the calc-alkaline Creporizão Granite and suggests that this granite had been the youngest source for the Jacareacanga schist. This approach suggests two principal sources for the Jacareacanga schist in the Espírito Santo region: a) Transamazonian terrane (2.14 and 2.19 Ga), yet these rocks (pre- 2.1 Ga), observed around 1000 km away, are not identified in the mapping; and b) Cuiu-Cuiu and Creporizão calc-alkaline associations (1.97 Ga to 2.00 and 2.03 Ga). Thus, the Jacareacanga sedimentation is delimited by Parauari granitic intrusions (1.88-1.89 Ga) and Creporizão-Cuiu-Cuiu basement rocks (1.97 Ga and 2.00-2.03 Ga). However, a similar Creporizão Granite source age is not registered in other Jacareacanga schist types. A post-1.97 Ga sedimentation for Jacareacanga Group is possible, however the results are not conclusive and new determinations are necessary.

U/Pb SHRIMP ZIRCON AGES OF MIGMATITES FROM THE BASEMENT OF THE EMBÚ COMPLEX, RIBEIRA FOLD BELT, BRAZIL: INDICATIONS FOR ~1.3-1.4 Ga Pb-Pb AND Rb-Sr "ISOCHRON" AGES OF NO GEOLOGICAL MEANING

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Rb-Sr and Pb-Pb Mesoproterozoic ages were determined on basement rocks of some geological units of the Ribeira Belt, and they were interpreted as the time of the metamorphism that affected these rocks. However, this Mesoproterozoic event (ca. 1.3-1.4 Ga) was not accepted by many researchers. The main objective of our work is to present additional data using multiple radiometric systematics to better constraint this event. The study was carried out on migmatites from the basement of the Embú Complex, in São Paulo State. The paleosome is made up by biotite-hornblende gneisses; two generations of neosome are recognized: an older of light gray colour, and a younger one of pink colour which is coarser and cuts the former.

The paleosome samples showed Pb-Pb and Rb-Sr isochron ages of ca. 2.3 and 2.0 Ga, respectively. Its Sm-Nd T_{DM} age of 2.95 Ga suggests that the paleosome was formed by melting of an Archean protolith. U/Pb SHRIMP ages from paleosome zircons showed ages of ca. 2000 Ma and 600 Ma indicating that this rock was formed in the Paleoproterozoic and was affected by a Neoproterozoic metamorphic event. The gray neosome samples yielded Pb-Pb and Rb-Sr isochron ages of ca. 1.3-1.4 Ga. The U/Pb SHRIMP zircon results can be separated into 3 groups: (a) Paleoproterozoic ages from homogeneous crystals; (b) Paleoproterozoic ages from shells of crystals with Archean cores; (c) Paleoproterozoic cores and Neoproterozoic metamorphic rims. Zircons from the pink neosome showed Paleoproterozoic crystallization ages with large Pb loss in the Neoproterozoic (lower concordia intercept).

The results of our study allow us to conclude that these migmatites do not record any Mesoproterozoic event. The Pb-Pb and Rb-Sr isochron ages (1.3-1.4 Ga) were calculated from pseudoisochrons formed due to the interposing of two different isochrons generated for two melt components of Paleo- and Neoproterozoic ages.

Pb-Pb AND U-Pb ZIRCON AGES OF ARCHEAN SYNTECTONIC GRANITES OF THE CARAJÁS METALLOGENIC PROVINCE, NORTHERN BRAZIL

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In this paper we discuss the tectonic significance of the Pb-Pb and U-Pb ages obtained in some granitoids from the Carajás region, southeastern of the Amazon Craton. The Estrela Granite Complex and the granitoids located to the north of Parauapebas were dated by Pb-Pb evaporation zircon method. U-Pb zircon method, recently put on routine in the Pará-Iso laboratories, was employed to date the granite from the Serra do Rabo area.

The Estrela granite complex, located to the east of the Carajás range is constituted of three main monzogranite plutons showing A-type signatures. Pb-Pb zircon dating has furnished an age of 2763 ± 7 Ma.

In the Serra do Rabo domains crop out two syenogranite stocks elongated in an E-W direction. U-Pb zircon dating has furnished an age of 2744 ± 1 Ma.

To the northwest of the Parauapebas village crops out a monzogranite stock, displaying a calc-alkaline chemical signature. Among twenty-one analyzed zircons, only three crystals could be aligned in a plateau. $^{204}\text{Pb}/^{206}\text{Pb}$ ratios have given an age of 2688 ± 11 Ma.

Structural evidence denotes that the emplacement of these granite bodies was synchronous to protracted horizontal shortening stresses: (elongated shape, foliations conformable with the regional structures, increasing of deformation and decreasing of temperatures, growing of syntectonic porphyroblasts in hornfelsed host rocks).

During the time interval between 2.76 Ga and 2.74 Ga the Carajás region was the scene of granitogenesis, metamorphism and deformation.

Granitoids earlier interpreted either as Palaeoproterozoic granites or as basement assemblages, are in fact related to this magmatic episode. The age of 2688 ± 11 Ma, obtained for the granites of the Parauapebas area, should be interpreted as a minimum age. Differences in chemistry (alkaline to calc-alkaline) of these granites seem to reflect differences in source rocks or differences of processes during the origin of the melts.

PRECAMBRIAN TERRANES OF AFRICAN AFFINITIES IN THE SOUTHEASTERN PART OF BRAZIL AND URUGUAY

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It is here postulated that the Major Gercino-Sierra Ballena lineament represents the main suture that separates the tectonic domains of African and South-American affinities. These domains are represented by two major units: the Granite Belt - outcropping along the whole eastern portion of the Brazilian southern region, and the Punta del Este Terrane (PET) in southeasternmost Uruguay.

The Granite Belt represents a Neoproterozoic mature magmatic arc generated from eastward subduction, evolving in a distinct geographic position and in a dissociated manner from the terranes located to the west. The probable back-arc basin for this arc would be situated on the African side (part of the Coastal Damara/Kaoko/Gariiep belts).

An analysis of the available model Nd ages shows that there is a considerable decrease in ages eastwards, with African rocks presenting the youngest ages. There is a concentration of values around 2.5 Ga for the foreland gneisses and 1.9 Ga for the DFB Schist Belt, whereas for the Granite Belt, Damara (sediments and granites) and Nama Group the average age lies close to 1.6 Ga.

The Granite Belt and Punta del Este Terrane were linked to the African supracrustal belts, being accreted to the South American side only during the formation of Gondwana. Its separation from Africa occurred only in the Cretaceous due to opening of the Atlantic Ocean.

RGN and TAM are being interpreted as previous fragments of the Atlantica Supercontinent that were amalgamated by the TAP fold belt during the Early Neoproterozoic (before the Brasiliano Cycle). This means that these three terranes together were connected as part of Rodinia.

NEW EVIDENCE OF RECURRING CONVERGENT MARGIN MAGMATISM IN THE EASTERN CENTRAL METALLOGENIC BELT, RONDÔNIA, BRAZIL

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The Rio Negro-Juruena Geochronological Province (Amazonian Craton) has been regarded as a single unit extending from 1.80 to 1.55 Ga. Preliminary new U-Pb zircon ages record a previously undocumented major accretion arc-related magmatic event within the time interval, 1.65 and 1.63 Ga, thus constraining a probable north-northeastward trending recurring subducting zone (present-day coordinates). U-Pb ages were determined for two samples: 1) sample 98-JWB-10/A has its zircons separated from a mafic charno-enderbitic gneiss paleosome of a migmatite, and four zircon fractions define a discordia line which yields an upper intercept of 1655 ± 11 Ma, and 2) sample 98-JWB-3/A is a gray well-banded tonalitic orthogneiss, and four zircon fractions define an age of 1631 ± 8 Ma which is interpreted as the time of emplacement of the tonalitic protolith.

A balance of recent achieved U-Pb geochronological data suggests successive westward growth including, at least, three separate orogenic events. They are: 1) northern Rondônia segment and western Mato Grosso calc-alkaline arc-accretions at 1.76 and 1.72 Ga, and the recognized counterpart termed Jauru Orogen at 1.79 and 1.74 Ga, 2) the herein proposed eastern central Rondônia arc-accretion at 1.65 and 1.63 Ga, and 3) Cachoeirinha Orogen (southern Mato Grosso) at 1.57 and 1.52 Ga.

Similar, time-correlative events also occur in eastern Laurentia and western Baltica during Labradorian and Gothian orogenesis, respectively, which reinforce recent models which postulate Laurentia – Baltica – Amazonia alignment along a continuous southern margin of a supercontinent, as previously postulated.

was the scene of granulitogenesis, metamorphism and deformation.

Granitoids earlier interpreted either as Palaeoproterozoic granites or as basement assemblages, are in fact related to this magmatic episode. The age of 2688 ± 11 Ma, obtained for the granites of the Parauapebas area, should be interpreted as a minimum age. Differences in chemistry (alkaline to calc-alkaline) of these granites seem to reflect differences in source rocks or differences of processes during the origin of the melts.

PRECAMBRIAN TERRANES OF THE EASTERNMOST PART OF THE BORBOREMA PROVINCE AND THEIR GEOCHRONOLOGICAL DATA

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Geological studies in the easternmost part of the Borborema province (northeast Brazil) in the last three decades, as well as recent geochronological (Rb/Sr, Sm/Nd and U/Pb methods) research projects, allow the recognition of a series of tectonostratigraphic terranes (Howell's sense) in this so-called "Saliente Oriental" of the continent, i.e. area east of meridian 36°. These terranes are separated from each other by important regional ductile-brittle shear zones (some of them also recognized in the African continent), part of which show evidence of having been polycyclically affected in the Paleozoic and Meso-Cenozoic history of the province. Several sedimentary basins and volcano-plutonic sites were associated with these weakness zones, from the Cambrian to the Tertiary.

The Rio Grande do Norte terrane (RGN), situated north of the Province, north of the Patos lineament (LP), is composed of high-grade rocks (with some overlying supracrustal Proterozoic belts) of Paleoproterozoic age (2.0-2.2 Ga) with some local Archean nuclei. The oldest rocks of South America (ca. 3.45 Ga) were found in the eastern part of this terrane. This terrane is being interpreted as a megafragment of the Atlantica Supercontinent.

The Alto Pajeú terrane (TAP) or fold belt is composed of metavolcano-sedimentary assemblages and orthogneisses of Early Neoproterozoic age (ca. 0.96 Ga), and is situated south of RGN, having the Patos shear zone as its limit. It is probably a segment of the worldwide Grenvillian net of orogenic belts that was deeply reworked by the Brasiliano orogenies.

To the south of TAP, and separated from it by another important shear zone ("Galante – Serra Redonda system of faults"), is the Alto Moxotó terrane (TAM) that presents geological and geochronological characteristics similar to RGN. It is a more or less linear fragment, ENE-WSW trending, also deeply reworked by the Brasiliano tectonic and magmatic overprint. Their Rb/Sr data show a scattered envelope of points (from 2.2 to 0.5 Ga), but the U/Pb ages confirm Paleoproterozoic ages and some local Archean protoliths.

RGN and TAM are being interpreted as previous fragments of the Atlantica Supercontinent that were amalgamated by the TAP fold belt during the Early Neoproterozoic (before the Brasiliano Cycle). This means that these three terranes together were connected as part of Rodinia.

PIEDRA ALTA TERRANE OF URUGUAY: Rb-Sr GEOCHRONOLOGICAL DATA OF TWO NEW PALEOPROTEROZOIC (TRANSAMAZONIAN) GRANITOIDS

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The Precambrian basement of Uruguay consists of three major terranes separated and crosscut by wide NE-striking subvertical transcurrent shear zones. The western terrane, as a part of the Río de la Plata Craton, is known as the Piedra Alta Terrane (PAT). A mafic dyke complex intruded the PAT at 1.8 Ga and was not later deformed. The PAT has equivalent rocks in the igneous-metamorphic basement of the Tandilia region, Buenos Aires Province, Argentina. New Rb-Sr geochronological data from the *Cerro Rospide* region and *Pintos massif* in the PAT are provided. From *Cerro Rospide*, eight granitoid samples were analysed. The Rb contents vary from 93 to 224 ppm and Sr contents from 93 to 277 ppm. The isochronic Isoplot/Ex Model 1 yielded an age of 1961 ± 46 Ma, with an IR: 0.7034 ± 0.0015 , and MSWD: 0.22. At the *Pintos massif*, seven granitoid samples from the quarries were analysed. Rb contents of the rocks vary between 46 and 95 ppm and Sr between 532 and 786 ppm. The Rb-Sr whole rock analysis using the Isoplot/Ex Model 1 yielded an isochronic age of 2081 ± 130 Ma, with IR: 0.70194 ± 0.00056 and MSWD: 1.4. With these results the main conclusions are: Rb-Sr geochronological data from the *Cerro Rospide* granitoid and *Pintos massif* presents a coherent Transamazonian age (1.96-2.08 Ga). The general age pattern between 1.9 to 2.2 Ga, with a low Sr IR, characterizes the granitized belts of the PAT. Despite the isotopic homogeneity, the PAT is a cratonic block preserved in the Rio de la Plata region, with magmatic rocks emplaced at different crustal levels. On the basis of all available isotopic data (Rb-Sr, Sm-Nd, U-Pb multigrain and SHRIMP), it is possible to confirm, as was postulated before, that the PAT is a juvenile Paleoproterozoic cratonic unit not affected by the Neoproterozoic Brasiliano Cycle.

GEOCHRONOLOGICAL CONSTRAINTS FOR THE EVOLUTION OF THE METAMORPHIC COMPLEXES NEAR THE TEBICUARY RIVER, SOUTHERN PRECAMBRIAN REGION OF PARAGUAY

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A reconnaissance geochronological program was carried out on rocks from the “Southern Precambrian” region of Paraguay, a basement complex for the Paleozoic sedimentary rocks of the Paraná Basin, exposed along the Tebicuary river. The northern part of the area is formed by the Caapecu magmatic Suite, including acid volcanic rocks and granitoid shallow intrusions formed in the last phases of the Brasiliano orogenic Cycle. In the central part, medium-grade metamorphic rocks, and migmatites, are reported near Villa Florida, intruded by the Centu Cué granodioritic complex. The southern part is made up of a retrogressed high-grade metamorphic complex, but large areas of quartzitic rocks are described near San Miguel and San Juan Bautista.

