K-