The many K-Ar and Ar-Ar dates already available for the region fell within the 470 – 590 Ma age interval, confirming the regional cooling after the events of the Brasiliano Cycle. However, a few older apparent ages indicated a possible rejuvenation of ancient rocks.

Rb-Sr whole rock isochron ages were attempted in the high-grade rocks and the migmatites, but all results were around 600 Ma, confirming once more the importance of the Neoproterozoic tectonomagmatic events. A similar apparent age was also determined by a two-point (garnet-total rock) Sm-Nd isochron for one of the migmatitic samples. However, better hints for the regional geological evolution were obtained through several U-Pb ages on zircon single crystals by the SHRIMP method. Two leucosomatic bands of the Villa Florida migmatites yielded zircons with about 625 Ma and about 500 Ma ages, in agreement with the Rb-Sr and the Sm-Nd results. A similar age of 622 ± 13 Ma was obtained in a few zircons from the Centu Cué granodiorite. A high-grade gneiss from the southern part of the region yielded a very heterogeneous zircon population, characterizing four age groups at about 2020, 1070, 610 and ca. 500 Ma. This age pattern demonstrates the Paleoproterozoic formation of the gneiss’ protolith, and its retrogressive transformation during the Neoproterozoic. Finally, the detrital zircons of a quartzitic rock from the same area confirmed a Paleoproterozoic age for their source rocks.

ARCHEAN AND PALEOPROTEROZOIC GRANITOIDS AND CRUSTAL EVOLUTION OF THE RIO MARIA GRANITE-GREENSTONE TERRANE, EASTERN AMAZONIAN CRATON, BRAZIL

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Nd and Pb isotopic data obtained for the Archean and Paleoproterozoic granitoids of the Rio Maria Granite-Greenstone Terrane, SE Amazonian Craton, Brazil, indicate that this domain of the craton differentiated from the mantle 3.0 to 2.9 b.y. ago as a juvenile domain. The different kind of Archean granitoids identified in this province were formed between 2.96 and 2.86 Ga, during two distinct periods of intense magmatic activity. These granitoids include: older TTG, high-Mg granodiorites, younger TTG and potassic calc-alkaline leucogranites. The Archean rocks are intruded by Paleoproterozoic (1.88 Ga) aluminous A-type granites, which have initial eNd values in the range of -8 to -10 and Pb geochemical signature compatible with derivation from lower crustal sources.

PROVENANCE AND DEPOSITIONAL AGE OF THE NEOPROTEROZOIC VOLCANO-METASEDIMENTARY SEQUENCE IN THE SANTA TEREZINHA REGION, GOIÁS BASED ON U-Pb SINGLE ZIRCON AND Sm-Nd ISOTOPE DATA

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We present new Sm-Nd and U-Pb zircon data for the supracrustal rocks that crop out in the northern part of the area and discuss their provenance and depositional age. The Proterozoic supracrustal rocks of the area are divided into a metasedimentary and a metavolcanic sequence. The former is overthrust onto the latter and both overthrust the Archean rocks, along the Mandinópolis Shear Zone, an east-west trending and northward shallow-dipping thrust fault with vergence to the south.

Results presented in this paper suggest that they also differ in age and provenance. Part of the supracrustal rocks in the area correlate with the Neoproterozoic Goiás magmatic arc, whilst other rocks derive from older sources. We recognize a wide range of source-ages that contributed during deposition of the metasedimentary sequence. Such variable T_{DM} model ages, decreasing from west to east, suggest distinct source-areas for the sediments, although the most significant contribution seems to have been from Paleoproterozoic crust. On the other hand, the metavolcanic sequence is characterized by T_{DM} model ages between 1.1 and 1.3 Ga. This is in keeping with a derivation from the Neoproterozoic magmatic arc. Only a minor part of sediments in this sequence show contribution from an older continental source, as indicated by inherited zircons with a wide age span.

Our data indicate that the best age estimate for the deposition of the supracrustal rocks in the Santa Terezinha region is ca. 660 Ma. Therefore, this sequence represents the late stage of the evolution of the Goiás magmatic arc.

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NEW Sm/Nd AND U/Pb GEOCHRONOLOGICAL CONSTRAINTS ON THE ARCHEAN TO NEOPROTEROZOIC EVOLUTION OF THE AMPARO BASEMENT COMPLEX OF THE CENTRAL RIBEIRA BELT, SOUTHEASTERN BRAZIL

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New Sm/Nd whole rock and new U/Pb single crystal zircon and monazite data obtained from the Amparo Basement Complex of southeastern Brazil's Ribeira Belt now furnish information on its crustal growth history and provide precise age constraints on the timing of events related to its geologic evolution. Based on these new data, it appears that the oldest rocks within the complex are polymigmatized trondhemitic gneisses located near the town of Amparo. The oldest phase of this migmatite yields a U/Pb zircon age of $3,024 \pm 9$ Ma. Sm/Nd data from this locale yields a Nd T_{DM} model age of 3.28 Ga suggesting that the genesis of this crustal unit involved some input from yet older crust. Data from banded tonalitic gneisses collected ca. 50 km south of Amparo indicate that subsequent Archean crustal growth around the older core occurred around 2.77 Ga (U/Pb zircon age of $2,772 \pm 26$ Ma). A Nd T_{DM} model age of 3.02 Ga obtained from these tonalites also indicate enrichment from older crustal sources during their genesis. U/Pb zircon results obtained from other tonalitic to granodioritic orthogneisses collected to the east and south of this Archean core suggest that subsequent growth around it may have occurred in two additional phases during the Paleoproterozoic; at around 2.23 and 2.14 Ga. The Nd data from these younger gneisses yield T_{DM} ages ranging from 2.25 to 3.28 Ga indicating that the two events involved both significant contributions from Archean sources as well as juvenile, presumably accretionary, growth. Analyses of metamorphic monazite obtained from these basement rocks, dated at 609 ± 2 Ma, provide a precise age for the timing of the peak of Brasiliano orogenesis in this region.

U-Pb SHRIMP AND Sm-Nd GEOCHRONOLOGY OF THE PALEOPROTEROZOIC SILVÂNIA MAGMATIC ARC IN THE NEOPROTEROZOIC BRASÍLIA BELT, GOIÁS, CENTRAL BRAZIL

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U-Pb SHRIMP and Sm-Nd isotopic ages were determined for felsic metavolcanic rocks from the Silvânia Sequence and Jurubatuba Granite in the central part of the Brasília Belt. Zircon grains from a metavolcanic sample yielded 2115 ± 23 Ma and from the granite yielded 2089 ± 14 Ma, which are interpreted as crystallization ages for these rocks.

Six metavolcanic samples of the Silvânia Sequence yielded a six-point whole-rock Sm-Nd isochron indicating a crystallization age of 2262 ± 110 Ma and positive $\epsilon_{Nd}(T) = +3.0$ interpreted as a juvenile magmatic event.

Nd isotopic analyses on samples from the Jurubatuba Granite have Paleoproterozoic T_{DM} model ages between 2.30 and 2.42 Ga and $\epsilon_{Nd}(T)$ values vary between -0.22 and -0.58 . The oldest T_{DM} value refers to a sedimentary xenolith in the granite.

These results suggest the crystallization ages of the Silvânia volcanic rocks and Jurubatuba Granite are the first evidence of a ca. 2.14-2.08 juvenile magmatic event in the basement of the central part of the Brasília Belt that implies the presence of an arc/suture hidden in reworked basement of the Brasília Belt.

U-Pb SHRIMP AND Sm-Nd GEOCHRONOLOGY OF THE ANÁPOLIS-ITAUCU COMPLEX, ARAXÁ GROUP AND ASSOCIATED GRANITES: NEOPROTEROZOIC HIGH-GRADE METAMORPHISM AND MAGMATISM IN THE CENTRAL PART OF THE BRASÍLIA BELT, GOIÁS

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In the southern part of the Brasília Belt occurs the Anápolis-Itaçu granulite complex that is located in the central of Goiás. It consists of a large complex of high-grade rocks, volcano-sedimentary sequences and granites, exposed in between metasediments of the Araxá Group, the main constituent of the internal zone of the Neoproterozoic Brasília Belt.

High-grade metamorphism and magmatism occurred at the same time in the Anápolis-Itaçu Complex and associated granites. U-Pb SHRIMP analyses on zircon show that the protoliths of the granite ANA 1 are Neoproterozoic in age. In sample ANA 239 the cores of zircon grains are Neoproterozoic, with concordant ages between 0.8 and 1.0 Ga. This age interval is similar to the age obtained in amphibolite associated with the Araxá Group, near Bonfinópolis (1010 ± 103 Ma with $\epsilon_{Nd} = +5.3$). The model ages for the Araxá Group can be interpreted as the result of mixing between younger juvenile sources and older, probably Paleoproterozoic sialic sources.

Zircon crystals from sample ANA 30 present a more complicated history. Most of the zircon grains are Neoproterozoic with significant differences between core and rim ages. Four of the analyzed grains are inherited. One has a Paleoproterozoic core, probably inherited from the basement of the Brasília Belt.

ANA 30 and ANA 239 are from the same granitic body, and the metamorphic ages are very similar. The zircon ages show that this granite intrusion contains inheritance from, at least, three distinct sources, with Paleoproterozoic and Mesoproterozoic age (1.7-1.5 Ga, in ANA 30) and Neoproterozoic ages varying between 1070 and 830 Ma found in grains from ANA 30 and ANA 239.

ARCHEAN AND PROTEROZOIC CONTINENTAL CRUST IN SOUTH AMERICA: MAIN BUILDING EVENTS

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Archean crust appears mainly in cratonic areas, although the oldest fragment is recorded in the Brasiliano Borborema Province. In the São Francisco Craton 3.42 Ga TTG suites were involved in 3.1-3.3 Ga crust-forming events and reworked during 2.8-2.9 Ga amalgamation events. Granitoid and basic intrusions and granulite metamorphism mark late Archean sialization. In the Amazon Craton 2.9-3.0 Ga greenstones and tonalite were intruded by 2.87-2.85 Ga TTG, followed by high-grade metamorphism, migmatization and intrusion of K-rich leucogranites. Late Archean stabilization is recorded in platform covers, granite intrusions, deformation, metamorphism, and metasomatism. Early Paleoproterozoic extension opened large basins, the closure of which during the ca. 2.15 Ga Transamazonian collage and other orogenies lead to the amalgamation of continental crust preserved in cratons or later reworked in Neoproterozoic fold belts. Late Paleoproterozoic taphrogenesis is recorded in many areas by bimodal volcanics, continental to marine sediments and A-type intrusions. 1.4-1.5 Ga magmatic arc rocks and 1.2-1.0 Ga orogeny are recorded in western Amazonia as part of Rodinia amalgamation. Rodinia break up lead to formation of large ocean basins, which were closed during Brasiliano orogeny with the main arc events recorded at 930, 860, 760, and 640 Ma in central Brazil, and 900-850 and 750-700 Ma in the Dom Feliciano Belt, the latest orogenic events being the 580-540 Ma Rio Doce orogeny and 530-520 Ma Pampean orogeny.

Nd ISOTOPES, U-Pb SINGLE GRAIN AND SHRIMP ZIRCON AGES FROM BASEMENT ROCKS OF THE TOCANTINS PROVINCE

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Here we present a preliminary Nd isotope survey on basement gneiss and associated rocks sampled along a transect from Arraias to Porto Nacional, Tocantins.

Our preliminary results demonstrate the existence of at least three crustal blocks of different ages in the northeastern basement of the Tocantins Province.

The younger ages were found in samples of tonalite gneiss and one intrusive leucogranite from outcrops under the Rio Surubim Bridge, some 50 km to the northwest of the town of Santa Rosa. They yield T_{DM} model ages of ca. 1.3 Ga. SHRIMP U-Pb analyses of zircon grains of the tonalite sample and of the intrusive leucogranite indicate that they crystallized ca. 850 Ma. The rocks show positive $\epsilon Nd(t)$ values, characteristic of juvenile island arc source, and very similar to the results for tonalite gneiss from Mara Rosa, within the Goiás Magmatic Arc. Thus, we believe that these rocks represent the northern extension of the Neoproterozoic magmatic arc in Tocantins.

T_{DM} model ages older than 2.5 Ga are found in local areas between the towns of Conceição do Tocantins and Natividade, suggesting derivation from a continental Archean source. The major crust formation event in the Tocantins Province, however, occurred later than 2.3- 2.4 Ga, as indicated by the majority of T_{DM} model ages.

We dated a granite gneiss sample near Conceição do Tocantins. Five single zircon grains yield the U-Pb age of 2394 ± 43 Ma, interpreted as the crystallization age of the granite protolith. $\epsilon Nd(t)$ values are predominantly positive and characterize a large fragment of a Paleoproterozoic juvenile continental crust in the Tocantins Province.

Another crustal block is defined at the Porto Nacional region, where T_{DM} model ages range mainly from 2.2 to 2.1 Ga. If we consider the previously published 2.15 Ga U-Pb zircon evaporation ages as representing an igneous event, a different segment of juvenile crust is identified in this terrane, where $\epsilon Nd(t)$ values range from +1.9 to +3.

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POST-GRENVILLIAN (CA. 930 Ma) S-TYPE GRANITES IN SW AMAZONIAN CRATON: CRUSTAL EXTENSIONAL MAGMATISM RESULTED FROM GRAVITATIONAL COLLAPSE?

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The Amazonian Craton can be divided into 6 geochronological provinces from the Archean to the Mesoproterozoic: Central Amazonian (Archean), Maroni-Itacaiúnas (ca. 2.2 Ga), Ventuari-Tapajós (1.95-1.85 Ga), Rio Negro-Juruena (1.80-1.5 Ga), Rondonian-San Ignacio Province (1.42-1.26 Ga) and Sunsás-Aguapeí (1.26-0.97 Ga). This study is about the S-type magmatism (São Domingos Suite) hosted in granitic rocks of the Rondonian/San Ignacio province.

The São Domingos Suite (SDS) comprises roughly a circular body, and the main lithology is a white, isotropic and fine-grained granite. K-feldspar, quartz, plagioclase, biotite, muscovite and garnet are the major minerals; zircon, apatite and oxides occur as accessories. Two U-Pb zircon analyses yielded ages of 930 ± 12 Ma and 936 ± 26 Ma. Pb/Pb isochron age obtained on leaches of garnets yielded an age of 891 ± 110 Ma. A two-point Sm/Nd mineral (K-feldspar and garnet) isochron yielded an age of 927 ± 5 Ma. Both isochron ages are in agreement with the U/Pb zircon ages and strongly indicate that the SDS crystallized at ca. 930 Ma, and post-dates the metamorphic peak of the Sunsás orogeny (1.00-0.97 Ga).

Arc-related granitoids of Grenvillian age have been recognized in Bolivia, suggesting the evolving continental margin was westward (actual) from the studied area. In such a framework, the S-type granites of the SDS may be related to extensional tectonics post-Grenvillian collision. The SDS rocks probably result from gravitational collapse following crustal overthickening achieved during the preceding Grenvillian collisional event, represented in the studied area by the Aguapeí Thrust Belt rocks.

COEVAL MIGMATIZATION AND INTRUSION OF THE NORMAL CALC-ALKALINE BRASILIANO GRANITOIDS IN THE PAJEÚ - PARAÍBA TERRANE, NORTHEAST BRAZIL

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The Timbaúba Complex, comprises an E-W elongated ~200km² intrusion, porphyritic to equigranular epidote-bearing biotite hornblende granodiorite to monzogranite. It shows an U-Pb crystallization age of 644 ± 4.8 Ma. It is intruded within the Pajeú-Paraíba Terrane, Borborema Province, Brazil, in the contact between two distinct sequences: a metasedimentary-metavolcanic sequence including metagreywackes, marbles and amphibolites, in the north, and a gneiss-migmatitic sequence, in the south, both with Nd model ages in the 1.5 - 1.4 Ga range.

The Timbaúba granitoids have SiO₂ ranging from 63 to 71%, are metaluminous to slightly peraluminous and subalkaline. Trace element distribution patterns are similar to those recorded in calc-alkaline arc granitoids. They have Sm-Nd T_{DM} model ages ranging from 1.3 to 1.5 Ga, negative epsilon Nd (640 Ma) values ranging from -4.2 to -5.4 and epsilon Sr (640 Ma) ranging from 47 to 86.

The period 620-630 Ma has been interpreted in Cameroon as a stage of convergence, which started with flat-lying foliation and garnet-kyanite (northern Cameroon), or granulite (southern Cameroon) metamorphism associated with calc-alkaline plutonism. The Timbaúba Complex was deformed under high-T conditions and intruded parallel to the main country-rock foliation, during a flat-lying foliation forming event. This evidence, associated with the crystallization age, and a possible correlation with the Cameroon Province, strongly suggests that crustal melting, during the peak of metamorphic conditions, generated the Timbaúba granitoids. The crystallization age of the Timbaúba granitoids is supposed to date the convergent tectonic stage in the Pajeú – Paraíba Terrane, during the late Neoproterozoic.

These granitoids are also defined at the Porto Nacional region, where T_{DM} model ages range mainly from 2.2 to 2.1 Ga. If we consider the previously published 2.15 Ga U-Pb zircon evaporation ages as representing an igneous event, a different segment of juvenile crust is identified in this terrane, where epsilon Nd(t) values range from +1.9 to +3.

Acknowledgements: To CNPq (process 46.0408/00-3) for funding the analytical work to RAF.

Sr-Nd EVIDENCE OF PALEOPROTEROZOIC MANTLE METASOMATISM IN THE LITHOSPHERIC MANTLE BENEATH NORTHEASTERN BRAZIL

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The Rio Grande do Norte Domain is an orogenic domain located in the northeastern part of the Borborema Province (NE Brazil), and its tectonic evolution is largely related to the Pan-African/Brasiliano orogeny. All the rock units have been metamorphosed up to the amphibolite facies, and their deformational fabrics are dominated by extensive ductile shear zones displaying predominantly a dextral transcurrent kinematic regime. These structures control the emplacement of several granitoid intrusions (*ca.* 600 Ma) which are made up mainly by subalkaline porphyritic suites associated with basic-to-intermediate suites. These basic suites present shoshonitic or high-K calc-alkaline affinity, exhibiting a large compositional variation which may reflect fractional crystallisation from a basic parental magma.

Geochemical and isotopic data (high contents of Ba, Rb, Sr, K, Th and $[La/Yb]_N$, and strongly negative ϵNd_{600} values) point to enriched lithospheric mantle as the source of these basic rocks, since they are incompatible with the crustal contamination/mixing hypothesis as an exclusive petrogenetic mechanism responsible for the enriched signature observed. T_{DM} model ages (1.9-2.2 Ga) indicate that the enrichment event was old, related to Paleoproterozoic subduction processes, as indicated by the negative Nb-anomaly on multi-element diagrams.

The data set indicate the existence of extensive old, strongly heterogeneous sub-continental lithospheric mantle beneath northeastern Brazil. Partial melting of such metasomatized mantle took place at *ca.* 600 Ma, possibly in response to a thermal effect related to asthenosphere upwelling due to lithospheric thinning at this time. The wide range of isotopic parameters ($ISr = 0.702$ to 0.712 , $\epsilon Nd = -9$ to -19) confirms that the mantle heterogeneity was a result of injection of metasomatizing veins derived from subducted dehydrated slab. This model is compatible with a geodynamic scenario of accretion and recycling envisaged for the Paleoproterozoic time in the Borborema Province.

LONG-LIVED PROTEROZOIC CHEMICAL HETEROGENEITY OF THE SUB-CONTINENTAL LITHOSPHERIC MANTLE BENEATH NORTHEASTERN BRAZIL

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Nd and Sr isotopic signatures of Neoproterozoic, Mesozoic and Cenozoic mantle-derived rocks exposed in the Rio Grande do Norte Domain (Borborema Province, NE Brazil) indicate the involvement of contrasting mantle sources in the origin of the magmas. Isotope data and trace element modeling point to distinct mantle-enrichment events whose isotopic signatures are printed on the Neoproterozoic basic and Juro-Cretaceous basaltic rocks. These events generated reservoirs which are defined as: (i) a Paleoproterozoic (2.2-1.9 Ga) mantle source strongly enriched in incompatible trace elements ($[La/Sm]_N$ average of 4.6), with highly negative present-day eNd values (-18 to -26) and radiogenic $^{87}Sr/^{86}Sr$ (mostly > 0.707), and (ii) a (late-Mesoproterozoic?) mantle source also chemically enriched ($[La/Sm]_N$ average of 2.1, eNd from -2 to -8), but not as much as the Paleoproterozoic reservoir. Trace element geochemical (mainly Nb contents) and isotope data suggest that these two independent mantle-enrichment events were related respectively to ancient subduction (Paleoproterozoic, T_{DM} 2.2-1.8 Ga) and intraplate (late-Mesoproterozoic?, T_{DM} 1.1-0.9 Ga) processes. This intraplate-metasomatism event could be related to the Cariris Velhos orogeny (*ca.* 1.0 Ga) or to the Mesozoic rifting during the melting of the mantle source.

A mantle reservoir showing dominantly depleted characteristics, such as low $^{87}Sr/^{86}Sr$ (< 0.7045) and positive eNd values, was the source of the Cenozoic basaltic rocks. These results suggest an effective asthenosphere contribution in the genesis of these rocks, although a minor role of the lithosphere can be assigned since some samples show Nd signatures similar to those obtained for the Mesozoic basaltic rocks.

The compositional signatures of the distinct mantle-derived magmas vary temporally but not geographically, suggesting that the upper mantle in northeastern Brazil was strongly heterogeneous.

PATTERN OF Sm-Nd T_{DM} DISTRIBUTION IN GRANULITES AND GRANITOIDS FROM AN EXPOSED SECTION OF MIDDLE TO LOWER CRUST IN SE BRAZIL: VERTICAL AND LATERAL ZONING

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Granulites and granitoids from a tilted section of middle to lower crust exposed in SE Brazil (the Neoproterozoic Socorro-Guaxupé Nappe, SGN) show a significant spread of Sm-Nd T_{DM} . The oldest ages (> 1.8-2.0 Ga) were obtained in depleted granulites forming the deepest portion of the SGN. Lower Sm-Nd T_{DM} (1.4-1.7 Ga) are observed throughout the southern and eastern portions of the SGN, both in granulites crystallized at high P (over 11 kbar) and in middle-crustal migmatitic orthogneisses and anatectic granites (P < 7 kbar). The distribution of the ages suggests that the lower crust, represented by felsic to intermeditate high-P garnet granulites, is formed by two different types of terranes, while the middle crust is dominated by rocks with the lower ages of crustal accretion.

URANIUM-LEAD AGES OF ZIRCON MEGACRYSTS AND ZIRCON INCLUDED IN CORUNDUM FROM PEIXE ALKALINE COMPLEX (BRAZIL)

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The Peixe Alkaline Complex (Brazil) is a plutonic body composed by nepheline syenites, quartz syenites and granites. It is crosscut by granitic and syenitic pegmatites. Some syenitic pegmatites are corundum bearing. In the nepheline syenites there are zircon megacrysts (up to centimetric size). Zircon also occurs as millimetric inclusions in pegmatitic corundum. Five samples of nepheline syenite zircons and two corundum-included zircons were analyzed for U-Pb ages. The nepheline syenite zircons yield concordant to slightly discordant ages of approximately 1.5 Ga. The most discordant ones delineate a discordia line whose lower intercept was calculated as 577 Ma. The more concordant ages are consistent with the proposed regional geological evolution, that proposes an intracontinental rifting in the Mesoproterozoic. The lower intercept indicates a metamorphic-metasomatic event, which is tentatively related to the end of the Brasiliano orogeny. The corundum-included zircons yield an apparent age of ≈ 558 Ma. This may indicate an igneous event during the same period as the metamorphism/metasomatism. The corundum was possibly formed by direct crystallization from a new generation of alkaline magma or from a reaction between the pegmatite and the alkaline rock.

PRELIMINARY Nd ISOTOPIC DATA FOR THE ANICUNS-ITABERAÍ SEQUENCE, ASSOCIATED ORTHOGNEISSES, AND GRANITE INTRUSIONS, GOIÁS, BRAZIL

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Supracrustal rocks in the Anicuns region, Goiás, have been interpreted as a greenstone belt association (the Anicuns-Itaberaí Sequence), based on field and structural data. Preliminary Sm-Nd isotopic data for metavolcanic and metasedimentary rocks and orthogneisses of that region, however, suggest that the Anicuns-Itaberaí Sequence is instead part of the Neoproterozoic Goiás Magmatic Arc.

Rocks of the regional granite gneiss terrains show $T_{(DM)}$ values between ca. 1.42 and 1.61 Ga, indicating some contribution of older (Paleoproterozoic?) crustal material.

Metavolcanic rocks of the Anicuns-Itaberaí sequence show T_{DM} model ages of ca. 1.0 Ga, while the sedimentary rocks in this sequence display much older T_{DM} values (ca. 1.82 – 2.01 Ga).

Metavolcanic and metasedimentary rocks of the Córrego da Boa Esperança Sequence have T_{DM} values within similar intervals. Metasediments have T_{DM} ages between ca. 0.82 and 1.37 Ga and the metavolcanic rocks have model ages between 0.92 and 1.12 Ga. Intrusive granites and the Córrego Seco gabbro-diorite complex have Nd isotopic signatures within the same range as the Goiás Magmatic Arc rocks, with T_{DM} values of ca. 1.0 Ga.

The sedimentary rocks of the Anicuns-Itaberaí and Córrego da Boa Esperança sequences show a Nd isotopic pattern which is very similar to that observed for the Araxá Group of the Brasília Belt. Two obvious sources provide sediments to the basin: a Paleoproterozoic, most probably within the São Francisco Craton, and a juvenile Neoproterozoic source, represented by the island arc rocks of the Goiás Magmatic Arc.

THE TELES PIRES VOLCANIC PROVINCE: A PALEOPROTEROZOIC SILICIC-DOMINATED LARGE IGNEOUS PROVINCE IN SOUTHWEST AMAZON CRATON AND TECTONIC IMPLICATIONS

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The Teles Pires volcanic province consists of large volumes of silicic-dominated volcanic and plutonic rocks, which outcrop over ca. 40,000 km², in the southwest portion of the Amazon Craton, in northern Mato Grosso State, Brazil. The main characteristics of the province are: 1) developed in an intracontinental rift setting, 2) dominated by silicic-rich compositions, 3) coeval plutonism and volcanism, and 4) a time span for its development of ca. 60 Ma from 1.81 to 1.75 Ga. These characteristics allow us to suggest the development of the Province, during the Paleoproterozoic, in a similar way of the well-known large igneous provinces from Paleozoic to Mesozoic times. Tectonic implications of this suggestion include the existence of a stable cratonic plate, in the southwest portion of the Amazon Craton, before 1.81 Ga, and a prolonged taphrogenic period. This suggestion is a new view of the Craton evolution and is not in agreement with actual theories. Therefore, the 1.85 to 1.55 Ga magmatic arc of Rio Negro-Juruena Province is either older than 1.81 Ga or younger Rb/Sr ages should be reviewed.

THE RIO ALEGRE VOLCANOSEDIMENTARY SEQUENCE (SW AMAZONIAN CRATON, BRAZIL): CHEMICAL AND ISOTOPE (U/Pb AND Sm/Nd) CONSTRAINTS AND TECTONIC IMPLICATIONS

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The Rio Alegre volcanosedimentary sequence occurs in the SW Amazonian craton and may be subdivided into the Minouro Formation comprised of metabasites, banded iron formations, chemical sedimentary rocks and cherts; Santa Isabel Formation comprised of metabasalts, metapyroclastic rocks and metarhyodacites; and the São Fabiano Formation, which includes clastic and chemical metasedimentary rocks (phyllites, quartzites and carbonaceous layers), cherts, and metavolcanoclastic rocks. Intrusive felsic plutons range from tonalite to granodiorite.

Metavolcanic and metaintrusive rocks suggest a subalkaline signature formed in a back-arc ocean-floor environment and are a result of an evolution and differentiation of tholeiitic magmas. Mineralogical alterations in these rocks are typical of ocean floor metasomatic processes such as epidotization, carbonatization and sericitization. The geochemical data for intrusive felsic rocks indicate a calc-alkaline suite.

Magmatic activity of the Rio Alegre Terrane occurred during two time periods. Basic to intermediate rocks from 1509 Ma to 1494 Ma, with $\epsilon_{Nd(t)}$ values from +4.3 to +4.7 that indicate the volcanic rocks are juvenile. Two intrusive felsic rocks yielded U/Pb ages of 1465 ± 4 Ma and 1481 ± 7 Ma, $\epsilon_{Nd(t)}$ values from +3.8 to +4.1 and T_{DM} from 1.53 Ga to 1.50 Ga, suggesting that these plutonic rocks may be part of a juvenile terrane.

The Rio Alegre orogen is interpreted as having originated at a mid-ocean ridge at ~ 1.50 Ga, metasomatized under sea water, and metamorphosed under greenschist to amphibolite facies and transposed until mylonitized. The accretionary process to the proto-Amazonian Craton probably occurred during the subduction of this oceanic crust at 1.48-1.46 Ga during the formation of the felsic arc-related rocks.

NEW Sm-Nd ISOTOPIC DATA FROM THE SOUTHERN ARAÇUAÍ-RIBEIRA BELT: PARAÍBA DO SUL GROUP AND ASSOCIATED GRANITIC INTRUSIONS

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The Araçuaí-Ribeira belt is a Neoproterozoic orogenic belt extending along the Brazilian Coast, bordering the eastern margin of the São Francisco Craton. The main collisional stage of the Araçuaí-Ribeira belt in this region lasted from 622 ± 7 Ma to 580 ± 13 Ma. During this period metamorphism reached high amphibolite to granulite facies.

Large gneissic batholiths intruded shortly after the main collisional phase and regional deformation. The I-type metaluminous metagranitoids are thought to be melts derived from mixed sources, with an important contribution of an oceanic plate and/or a mantelic source mixed or mingled with partial melts from a prevailing meta-igneous and minor meta-sedimentary crust. S-type suites (peraluminous) were synchronous with the intrusion of the 580 Ma I-type. From 560 to 535 Ma there was a tectonic relaxation followed by a quiescence in the magmatic activity. A new magmatic episode started only around 535 Ma and lasted until 480 Ma.

New Sm-Nd isotopic data from the Southern Araçuaí-Ribeira belt, Paraíba do Sul group and associated granitic intrusions are discussed in this work.

The Sm-Nd ratios for the Paraíba do Sul and Costeiro Complexes vary from 0.1021 to 0.1296 indicating crustal rocks of meta-sedimentary origin. T_{DM} -model ages vary from 1.81 to 1.608 Ga. These values suggest a sedimentary source of at least Mesoproterozoic age for the Paraíba do Sul and Costeiro rocks.

The late orogenic Santa Angélica bimodal pluton points towards important negative ϵNd values for both the gabbroic and granitic rocks ($\epsilon Nd \sim -20$). This reinforces the idea of an anomalous enriched mantle under this region. One sample from the granodiorite gneiss (Estrela Muniz Freire Batholith) shows a T_{DM} -model age of 1.628 Ga. Comparing to the Santa Angélica values, this single value indicates that the synorogenic magmatism has less mantle contribution than the later one.

GEOCHRONOLOGY $^{207}\text{Pb}/^{206}\text{Pb}$ AND Rb/Sr AND Sm/Nd ISOTOPIC SIGNATURES OF THE NEOPROTEROZOIC QUARTZ-MANGERITE-MONZOGRAHITE-CHARNOCKITE SÃO FRANCISCO XAVIER SUITE, NORTHEASTERN STATE OF SÃO PAULO, BRAZIL

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This work presents Rb/Sr, Sm/Nd and $^{207}\text{Pb}/^{206}\text{Pb}$ isotopic data from the Neoproterozoic quartz mangerite-monzogranite-charnockite São Francisco Xavier Suite, granitic Serra do Mato Mole Suite and associated orthogneiss of the Socorro Block, Ribeira Belt, Northeastern São Paulo State, Brazil.

The Socorro Domain constitutes an important geotectonic unit that crops out in the northeastern part of the State of São Paulo. It is represented by a charnockite-granite batholithic mass, intrusive in migmatitic gneiss of medium to high metamorphic grade. In the study region it is composed chiefly by charnockitic-granitic rocks, that constitute the following suites: quartz mangerite-monzogranite-charnockite (São Francisco Xavier), granitic (Serra do Mato Mole) and orthogneissic. The charnockitic facies is almost always present.

$^{207}\text{Pb}/^{206}\text{Pb}$ geochronology using single zircon crystals were made in three samples of the São Francisco Xavier Suite, two samples of the porphyroblastic orthogneisses and one of the granodiorite related to the granite-granodiorite gneiss suite. The charnockite-granite of the São Francisco Xavier Suite yields $^{207}\text{Pb}/^{206}\text{Pb}$ ages between 587 ± 5 and 591 ± 8 Ma and the sample of the porphyroblastic orthogneiss an age of 585 ± 5 Ma. These values are quite similar and indicate that the charnockite-granite rocks have the same origin in a late-orogenic magmatic event. This is based on the fact that the chief metamorphism has been dated at 625 ± 5 Ma. There is also an age of 612 ± 8 Ma obtained in the porphyroblastic orthogneisses that may indicate the beginning of the magmatic emplacement.

An older age (649 ± 4 Ma) has been obtained for the granodiorite gneiss, that permit to consider this rock as belonging to a pre- to synorogenic event, the beginning to the Socorro magmatism.

Seven rock samples were analyzed for Sm/Nd and 12 for Rb/Sr. $^{87}\text{Sr}/^{86}\text{Sr}_{590}$ ratios are between 0.709157 and 0.715226, while ϵNd_{590} are between (-10.23) and (-11.83) with T_{DM} between 1.86 and 2.08 Ga. A crustal origin is considered for the São Francisco Xavier Suite, consequence of the partial melting of a granulitic crust with a very long crustal residence. A common origin for charnockitic and granitic types is suggested.

Nd, Sr AND Pb ISOTOPE ANALYSES AND Sm/ Nd AGES OF ADRIANOPOLIS AND APIAÍ METABASIC ROCKS, AÇUNGUI GROUP, SOUTHERN PORTION OF THE RIBEIRA BELT, BRAZIL

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Geochemical studies of metabasic rocks associated with the metasediments of the Açungui Group, South of the Ribeira Belt, indicate that these rocks have tholeiitic basalt affinities. Isotopic studies involving Nd, Sr and Pb are now presented for these rocks.

The occurrence at Apiaí contains essentially the minerals augite, hypersthene, plagioclase (An 50-70) and hornblende. In the types from Adrianópolis, ortho and clinopyroxene, labradorite and metamorphic actinolite are the commonest minerals. Both occurrences show very well preserved subophitic textures.

Geochemically they are related to subalkaline olivine tholeiites with E-MORB type basalt signatures, emplaced in a retro-arc type basin.

Age determinations for the Apiaí Metagabbro indicate 850 ± 85 Ma by the Rb/Sr method and 617 ± 4 Ma determined by U/ Pb in zircon, with the last value considered as the age of the metamorphism.

Two samples from Adrianópolis and two from Apiaí were analyzed for Sm, Nd and Pb isotopes. For PI 28 and AD 27 pyroxene and plagioclase were also analyzed. The results are plotted in variation diagrams. We observe that both Apiaí and Adrianópolis plot in the diagrams in the areas of the ocean island basalt (OIB) and continental flood basalt with some enrichment in the isotopes. This enrichment may be a possible consequence of inheritance or more probably crustal contamination of these rocks.

Sm/ Nd determinations in the metabasites show positive values of ϵ_{Nd} for the age of 615 Ma ($\epsilon_{Nd_{615}}$) for the samples AD (2.55 and 2.76) and negative ones for the samples PI (-1.67 and -1.82). T_{DM} for the samples of Apiaí indicate values between 2.4 and 2.8 Ga.

Age determinations by Sm/Nd mineral isochron using total rock, plagioclase and pyroxene give values of 820 ± 84 Ma for Adrianópolis and 885 ± 53 Ma for Apiaí. These ages could indicate the time of magmatic crystallization of the basic bodies or represent an intermediate value, consequence of the inheritance or crustal contamination detected in these rocks.

THE RIO CRESPO INTRUSIVE SUITE: GEOLOGICAL U-Pb AND Sm-Nd ISOTOPIC EVIDENCE FOR A MAJOR 1.43 Ga ARC-RELATED MAGMATISM IN THE RONDÔNIA STATE, SW AMAZONIAN CRATON, BRAZIL

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The Rio Crespo Intrusive Suite occurs in the central-eastern part of the Rondônia state. It comprises arc-related magmatic rocks with U-Pb ages between 1433 to 1424 Ma. It has scanty areal expression within the study area, but these rocks are widespread further south and west, and provide the first evidence of a major arc-related magmatism in Rondonian-San Ignacio time in the region. These rocks are fine- to medium-grained quartz-feldspathic banded gneisses of granitic composition, which were metamorphosed at granulite facies grade. Xenoliths of meta-charnockite (1560 Ma) and mafic granulites (~1730 Ma) support an intrusive origin for the protolith of the fine-grained gneisses and granulites. The rocks range from metaluminous to marginally peraluminous in composition and are characterized by high Fe/Mg ratios and K₂O contents. The trace element data point to an A-type and within-plate granite geochemical signature. Three samples of this suite yield slightly positive $\epsilon\text{Nd}(T)$ (+1.22 to +0.60) and narrow range T_{DM} between 1733 and 1753 Ma. These Nd data indicate that the original granitic magma was neither typically juvenile nor a direct melt of the surrounding older crust, and appear to represent a mixture of these materials. The geochemical and Nd signatures of these rocks are very similar to the correlatable most evolved granites of the calc-alkaline Santa Helena batholith situated further southeast in the Mato Grosso state. This implies an almost continuous magmatic arc along the SW margin of the Amazonian Craton in the time interval 1.45-1.42 Ga, related to the Rondonian-San Ignacio orogeny.

U-Pb AGE AND ORIGIN OF THE URUANA QUARTZ SYENITE AND ITAPURANGA ALKALI GRANITE IN GOIÁS, CENTRAL BRAZIL: LATE BRASILIANO ALKALI-RICH MAGMATISM IN THE ANÁPOLIS-ITAUÇU COMPLEX

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The Brasília Belt is a N-S Neoproterozoic orogen developed along the western margin of the São Francisco-Congo Craton. The Anápolis-Itaçu Complex is a high-grade terrain exposed in the central part of the belt. It is made of granulites of sedimentary origin, mafic-ultramafic bodies, metatonalites, amphibolites and a number of intrusive bodies, some of which of Brasiliano (Pan-African) age. The Uruana quartz syenite and Itapuranga alkali granite are large intrusive bodies, elongated in the EW direction, in the northern part of the high-grade complex. Their age has been a subject of debate for many years. In this study we present new U-Pb (conventional and SHRIMP) for these alkali-rich intrusions. The Uruana quartz syenite yielded a conventional U-Pb age of 627 ± 27 Ma and the Itapuranga zircons were dated at 630 ± 36 Ma by the U-Pb SHRIMP method. Both display important inheritance with ages varying from ca. 0.8 to 1.8 Ga, suggesting the participation of a sedimentary component in the original magma. Sm-Nd isotopic analyses yielded T_{DM} ages of 1.4 Ga for both intrusions. They represent mixing ages. The intrusions are, therefore, related with the final stages of the Brasiliano orogenic cycle in central Brazil. Their age coincide with the peak of the Brasiliano regional metamorphism. They were probably emplaced in transtensional settings associated with the development of important E-W lineaments which characterize the southern part of the belt.

Negro-Juruena Province (RNJP) while others considered different interpretations. Even though the present data are preliminary, they show a much more complicated history and that the history is much longer than was interpreted previously.

ISOTOPIC EVIDENCE FOR TWO NEOPROTEROZOIC HIGH-GRADE METAMORPHIC EVENTS IN THE BRASÍLIA BELT

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The Brasília Belt is a Neoproterozoic orogenic belt formed in the N-S direction along the western margin of the São Francisco-Congo Craton. High-grade rocks are exposed in two main regions: (i) in the northern part of the belt they are represented by the mafic-ultramafic granulites in the eastern portion of the Barro Alto, Niquelândia and Cana Brava large layered mafic-ultramafic complexes, and (ii) in the southern part of the Brasília Belt, granulites form the Anápolis Itauçu Complex, including paragránulites (garnet-sillimanite gneisses) associated with amphibolites, mafic-ultramafic complexes, metatonalites and a number of intrusive granites, some of which also display mineral assemblages of the granulite facies. Recent geochronological data have revealed that high-grade metamorphic rocks in the Brasília Belt have been formed in two distinct metamorphic episodes. Granulites of the northern part of the Brasília Belt have consistently shown U-Pb zircon ages (metamorphic zircons) and garnet-whole rock Sm-Nd ages within the range 790-740 Ma. High-grade rocks of the Anápolis Itauçu Complex, on the other hand, display both U-Pb SHRIMP and Sm-Nd garnet ages in the range 670-620 Ma. The younger event is also registered in rocks of the mafic-ultramafic complexes, as indicated by U-Pb rutile and Sm-Nd garnet ages. The early event is being interpreted as the result of the early collision of an allocthonous block (northern Goiás Arc or Goiás Massif?) to the western margin of the belt, while the typical Brasiliano event is most probably the result of continental collision and final ocean closure.

CABAÇAL BELT, SOUTHERN AMAZON CRATON IN MATO GROSSO – BRAZIL: IMPLICATIONS FOR THE TECTONIC EVOLUTION (MORE COMPLICATIONS)

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The Cabaçal Belt covers an area of approximately 350 square kilometers in the southern region of the Amazon Craton, Mato Grosso-Brazil. It is a narrow NNW-trending belt of greenschist to amphibolite grade volcano-sedimentary rocks intruded by plutonic rocks of tonalitic to granitic composition and mafic sills/dikes. The west border of the belt is represented by a basement gneiss.

Zircons from the gneiss yielded two distinct ages: 1666 ± 7 Ma and 1712 ± 9 Ma. We interpret the younger age as a possible crystallization age; the older age may be due to xenocrysts or cryptic cores. The 1666 Ma age is different from other gneiss ages reported from the region (1550 and 1750 Ma), suggesting that it too may be influenced by inherited zircons. The Cabaçal Tonalite shows different populations of zircons and yields several apparent ages ranging from ca. 645 Ma to ca. 2635 Ma, (Pb207-Pb206 ages for more concordant grains include ages of 710, 1026, 1464, 1713, 1862, 1970, 2039, and 2636 Ma). These zircons are probably xenocrysts from assimilated Neoproterozoic sedimentary rocks and strongly imply a late Neoproterozoic (Brasiliano) age for this tonalite. A nearby andesitic pyroclastic metavolcanic unit yields a similar age spectrum (600 to 2100 Ma). Thus, it appears that at least two igneous units previously mapped as Paleoproterozoic may be outliers of Brasiliano rocks of the Alto Paraguai fold belt (?).

The evolution of the southern portion of the Amazon Craton is a matter of long-standing debate. Some interpreted those rocks as a SE extension of the Rio Negro-Juruena Province (RNJP) while others considered different interpretations. Even though the present data are preliminary, they show a much more complicated history and that the history is much longer than was interpreted previously.

THE ALTO RIBEIRA MAGMATIC ARC (PARANA STATE-SOUTHERN BRAZIL): GEOCHEMICAL AND ISOTOPIC EVIDENCE OF MAGMATIC FOCUS MIGRATION AND ITS TECTONIC IMPLICATIONS

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The Ribeira fold belt in Paraná State, Brazil, is the result of a series of superposed tectono-metamorphic events. Between 640 and 550 Ma an important crustal accretion event within the Brasiliano Megacycle was responsible for the generation of the Alto Ribeira Magmatic Arc (ARMA). This arc is represented by the Cunhaporanga (CPB) and Três Córregos (TCB) granitic batholiths, which occupy ca. 6,500 km².

The CPB is more homogeneous, being mainly composed of porphyritic to inequigranular, isotropic monzogranite, accompanied by rare granodiorite. The TCB is more heterogeneous, and includes quartz monzonite, granodiorite and monzogranite, as well as rare tonalite and syenogranite.

The rocks of the CPB are metaluminous to weakly peraluminous, and those of the TCB are predominantly metaluminous. Both batholiths are calc-alkaline. The main chemical contrast is in the alkali elements, the CPB being more potassic and less sodic, while the TCB is more sodic and less potassic.

Conventional multi-grain U-Pb (zircon) dating of the crystallization age is complex where inherited zircons are present. Nevertheless, a short time interval for intrusion of the CPB at ca. 590 Ma has been inferred. In contrast, intrusion of the TCB took place over a much longer interval (636-600 Ma). Titanite fractions from granites of both batholiths yielded U-Pb ages between 570 and 550 Ma.

Different Nd T_{DM} ages are inferred for CPB (1.8-2.0 Ga) and TCB (2.2-2.4 Ga). ϵ_{Nd} values are highly negative (-11 to -13 CPB and -17 to -19 TCB). (⁸⁷Sr/⁸⁶Sr) values are higher than 0.709, while Pb isotopic compositions favor an upper crustal source for CPB, and a lower crustal source for TCB.

The geochemical and geochronological differences between the two batholiths are a result of the northwestward movement of the ARMA, a response to continuous northwestward subduction of an oceanic plate, towards the Paranapanema block, under a Paleoproterozoic continental margin. The titanite data could represent the age of collision between the Paranapanema and Curitiba blocks.

DOM FELICIANO BELT AND PUNTA DEL ESTE TERRANE: GEOCHRONOLOGICAL FEATURES

(BUENOS AIRES PROVINCE, ARGENTINA)

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The aim of this paper is to perform an analysis of the Dom Feliciano Belt and the Punta del Este Terrane from a geochronologic point of view using a radiometric profile. The Dom Feliciano Belt presents ages for its basic magmatism around 700 Ma and for its basement around 2.1 Ga. This belt originated during the Brazilian orogenesis. Associated with metamorphic rocks and occurring to the west of Sierra Ballena Shear Zone predominate granitoids with ages from 0.8 to 0.6 Ga, which probably were the magmatic arc of the metamorphic belt. These show isotopic signatures different from those granites which are developed to the east of the Sierra Ballena Shear Zone, which were generated during the Rio Doce orogenesis in a restricted period of time around 0.61 to 0.5 Ga. The Punta del Este Terrane is considered as an integral unit composed of a gneissic-migmatitic basement, deformed granitoids and a metasedimentary cover (Rocha Group) without continuity, up to date, in Brazil and Argentina. Its age is around 1000 Ma (Namaqua orogenesis) and it is extremely affected by the Neoproterozoic orogenesis. Nevertheless, it is not discarded the existence of older cores as it can be noticed in several upper intercepts in concordia diagrams around 1.8 Ga.

WESTERN CRATONIC DOMAINS IN URUGUAY: GEOCHRONOLOGY

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The western cratonic domains of Uruguay acted as a foreland during the development of the Dom Feliciano Belt. They are composed of the Piedra Alta Terrane (1.3 to 2.5 Ga), the Valentines Block (1.78 to 2.6 Ga) and the Pavas Block (2.7 to 3.4 Ga). The Piedra Alta Terrane comprises three different metamorphic belts separated from one another by a gneissic-migmatitic complex. The Valentines Block's limit with the former terrane is the Sarandí del Yí - Arroyo Solís Grande shear zone. Wide gneissic granulitic areas, granitoids and basic rocks of diverse nature compose the Valentines Block. Intrusive granitoids with ages between 0.6 and 0.5 Ga are also included. This Block is separated from the Pavas Block by the Cueva del Tigre shear zone. The Pavas Block has an orthogneissic basement and a supracrustal sequence with ages between 3.4 to 2.7 Ga. The aim of this paper is the identification of events in order to make a geologic characterization of the units using a radiometric profile.

The rocks of the CPB are mainly gneissic and amphibolitic. The TCB are predominantly metagabbroic. Both batholiths are calc-alkaline. The main chemical contrast is in the alkali elements, the CPB being more potassic and less sodic, while the TCB is more sodic and less potassic.

Conventional multi-grain U-Pb (zircon) dating of the crystallization age is complex where inherited zircons are present. Nevertheless, a short time interval for intrusion of the CPB at ca. 590 Ma has been inferred. In contrast, intrusion of the TCB took place over a much longer interval (636-600 Ma). Titanite fractions from granites of both batholiths yielded U-Pb ages between 570 and 550 Ma.

Different Nd T_{DM} ages are inferred for CPB (1.8-2.0 Ga) and TCB (2.2-2.4 Ga). ϵNd values are highly negative (-11 to -13 CPB and -17 to -19 TCB). ($^{87}Sr/^{86}Sr$) values are higher than 0.709, while Pb isotopic compositions favor an upper crustal source for CPB, and a lower crustal source for TCB.

The geochemical and geochronological differences between the two batholiths are a result of the northwestward movement of the ARMA, a response to continuous northwestward subduction of an oceanic plate, towards the Paranapanema block, under a Paleoproterozoic continental margin. The titanite data could represent the age of collision between the Paranapanema and Curitiba blocks.

CRUSTAL EVOLUTION OF GRANITOIDS AND GNEISSES FROM THE CAMBAIZINHO BELT, SOUTHERN BRAZIL: REVIEW, NEW ZIRCON Pb-Pb EVAPORATION AGES AND Pb-Nd-Sr ISOTOPES

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Deformed granitoids and gneisses from the Cambaí Complex (900-700 Ma) along Cambaizinho Creek and in the Vila Nova do Sul region, state of Rio Grande do Sul, Brazil, were formed in a remarkably short time, about 10 m.y., between 704 ± 13 and 697 ± 3 Ma. The data base of this work includes eighteen zircon Pb/Pb evaporation analyses, and five Pb isotope analyses of feldspar and whole rock.

The oldest known rocks in the region are polydeformed dioritic gneisses dated by conventional U-Pb zircon at 704 ± 13 Ma. New Pb-Pb zircon evaporation data on the late transcurrent, less deformed and more evolved granitoids (Sanga do Jobim Granitoids) yield a 697 ± 3 Ma age and indicates that the evolution of the plutonic magmatism in the area was nearly contemporaneous. These data contrast with previous interpretations based on Rb-Sr data which considered that these rock associations were formed during a longer time period (700-640 Ma). All these granitoids intruded the supracrustal sequence. These granitoids yield a minimum age of about 700 Ma for the formation of the supracrustal sequence and its regional dynamothermal metamorphism. Lead isotope compositions of K-feldspar from Sanga do Jobim Granitoids plot close to, but slightly below the lead isotope evolution curve of orogeny in the Zartmann and Doe model. This indicates that the setting for these granitoids was that of a juvenile magmatic arc.

These new data, plus previous data in the region, corroborate that the crustal evolution involved juvenile crustal accretion between 760 and 700 Ma. In contrast, the Caçapava and São Sepé Granites intruded the supracrustal sequences along the eastern side of the São Gabriel Block at 562 Ma and 550 Ma, respectively, and show Pb and Nd isotope signatures from an old basement. This evidence suggests that the juvenile terrane was thrust over the older basement situated along the eastern part of the shield during the Dom Feliciano collisional orogeny at about 620-590 Ma.

OLDEST CHARNOKITIC MAGMATISM IN THE AMAZON CRATON: ZIRCON U-Pb SHRIMP GEOCHRONOLOGY OF THE JABURU CHARNOKITE, SOUTHERN RORAIMA, BRAZIL

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Charnokitic rocks are common in three regions of the Amazon Craton, focused in the following states: southeast and southwest of Amapá, east-central Rondônia, and south-central Roraima/northeast Amazonas. They have been interpreted as granulites by several authors. The misidentification was caused by the difficulty in discriminating between granulite facies rocks with amphibolite facies retrograde orogenic metamorphism and igneous rocks sheared under amphibolite facies conditions. The shearing process is related to the Sunsas Orogeny or K'Mudku Shearing Episode at 1330-1050 Ma.

The charnockitic rocks from central Roraima (1564 ± 21 Ma) and Rondônia (1566 ± 3 Ma and 1544 ± 4 Ma) have Mesoproterozoic (Calimian) ages and occur associated with rapakivi granites, such as the Mucajaí Granite and the Surucucus Intrusive Suite in Roraima and the Serra da Providência Intrusive Suite in Rondônia.

The Amapá charnockites remain undated and this paper presents results of the first U-Pb dating of a southern Roraima charnockite: the Jaburu Charnockite. The Orosirian age of 1873 ± 6 Ma is interpreted as the crystallization age and indicates that the Jaburu Charnockite is much older than the Calimian Serra da Prata Charnockites of central Roraima (1564 ± 21 Ma) and the Jaru Charnockites of Rondônia (1566 ± 3 Ma and 1544 ± 4 Ma). The Jaburu Charnockite age correlates well with the A-type Mapuera (1864 ± 15 Ma) and Maloquinha (1870 Ma) Intrusive Suites. This granite-charnockite association has similarities with the 1870 Ga post-tectonic suite of the Central Finland Granitoid Complex. Among the several charnockitic occurrences in the central-north Amazon Craton, only a few were dated and more isotopic work is required to define which occurrences are related to the younger Serra da Prata or with the older Jaburu Charnockites. There may possibly have been a third, Grenvillian, epoch of generation of charnockitic C-type magma, as found in the Baltic Shield.

AGES OF THE CALIMIAN REPARTIMENTO ANORTHOSITE AND THE MESOZOIC APIAÚ ALKALINE PIPES IN NORTHERN AMAZON CRATON, BRAZIL, BASED ON BADDELEYITE AND ZIRCON U-Pb AND Rb-Sr GEOCHRONOLOGY

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Anorthosites are scarce in the Amazon Craton. The better known are the Archean Luanga Stratiform Complex in the Carajás Province and some Mesoproterozoic occurrences in the Tapajós-Parima and Rondônia-Juruena Provinces. These generally are minor bodies or layers associated with gabbroic rocks such as the Siriquiqui, Cacaual and Tapuruquara Gabbro Complexes. The Repartimento Anorthosite is a batholith in central Roraima State, which was related by prior workers to two other Mesoproterozoic units: the Mucajaí Rapakivi Granite (1544 Ma) and the Apiaú Alkaline Suite. We present a precise Calimian age of 1527 ± 7 Ma for the Repartimento Anorthosite, which confirms the inferred Mesoproterozoic age and the correlation to the Mucajaí Rapakivi Granite (1544 Ma) and the Serra da Prata Charnockite (1564 ± 21 Ma). Here, this correlation is extended to the undated Caracarái Gabbro. However, contrary to prior interpretations, the Repartimento Anorthosite is the youngest member of the Anorthosite-Charnockite-Rapakivi-Gabbro assemblage.

The Rb-Sr age of 140 ± 10 Ma of the Apiaú Alkaline Pipes indicates that these rocks are Mesozoic and not Mesoproterozoic in age. In view of the uncertainty of 10 m.y. the possible age ranges from 130 Ma (Berriasian, Early Cretaceous) to 150 Ma (Oxfordian, Late Jurassic). The Apiaú pipes are interpreted as related to the Tacutu Graben evolution, located to the northeast, according to its age and geographic position. The Mesozoic N40°E fault system, which delimits the graben in the Roraima-Guyana border, extends to the pipe swarm area to the southwest. The Apoteri basaltic flows of the Tacutu Graben have an Rb-Sr age of 135 ± 14 Ma, comparable to the alkaline rocks age of 140 ± 10 Ma.

FIRST INDICATION OF MESOPROTEROZOIC AGE FROM THE WESTERN BASEMENT OF SIERRA DE SAN LUIS, ARGENTINA

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The komatiites and amphibolites cropping out in the western basement of Sierra de San Luis (Eastern Sierras Pampeanas) have been subjected to Sm-Nd isotopic study. These mafic to ultramafic rocks are in association with a supracrustal sequence that includes banded iron formations and gneisses, and preserve relict NW-SE trending structures acquired prior to the main Lower Paleozoic NNE-SSW trending ones. The Sm-Nd whole rock isochron yielded an age of 1502 ± 95 Ma, with initial $^{143}\text{Nd}/^{144}\text{Nd} = 0.51086 \pm 0.00010$ and MSWD of 1.1. The T_{DM} calculated is in the range 1638 - 1883 Ma. This is the first mention of an Early Mesoproterozoic date from the Sierra de San Luis, and therefore, we discuss its validity within the geological and regional context. The analysis comprises the following alternatives: (1) crust-mantle differentiation age, (2) magmatic crystallization age, (3) metamorphism age, and (4) a fictitious age. Although we do not exclude the possibility that the isochron age represents the crust-mantle differentiation process, we suggest a possible crystallization age on the basis of the local geology and the regional information. The local geology refers to the lithological association typical of the Precambrian (komatiites and banded iron formations), and the regional information refers to the considerable number of K-Ar and Rb-Sr Mesoproterozoic dates reported from amphibolites and gneisses of Sierra de Córdoba and the underground of the Llanura Chacopampeana, both located to the east of Sierra de San Luis. The magmatic crystallization process is understood in relation to an extensive komatiitic to basaltic extrusion, probably associated with marine sedimentation and volcanic-hosted iron formations.

THE ITAIACOCA GROUP: U-Pb (ZIRCON) RECORDS OF A NEOPROTEROZOIC BASIN

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The main objective of this work is to discuss the U-Pb ages obtained for zircon grains from metavolcanic rocks of the Itaiacoca Group. The Itaiacoca Group is a metavolcano-sedimentary sequence which occurs as a narrow belt between the Cunhaporanga granite batholith to the northwest and the Itapirapuã shear zone to the south and southwest, which separates the sequence from the Três Córregos granite batholith and metasedimentary rocks of the Açungui Group. Geological studies of the southern part of the Itaiacoca belt led to the recognition of three units, represented by (from base to top) metawackes with an important volcanic component, metacarbonate, metapelitic and metapsammitic rocks.

The U-Pb geochronological analyses of zircon grains from two outcrops of metavolcanic rocks yielded ages of 628 ± 18 Ma (SHRIMP) and 636 ± 30 Ma (conventional multi-grain analysis). These ages suggest that the Itaiacoca Basin developed during the Neoproterozoic at about 630 Ma, slightly before the formation of the granitic batholiths which are believed to be magmatic arcs. The metamorphism which affected the sequence seems to have occurred soon (10-15 Ma) after its deposition, which suggests that basin closure was rapid. This scenario could imply that the initial tectonic situation was a back-arc basin which evolved as a function of the collisional process and its accompanying magmatic activity into an intra-arc basin and, later still, into an interarc basin during the closing phases of the Neoproterozoic.

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MANTLE ACCRETION EVIDENCE DURING THE NEOPROTEROZOIC OF THE PERNAMBUCO-ALAGOAS TERRANE, AND ITS SIGNIFICANCE TO THE EVOLUTION OF THE BORBOREMA PROVINCE, NE BRAZIL

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The Borborema Province is located in NE Brazil, corresponding to the western part of a major fold belt, which extends from Brazil to West Africa. According to paleogeographic reconstruction, it is located between the Congo, São Francisco and West Africa cratons. The Pernambuco-Alagoas Terrane is a major tectonic unit of the Borborema Province and comprises high-grade metamorphic sequences and the greatest granitic batholiths of this province. The granitic batholiths Maribondo-Correntes, Buique-Paulo Afonso and Águas Belas-Canindé and their ortho- derived country rocks show metaluminous and peraluminous compositions, ϵNd (0.60 Ga) between +3.2 and -2.0, and T_{DM} between 0.90 Ga and 1.20 Ga. These Nd isotopic data favour a crustal evolution hypothesis involving accretion of juvenile material at least during the Brasiliano orogenesis collision and perhaps the formation of a juvenile lithosphere during the end of the Mesoproterozoic.

ARCHEAN AND PROTEROZOIC MULTIPLE TECTONOTHERMAL EVENTS RECORDED BY GNEISSES IN THE AMPARO REGION, SÃO PAULO STATE, BRAZIL

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The basement of the Mesoproterozoic arc of the Alto Rio Grande Belt, is a microplate between the São Francisco Craton and the Ribeira Fold Belt of southeastern Brazil. This basement is composed of migmatites/orthogneisses and intrusive metagranitoids. In order to investigate further the age of the protoliths plus their subsequent high-temperature crustal history, U-Pb zircon (SHRIMP) and Sm-Nd model ages were determined for components of the migmatites and metagranitoids.

The samples from the Amparo Migmatite yielded U-Pb zircon (SHRIMP) ages of 2850 ± 19 Ma for the upper intercept and a lower intercept of 1218 ± 150 Ma for the paleosome; an upper intercept of 2019 ± 15 Ma and a lower intercept of 525 ± 450 Ma for igneous zircons from a subconcordant amphibolite sheet; a $^{207}\text{Pb}/^{206}\text{Pb}$ date of 2032 ± 28 Ma (cores) and a weighted mean $^{206}\text{Pb}/^{238}\text{U}$ date of 595 ± 26 Ma (overgrowths) for the pink foliated granitic neosome component; and a weighted mean $^{207}\text{Pb}/^{206}\text{Pb}$ date of 3003 ± 16 Ma (cores) and a weighted mean $^{207}\text{Pb}/^{206}\text{Pb}$ date of 607 ± 29 Ma (overgrowths) for the late/post-kinematic granite dyke.

Zircons from the sample of the Serra Negra orthogneiss yielded an imperfect model 1 regression (MSWD=5.4), with an upper intercept of 2758 ± 70 Ma and a lower intercept of 644 ± 110 Ma.

Sm-Nd whole-rock analyses were undertaken on samples from both the Amparo Migmatites and Serra Negra Orthogneiss. The results indicate Archaean T_{DM} with 3220 Ma for the Serra Negra Orthogneiss and 2860 Ma for the Amparo Migmatite. e_{Nd} values at the time of crystallisation are -3.76 and +1.85, respectively. Our results suggest a crustal geological history for the basement of the Alto Rio Grande Belt dating back at least to 3000 Ma, affected by multiple tectonothermal events, around 2000 and 600 Ma.

ARCHEAN CRUSTAL GROWTH OF THE IMATAKA COMPLEX, AMAZONIAN CRATON: EVIDENCE FROM U-Pb, Sm-Nd AND Rb-Sr GEOCHRONOLOGY

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The Archean Imataka Complex (IC), NW Amazonian Craton, forms a ENE-trending, fault-bounded block adjacent to the Paleoproterozoic Maroni-Itacaiúnas magmatic arc (2.2 – 2.0 Ga). The IC rocks are complexely deformed, exhibiting elongated and symmetrical domes and thrusts combined with isoclinal folds. Transcurrent faults are also important, like the Guri Fault System, a zone of multiple faulting, shearing and mylonitization, along the southeastern edge of the IC. The IC is mainly composed of medium- to high-grade quartz-feldspathic paragneiss, and exhibits extensive mortar, augen, flaser and mylonitic textures. Calc-alkaline gneiss and granitoid rocks of igneous protolith are also present in the IC, as well as dolomitic marbles, orthopyroxene and magnetite quartzites, and BIFs.

This paper reports zircon U-Pb SHRIMP, Sm-Nd and Rb-Sr isotopic data of different IC rocks in order to investigate their age and geological evolution within the tectonic framework of the Amazonian Craton.

The sample of a felsic component of banded garnet-bearing granulites yielded a weighted mean $^{207}\text{Pb}/^{206}\text{Pb}$ date of 3229 ± 39 Ma (MSWD = 5.2). A sample of the La Ceiba migmatite gave a ^{204}Pb corrected weighted mean $^{207}\text{Pb}/^{206}\text{Pb}$ date of 2787 ± 22 Ma (MSWD = 1.9). Sm-Nd whole rock isotopic mapping of the IC yielded ages mostly between 3.23 – 3.00 Ga and 2.90 – 2.80 Ga, in close agreement with the zircon U-Pb ages, supporting the juvenile nature of the crust, which is associated with two major mantle-differentiation events.

As a whole, the isotopic inferences in conjunction with the recognized polyphase tectonic framework of the Archean crust (e.g., faults, mylonites, folding, juvenile accretion vs. crustal reworking) demonstrate that the IC is an allochthonous block which was juxtaposed to the Maroni-Itacaiunas belt during the Late Paleoproterozoic.

GEOCHRONOLOGY OF CALC-ALKALINE AND THOLEIITIC DYKE SWARMS OF TANDILIA, RIO DE LA PLATA CRATON, AND THEIR ROLE IN THE PALEOPROTEROZOIC TECTONICS

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Two distinct, unmetamorphosed dyke swarms intrude the Paleoproterozoic Tandilia Orogenic System: *i*) intermediate (I) and acid (A); *ii*) basic (B₁ and B₂). The latter dykes are composed of tholeiites, whereas the (I) and (A) dykes show a contrasting calc-alkaline signature (e.g., higher SiO₂, K₂O and Ba contents).

The calc-alkaline dykes yielded ⁴⁰Ar/³⁹Ar plateau ages of 2,020 ± 24 Ma and 2,007 ± 24 Ma for their emplacement, in agreement with a Rb-Sr errorchron of 1,956 ± 110 Ma (initial ⁸⁷Sr/⁸⁶Sr = 0.7038 ± 0.0025). The (B₁) dykes erupted at 1,588 ± 11 Ma (upper intercept U-Pb age; two baddeleyites). The lower intercept of 644 ± 170 Ma reveals an episodic Pb loss, probably induced by the adjacent Neoproterozoic Dom Feliciano belt. This is consistent with K-Ar whole rock ages (B₁ and B₂ dykes) from 803 ± 14 to 1,193 ± 18 Ma and a ⁴⁰Ar/³⁹Ar plagioclase plateau age of 811 ± 36 Ma.

The calc-alkaline dykes were emplaced during the transtensional stage of the Transamazonian orogeny when the Tandilia granitoids were formed. Such a scenario has similarities with the Eburnean evolution of the Richtersveld plutonic arc of the Southern African subcontinent. The Tandilia tholeiites (1.59 Ga) were emplaced under an extensional regime, in agreement with geodynamic conditions of continental crust at the Paleo- Mesoproterozoic boundary during which basin tectonics and associated anorogenic igneous activities took place worldwide.

AGES OF DETRITAL ZIRCON FROM SILICICLASTIC SUCCESSIONS OF THE BRASILIA BELT, SOUTHERN BORDER OF THE SÃO FRANCISCO CRATON, BRAZIL: IMPLICATIONS FOR THE EVOLUTION OF PROTEROZOIC BASINS

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In this work we report ²⁰⁷Pb/²⁰⁶Pb LA-ICPMS ages of 130 detrital zircons from lower greenschist facies quartzites from Proterozoic basin successions of the southern border of the São Francisco Craton, southern Minas Gerais State, Brazil. These are the intracratonic São João del Rei basin and the intraplate continental margin Andrelândia basin. These basin sequences were developed on a crystalline basement older than 1.8 Ga and were deformed and metamorphosed during the Brasiliano Orogeny, ca. 0.6 Ga. The data yield information about the ages of the source areas and provide an approach for constraining sedimentation ages. The data obtained on zircons extracted from a shelf quartzite of the lowermost sequence of the São João del Rei basin show that their detrital sediments were derived predominantly from erosion of a Transamazonian crust, 1.8-2.2 Ga, with a subordinate contribution from an Archean crust, 2.5-2.9 Ga. The 1809 ± 41 Ma age could be interpreted as the maximum sedimentation age for this basin. The results confirm the regional correlations with the Espinhaço Rift successions. The zircons extracted from the autochthonous quartzite of the Andrelândia sequence yield ages in the 1.0-2.2 Ga range, with a modal class at 1.2-1.3 Ga. Only two of the forty analysed zircons yield Archean ages. The youngest zircon yields 1050 ± 166 Ma. The zircons from the allochthonous quartzite yield ages between 1.0-2.7 Ga, with a modal class at 2.1-2.2 Ga. Only 5 of 45 analysed grains yield Archean ages. The youngest zircon has an age of 1047 ± 77 Ma. The results indicate that the detrital sediments deposited during the second marine flooding event of the Andrelândia sedimentation were mainly derived from the erosion of Mesoproterozoic and Paleoproterozoic rocks. The 1047 ± 77 Ma age could be interpreted as the maximum depositional age for the described association.

MICROPROBE MONAZITE CONSTRAINTS FOR AN EARLY (*ca.* 790 Ma) BRASILIANO OROGENY: THE EMBU TERRANE, SOUTHEASTERN BRAZIL

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The evolution of the Mantiqueira Orogenic System, Southeastern Brazil, comprises discrete episodes of tectonic collage and docking of remnants of Rodinia on the borders of the São Francisco Craton. This system is related to the closure of the Adamastor ocean and assemblage of western Gondwana during the Neoproterozoic.

Monazite dating with the microprobe was performed for metapelites from the Embu Complex, a metamorphic-migmatitic unit currently included in the Juiz de Fora terrane, in the northern branch of that orogenic system, State of São Paulo, Southeastern Brazil. Two samples of muscovite-bearing garnet-sillimanite-biotite gneisses from the western Embu area and one sample from eastern Embu in the amphibolite facies of metamorphism were studied. Rock textures show that monazite crystallized mainly together with garnet and sillimanite in these rocks. The chemical ages obtained for all samples are almost the same, close to 790 (± 20) Ma, and are undoubtedly related to the main metamorphism in the whole Embu Complex.

This metamorphic episode unravels important convergent tectonic processes in this region. Available stratigraphic and geochronological data from other Brazilian orogenic systems display a similar picture, leading to the conclusion that convergence tectonics were of continental-scale importance by that time and a number of terranes, such as the Embu Complex, were just collating and docking to the Gondwana-forming continent. This event should correspond to the first orogenic period of the Brasiliano-Pan-African Cycle in western Gondwana and neighboring areas.

The monazite clock was also partially reset at 730 (± 20) Ma in western Embu by a ductile-brittle shear event whose significance is not well understood. Late monazite also developed over primary monazite rims and in-fillings by 590 (± 20) Ma in the eastern area in response to the collision of the Juiz de Fora terrane with the continent and related metamorphism and granite magmatism.

NEOPROTEROZOIC ALKALINE ROCKS AFFINITY FROM SOUTHEAST OF SÃO PAULO STATE - BRAZIL

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The aim of this work is the review of geochronological data of rocks cropping out on Cardoso Island, on the southeastern coast of São Paulo State, close to the boundary with Paraná State.

The terrains which compose the island are mainly a syenitic igneous complex with flow orientations of the main phenocryst phases (a magmatic flow structure), light grey leucocratic, inequigranular, medium- to coarse-grained syenites, composed of pyroxene, hornblende, and perthitic to mesoperthitic microcline, named the Três Irmãos Syenite (TIS), and is cut by the Cambriú alkali-feldspar Granites (CG), which are pinkish grey, leucocratic and medium-grained, with microcline twinning, quartz and oligoclase, accompanied by hornblende and biotite.

Geochemical analyses of TIS and CG demonstrate their metaluminous alkaline nature and late orogenic to anorogenic character.

The geochronological results suggest that the bodies were formed between 618 and 574 Ma according to the U-Pb method in zircons, with cooling between 597 and 531 Ma (K-Ar in amphiboles). Whole rock Sm-Nd analyses yield T_{DM} ages in the Meso- and Paleoproterozoic (1500 – 2200 Ma).

A belt of low-grade metasedimentary rocks occurs in the northern part of the island. Quartz schist, quartz-mica schist and mica-quartz schist, often containing andalusite and cordierite, predominate. The geochemical and geochronological data suggest that the sources of the metasediments were andesites of continental arc origin whose protoliths separated from the mantle during the Paleoproterozoic, between 1800 and 2200 Ma. These metasediments probably continue on the continent in the Taquari region and extend southwards in narrow strips between the granitoids of the Paranaguá Domain.

Sr-Nd-C-O ISOTOPES OF CARBONATITES FROM THE EARLY PROTEROZOIC INTRUSIVE COMPLEX OF THE ANGICO DOS DIAS (BAHIA, BRAZIL)

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The evolution of the Mantiqueira Orogenic System, Southeastern Brazil, is discussed in the context of the review of geochronological data to rocks cropping out in the region. The Early Proterozoic (2011 Ma) intrusive complex of Angico dos Dias (Bahia, Brazil) consists of associated alkaline and carbonatitic rocks. The latter have extremely high rare earth element (REE) contents, characterized by high LREE/HREE, which approach those of typical Precambrian carbonatites. Borehole samples of apatite carbonatites and two carbonate-rich phlogopite-pyroxenite have been investigated for Sr-Nd and O-C isotopes. ⁸⁷Sr/⁸⁶Sr composition measured both on the whole rock and on the carbonate fraction reveals local re-opening of the Rb-Sr system after crystallization of the AdD complex. In particular, for the carbonate-rich phlogopite-pyroxenite, the initial ⁸⁷Sr/⁸⁶Sr of whole rock overlaps that of the carbonate fraction when computed at 1250 Ma, corresponding to the time of the Espinhaço-Paramirim aulacogen evolution of the São Francisco Craton. The ϵ_{Sr^T} values of the investigated samples are positive and range from 12.2 to 24.9, with the carbonate-rich phlogopite-pyroxenite having the lowest value. ϵ_{Nd^T} values indicate a general enrichment in ¹⁴⁴Nd with respect to the Chondritic Uniform Reserve (CHUR), ranging from 0.7 to -4.5. Nd model ages calculated for a depleted-source curve range from 2.5 to 2.2 Ga. In the ϵ_{Sr^T} vs. ϵ_{Nd^T} diagram, the Angico dos Dias carbonatites appear generally more enriched than the other Precambrian carbonatites, excluding the South African carbonatites of Palaborwa. These isotopic data conform to the enriched isotopic signature common to the main Archean-Proterozoic alkaline complexes intruding the São Francisco Craton. $\delta^{13}\text{C}$ and $\delta^{18}\text{O}$ values on whole rocks and apatites range from -5.7 to -7.1 ‰ (PDB) and from 11.9 to 15.8 ‰ (V-SMOW), respectively. The high $\delta^{18}\text{O}$ values shown by the AdD carbonatites are well distinct from those of primary carbonatites and probably reflect post-magmatic metamorphic and/or hydrothermal processes.

Os ISOTOPE SYSTEMATICS IN THE CRETACEOUS POTASSIC ROCKS FROM BRAZIL

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Mafic potassic rocks of the Alto Paranaíba (Minas Gerais State), Paranatinga (Goiás State), Juína (Mato Grosso State) and Pimenta Bueno (Mato Grosso State) provinces belong to a large lineament of rocks that crosses from the western to southeastern part of Brazil. These provinces intruded three different mobile belts (Neoproterozoic Brasília and Paraguay belts to Alto Paranaíba and Paranatinga provinces, respectively; and Mesoproterozoic Rio Negro-Juruena belt to Juína and Pimenta Bueno provinces).

The Pb isotopic compositions of the studied provinces show a wide variation. The ²⁰⁶Pb/²⁰⁴Pb of kimberlites (18.47-19.23) and kamaflagites (17.79-18.71) from the Alto Paranaíba Province are close to the Tristan/Walvis Ridge composition. The ²⁰⁶Pb/²⁰⁴Pb of the Paranatinga (19.38-19.67) and Pimenta Bueno (19.78-21.00) provinces are similar to the South African group I kimberlite compositional fields, but the samples from the Juína Province are displaced to higher Pb isotopic values (21.38-22.26), close to those shown by HIMU ocean island basalts (OIB). Although the Pb isotopic composition of the more northern alkalic provinces ranges towards the values seen for HIMU and OIB, the Sr and Nd isotopic composition of these samples is not like HIMU, nor in combination with Pb, like any other ocean island basalt. With the exception of the kimberlites from the Alto Paranaíba, which range to quite unradiogenic compositions, most of the samples have ¹⁸⁷Os/¹⁸⁸Os between 0.13 and 0.15. The Nd model ages of Juína kimberlites vary from 1.70-1.73 Ga, Paranatinga kimberlites from 0.56-0.64 Ga, and Pimenta Bueno from 0.72-1.05 Ga. Os model ages for Paranatinga vary from 0.74-0.93 Ga and Pimenta Bueno from 0.9-1.3 Ga.

GEODYNAMIC CONTROL ON THE CHEMICAL COMPOSITION OF TERTIARY CONTINENTAL ARC MAGMAS OF ECUADOR?

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Ecuador consists of terranes separated by NNE-trending crustal sutures and faults. In SW Ecuador, deep crustal E-W fault zones mark the transition from the Central to the Northern Andes (Huancabamba deflection). The Tertiary tectonic regime of the Ecuadorian Andes is determined by the NE-vergent subduction of the Farallon/Nazca plate which induces dextral transpression along the N-S faults and transtension along the E-W faults. The spatial distribution of Tertiary stocks, likely feeders of the subaerial continental volcanism, follows the NNE sutures and the E-W faults, suggesting that melt ascent from the mantle was controlled by these crustal-scale structures.

Major and trace element geochemistry allows differentiation of the investigated magmatic rocks into two geographic groups identified as west-belt (W-belt) and east-belt (E-belt). The W-belt outcrops in the southwestern part of Ecuador. The E-belt includes rocks straddling the NNE-trending sutures.

Lead and strontium isotopes as well as REE geochemistry of least evolved magmatic rocks of the two belts suggest a common magma source, possibly an enriched mantle. Geochemical differences between magmatic rocks of the two belts arise from fractional crystallization and assimilation processes determined by different geodynamic settings with which the mantle-to-crust transfer of melt was associated in the two belts. The W-belt magmas could rise rapidly from the mantle through the extensional E-W faults of SW Ecuador. These magmas evolved at high crustal levels through AFC processes involving plagioclase and clinopyroxene fractionation and assimilation of upper continental crust characterized by radiogenic Pb and Sr. In contrast, REE features indicate that E-belt rocks evolved through fractionation of small amounts of garnet. This implies that E-belt magmas likely ponded at the mantle-crust interface, here situated at ~45 km, before rising through the NNE sutures, because the latter were under transpression induced by the oblique subduction of the Farallon/Nazca plate.

MANTLE XENOLITHS FROM ÑEMBY, EASTERN PARAGUAY: O-Sr-Nd ISOTOPES AND TRACE ELEMENTS OF HOSTED CLINOPYROXENES

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Clinopyroxenes from protogranular spinel-peridotite mantle xenoliths in Eocene melanephelinite of Ñemby hill, central eastern Paraguay (Asunción-Sapucaí-Villarrica graben), are studied for: (1) oxygen isotopes; (2) trace element behaviour; (3) Sr-Nd relationships between whole rock and hosted pyroxenes. The mantle xenoliths are distinguished into two main suites, i.e. LK (relatively low in K and incompatible elements, IE) and HK (high in K and IE), both ranging from lherzolite to dunite and showing trends of "melt extraction". Clinopyroxene crystal chemistry revealed the equilibration pressure over a range of 12-18 kb, in both the two suites. The hosted clinopyroxenes display extremely variable enrichment/depletion behaviours, mainly in LREE. The enriched components were mostly trapped in clinopyroxenes which previously crystallized from depleted to quasi-chondritic mantle sources. Oxygen isotopes (clinopyroxene-olivine pairs) suggest that equilibration temperatures were higher in the HK suite than in LK suite. On the whole, the isotopic Sr-Nd data seem to indicate that, prior to enrichment, the lithospheric mantle was dominated by a depleted component, isotopically resembling a MORB source or even more depleted. Model ages ($Nd-T_{DM}$) of clinopyroxenes and host rocks confine the main enrichment, metasomatic, events to the Brasiliano cycle (i.e. 900-460 Ma). In contrast, Rb-Sr isotope systematics may be related with fluids induced by melting episodes occurring in Early Cretaceous times, during the different phases of lithospheric thinning in the area.

Sr-Nd-Pb ISOTOPES OF THE POST-PALEOZOIC MAGMATISM FROM EASTERN PARAGUAY

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The Paraná-Angola-Namibia igneous province (PAN) is characterized by Early Cretaceous flood tholeiites and tholeiitic dyke swarms associated with alkaline rocks of Early and Late Cretaceous ages, respectively, and with scarce post-Mesozoic magmatic rocks. The Eastern Paraguay, at the westernmost side of the Paraná basin, is of special interest because: (1) it is located between two main cratonic blocks, i.e. the southernmost tip of the Amazon Craton, and the northernmost exposure of the Rio de La Plata Craton; (2) it was the site of repeated Na-K-alkaline magmatism since Late Permian-Triassic times (i.e.: 253-235 Ma, Na-alkaline; 145-138 Ma, K-alkaline; 132-126 Ma, K-alkaline; 110-90 Ma, Na-alkaline; 60-32 Ma, Na-alkaline), and of Early Cretaceous tholeiitic magmatism, both low- and high-Ti variants, L-Ti and H-Ti, respectively (132-130 Ma); (3) the younger sodic magmatic rocks are closely associated in space to the potassic analogues.

The paper aims at discussing the most important Sr-Nd-Pb isotope features of the alkaline and tholeiitic magmas from Eastern Paraguay, in comparison with the PAN analogues. The isotope data indicate contributions from different mantle sources. The isotope differences among tholeiitic basalts, alkaline rocks, MAR, Tristan, Tristan da Cunha and Trindade volcanic rocks show that any asthenospheric source did not play a significant role in the magma genesis, suggesting generation from different melting degrees of heterogeneous lithospheric mantle sources, at different times. Moreover, the isotope trends suggest an involvement of different contributions of depleted and enriched components in the magma genesis: the enriched components may be related to ancient metasomatic events. T_{DM} (Nd) model ages show that almost two notional distinct events may have occurred during Middle and Late Proterozoic times as precursor to the tholeiitic and alkaline magmas in the PAM.

In summary, the alkaline and tholeiitic magmatism in Eastern Paraguay appears to be related to the lithospheric mantle. A contribution of asthenospheric components, as those derived from the hypothetical Tristan da Cunha and Trindade mantle plumes, is not appreciable in terms of Sr-Nd-Pb isotope systematics.

OXYGEN ISOTOPE COMPOSITIONS AS INDICATORS OF EPIDOTE GRANITE GENESIS IN THE BORBOREMA PROVINCE, NE BRAZIL

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The Emas and Sao Rafael epidote-bearing granitoids from the Borborema province, NE Brazil, contain biotite and hornblende, and are metaluminous, calc-alkalic, and oxidized I-type granites. Values of $\delta^{18}\text{O}(\text{Zrc})$ are homogeneous within each pluton, but quite different among plutons ($5.77 \pm 0.12\text{‰}$ and $9.90 \pm 0.20\text{‰}$, in the Sao Rafael and Emas plutons, respectively), and measured $\Delta(\text{Zr-Tnt})$ is highly consistent ($1.11 \pm 0.27\text{‰}$ and $1.10 \pm 0.41\text{‰}$). Samples from the Emas pluton have average $\Delta(\text{Qtz-Zrc})$ of $4.32 \pm 0.52\text{‰}$, and from the Sao Rafael pluton $4.04 \pm 0.37\text{‰}$, while $\Delta(\text{Qtz-Tnt})$ is $5.48 \pm 0.41\text{‰}$ and $5.11 \pm 0.19\text{‰}$, respectively. The average $\Delta(\text{Qtz-Epi})$ is high, and away from the expected equilibrium fractionation between these minerals at magmatic temperatures. The measured mineral-mineral fractionations suggest continued sub-solidus inter-mineral isotope exchange through diffusion processes at high T, during slow cooling. High $\delta^{18}\text{O}(\text{Zrc})$ values for the Emas granitoid are explained as due to inheritance from the source. Amphibole-rich clots, believed to be source rock fragments, have high w.r. $\delta^{18}\text{O}$ values (10.5‰), and likely resulted from exchange of seafloor basalt with low-T water. In contrast, $\delta^{18}\text{O}$ mineral values for the Sao Rafael granitoid are compatible with a normal I-type source. These results indicate that differences in the $\delta^{18}\text{O}$ mineral values are predominantly a function of the $\delta^{18}\text{O}$ of source materials rather than differences in the crystallization history. The systematic mineral-epidote fractionation suggests that epidote cooled in a closed system and that it is magmatic in origin. Alternatively, the epidote $\delta^{18}\text{O}$ values may reflect mixing values (magmatic and subsolidus grains).

Sr-Nd ISOTOPE CHANGES OF LATE CRETACEOUS TO EARLY MIOCENE VOLCANIC ROCKS IN CENTRAL CHILE (33°S)

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Here, we report new $^{40}\text{Ar}/^{39}\text{Ar}$ data and Sr-Nd isotope ratios for volcanic rocks from an area located at *c.* 33°S, extending from Cuesta de Chacabuco in the easternmost part of the Coast Range to Cerro Llaretas in the foothills of the High Andes (70°45' to 70°25'W). These results, supported by mapping in progress, allow the subdivision of the rocks in three age groups: Late Cretaceous, Oligocene, and Early Miocene. The three groups have different Sr-Nd isotopic signatures with a trend of increasing initial $^{87}\text{Sr}/^{86}\text{Sr}$ ratios from Late Cretaceous to Early Miocene (from 0.7031-0.7034 to 0.7036-0.7038), and increasing ϵ_{Nd} from Late Cretaceous (+4.0 to +4.9) to Oligocene (+4.8 to +6.2) and then decreasing from Oligocene to Early Miocene (+4.4 to +6.0; the lowest values corresponding to the youngest Early Miocene rocks; ϵ_{Nd} for three Early Miocene separates of amphibole are +5.1 to +5.5). These trends correspond to a trend with time towards N-MORB from the Late Cretaceous to Oligocene and then away from N-MORB from the Oligocene to Early Miocene, the latter trend suggesting a more enriched mantle source or more crustal contribution with time.

librospheric mantle sources, at different times. Moreover, our results suggest an involvement of different contributions of depleted and enriched components in the magma genesis: the enriched components may be related to ancient metasomatic events. T_{DM} (Nd) model ages show that almost two notional distinct events may have occurred during Middle and Late Proterozoic times as precursor to the tholeiitic and alkaline magmas in the PAM.

In summary, the alkaline and tholeiitic magmatism in Eastern Paraguay appears to be related to the lithospheric mantle. A contribution of asthenospheric components, as those derived from the hypothetical Tristan da Cunha and Trindade mantle plumes, is not appreciable in terms of Sr-Nd-Pb isotope systematics.

CERRO AMARILLO RHYOLITES, ADVANCED AFC IN THE NORTHERN SVZ, CHILE

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Cerro Amarillo is a Quaternary medium-size (2 km²) rhyolite dome complex located close to the Chile-Argentina border at 34°S. It consists of two units: a young, massive felsitic dome and an older lava - pyroclastic sequence.

A thick, opening blast collapse breccia from the lower unit concordantly overlies the Jurassic pelites, followed by felsitic to perlitic banded rhyolite flows, bearing only scarce plagioclase and biotite. The base of the upper unit is highlighted by a two meter thick vesiculated to massive black obsidian overlying a 100 m thick, finely laminated, vent-clearing plinian fallout. The obsidian rolls over from a subvertical attitude on the western margin into a subhorizontal, broad funnel shape towards the east.

The rhyolites are high-silica, high-K rhyolites, slightly more silicic and less potassic than the Puelche Volcanic Field Rhyolites. Compared to them they are slightly enriched in Cs and Nb, while depleted in TiO₂, Ce, La, Rb, Sr, Th, Y and Zr.

The ⁸⁷Sr/⁸⁶Sr from an obsidian from the upper dome's western carapace is high: 0.705732 ± 0.000021 (500ka = 0.705683; 100ka = 0.705722).

In a Sr vs ⁸⁷Sr/⁸⁶Sr diagram the Amarillo obsidian is close to the Diamante pumice values. The Puelche rhyolites, instead, lie close to a trend controlled mainly by fractional crystallization, while the Tatará rhyolite plots halfway towards the AFC-controlled trend.

The Cerro Amarillo rhyolites may represent the result of both advanced assimilation and fractional crystallization inside a thick crust, through which coeval heat-transporting andesitic magmas were channeled and stored. They are not related to the nearby Espíritu Santo - San José andesitic complex. Instead, they bear geochemical and ⁸⁷Sr/⁸⁶Sr signatures similar to the Diamante Ignimbrite, the end product of a much larger scale AFC process.

DEVELOPMENT OF LARGE-VOLUME RHYOLITIC IGNIMBRITES (LRI'S): THE CHALUPAS CALDERA, AN EXAMPLE FROM ECUADOR

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The mechanisms responsible for the generation of large volumes of silicic magma and the eruption of large-volume rhyolitic ignimbrites (LRI's) remain poorly understood. Of particular interest are the relative roles of crustal assimilation, fractional crystallization and magma supply and the processes by which large volumes of magma accumulate in crustal chambers. The 12 km diameter Chalupas caldera formed at approximately 280 ka with the eruption of 100 km³ of rhyolitic pyroclastic material.

Samples from the Chalupas system and local metamorphic rocks have been analyzed to compile an evolutionary history of the magma chamber. Nd and Sr isotopic values ($\epsilon_{Nd} = +2 - +3.5$; $^{87}Sr/^{86}Sr = 0.7040 - 0.7045$) are shifted significantly from typical oceanic arc values but are more primitive than values for the underlying metamorphic rocks ($\epsilon_{Nd} = -5$ to -12 ; $^{87}Sr/^{86}Sr = 0.7178$ to 0.7358), strongly suggesting that they have been affected by crustal assimilation. High Sr contents suggest that this occurred under sufficiently high P_{H_2O} conditions to suppress plagioclase fractionation. The narrow range in isotopic values indicates that the high silica magmas were derived from lower silica magma by fractional crystallization in the absence of crustal assimilation. These observations require, and can be quantitatively modeled with, a two-stage model. During stage 1, mantle-derived basalt evolves to andesite in the lower crust by fractional crystallization with concomitant assimilation of crustal material. Stage 2 involves fractional crystallization in a shallow chamber during which andesite evolves to dacite and rhyolite. Our results show that the lavas with ca. 54-56% SiO₂ can be modeled with a ratio of assimilation rate to fractional crystallization rate (a) of 0.3. The resultant magmas contain 15% to 20% of the crustal component. To generate rhyolite with SiO₂ = 70% from andesite with SiO₂ = 55% requires ~45% crystallization of cpx + amph + plag + apatite during stage 2.

ISOTOPIC CLUES TO MAGMATIC SOURCE REGIONS FOR NEOGENE ANDEAN VOLCANIC ROCKS IN THE EL TENIENTE AREA NEAR 34°S LATITUDE

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The origin of isotopic variations in Central Andean arc lavas is a long-standing problem that involves identifying mantle and crustal source regions. Important advances have come from temporal and spatial analyses in well-constrained tectonic settings. Nd, Sr and Pb isotopic data in such a study highlight similarities between temporal variations in an east-west transect through Neogene magmatic units in the El Teniente area near 34°S and spatial variations along a south-north transect of the modern Southern Volcanic Zone (SVZ). In detail, the El Teniente region data fall in groups that show a progression from an older Early Miocene “depleted” source marked by lower initial $^{87}\text{Sr}/^{86}\text{Sr}$ (~ 0.7036) and Pb isotopic ratios and higher eNd (+6 to +4.5) values to a more “enriched” Pliocene source with higher initial $^{87}\text{Sr}/^{86}\text{Sr}$ (~ 0.7042) and Pb isotopic ratios and lower eNd values (+1 to 0). Temporal boundaries of these groups correspond to times of uplift and eastward migrations of the arc front. A comparison with young SVZ centers shows a parallel of isotopic and REE ratios in the Early Miocene group with SVZ centers south of 37°S, in the Middle to early Late Miocene group with SVZ centers near 34.5° to 36°S, and in a latest Late Miocene to Pliocene group with SVZ centers near 34.5°S. Analogies with the modern SVZ and the link to arc migration strengthen models that stress: a) the importance of crustal thickening processes associated with compressional shortening, and b) lithospheric scale adjustments associated with eastward migration of the arc front in explaining continental crustal components in SVZ magma sources. The isotopic data further support models that explain steep REE patterns in Late Neogene magmas as being due to eclogitic residues associated with melting of in situ thickened crust and/or basal forearc crust incorporated into the mantle wedge above the migrating subduction zone.

Sr ISOTOPES AT COPAHUE VOLCANIC CENTER, NEUQUEN, ARGENTINA: PRELIMINARY REPORT

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The Copahue Volcanic Center is located in the Cordillera Principal, at 38 L.S., on the Argentine-Chilean border. Three main Eruptive Epochs have been recognized: Pre-Caldera, Las Mellizas and Copahue. Major element plots show that each eruptive epoch has its own fingerprint.

Pre-Caldera unit (Hualcupen Formation) shows a composition range from basandesites to trachyandesites. For Las Mellizas Eruptive Center, two well-defined groups of andesitic and dacitic composition are depicted. A measurable interval of time also separates both. The younger volcanic activity of the Copahue Epoch (Copahue volcano, Derrames de Fondo de Valle, and Cerro Trolon) has a restricted range of compositions (andesites and trachyandesites), if we do not include the dome southwards of the Volcano and the Cerro Bayo, both of rhyolitic composition.

Al₂O₃ and CaO decrease and Al₂O₃/CaO ratio increases with decreasing MgO from 3% for most units, reflecting relatively low-pressure fractional crystallization. This trend is opposite for the least evolved lavas from Hualcupen Formation and Las Mellizas Eruptive Center. In the latter case, a higher pressure relative to the younger units can be suspected.

The range in Sr isotopes for the Volcanic Center is restricted and shows little variation with differentiation index like MgO and also with Sr contents. Most values range from 0.70369 to 0.7039; only one sample from the Copahue volcano itself has a higher value (0.70408), although this value can be attributed to hydrothermal alteration. This limited variation, even in highly evolved samples, reinforces the idea that the main process that controlled the geochemical evolution of the volcanic center was fractional crystallization.

The proposed model can be associated with magmatic chambers periodically tapped with different degrees of evolution and a common source. The latter probably suffered different degrees of melting in distinct episodes. The lack of an important crustal contribution is associated to the crustal thickness (~35 km) and rapid ascent of magmas.

PETROLOGY AND OXYGEN ISOTOPE GEOCHEMISTRY OF THE PUCÓN IGIMBRITE - SOUTHERN ANDEAN VOLCANIC ZONE, CHILE: IMPLICATIONS FOR GENESIS OF MAFIC IGIMBRITES

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The 3.7 Ka Pucón Ignimbrite is a voluminous, unusually mafic pyroclastic flow deposit. Magmatic pyroclasts span a narrow compositional range from basaltic andesite (53% SiO₂) to low-Si andesite (57.5% SiO₂), and contain an assemblage of euhedral to subhedral phenocrysts of plagioclase (An₅₂₋₉₀), olivine (Fo₇₂₋₈₀), aluminian magnesium-rich augite, and trace Mg-Al-chromite. Many pyroclasts also contain euhedral to subhedral xenocrysts of reverse zoned plagioclase (rims as calcic as An92) and augite, as well as abundant accidental and accessory xenoliths, prominently granitoid xenoliths, some of which exhibit partial melting and evidence of dehydrative release of H₂O. Rare magmatic enclaves of dacite have major-element characteristics which appear to preclude a basaltic andesite parent, or assimilation of granitic country rocks by the basaltic andesite.

Whole rock oxygen isotope compositions of the matrix of two basaltic andesite pyroclasts vary from + 5.2 to 5.8‰, increasing to + 6.4‰ where pyroclasts have been palagonitized. Non-palagonitized values overlap the isotopically lighter end of the range for effusively erupted rocks in the same area. Quartz separates from a typical granitic lithic yield δ¹⁸O results of + 6.1‰.

Eruption of the mafic ignimbrite is modeled as occurring from a compositionally zoned magma chamber that had become buoyant and stagnant in its upper parts by accumulation of up to 6% dissolved volatiles, most of which was H₂O. Our preliminary oxygen isotope data indicate that up to 4% H₂O may have been derived from meteoric sources. Additional H₂O was derived from dehydration of stoped granitic wall-rock fragments (calculated H₂O composition of +5‰ from the previous quartz analyses) and volatile transfer from deeper parts of the chamber (~ +5.8‰ magma composition).

THE LOWER CRETACEOUS VOLCANISM IN THE COASTAL RANGE OF CENTRAL CHILE: GEOCHRONOLOGY AND ISOTOPIC GEOCHEMISTRY

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The Lower Cretaceous in the Coastal Range of Chile conforms an almost continuous 1200 km N-S long (25°20' to 35°40' Lat. S) and narrow (\approx 30 km average) belt, with an average thickness of 3-5 km. Highly porphyritic (20-30% phenocrysts) lavas dominate but sedimentary shallow-marine intercalations can be abundant in some sections. Unzoned Ca-rich plagioclase (c. $An_{60}Ab_{37}Or_3$), clinopyroxene (c. $Wo_{40}En_{40}Fs_{20}$), Ti-magnetite, and minor idiomorphic, altered olivines, are the main phenocrysts. Geochemically, these lavas are characterised by a relative homogeneity with high Al_2O_3 and low MgO contents, classifying as high-K to shoshonitic basaltic andesites and andesites. $^{40}Ar/^{39}Ar$ plateau ages obtained in four sections of the Lower Cretaceous volcanic belt range from 119-115 Ma, conforming a unique and major magmatic event, with an evolution in time from south to north. The genesis of this magmatism could be related to a global low-spreading rate of 5 $cm\ yr^{-1}$ in the SE Pacific during the interval 125-110 Ma. Initial Sr and Nd isotopic values show highly homogeneous values ($(^{87}Sr/^{86}Sr)_0$, c. 0.7036; $(^{143}Nd/^{144}Nd)_0$, c. 0.5127), and only slight variations with latitude have been found. In a $(^{87}Sr/^{86}Sr)_0$ vs ϵNd diagram, lavas plot within a model mixing curve where the extreme members are the Pacific MORB and the Jurassic plutonic rocks from the Coastal Range. Coeval granitoids from the Coastal Range and lavas from the High Andes plot in the same field. This fact could be interpreted as the effect of crustal contamination of an asthenosphere-derived magma. Mafic magmas, isotopically depleted, would be metasomatised by the subducted sediments, increasing their LILE content, and partially contaminated by the Jurassic plutonic rocks conforming the arc.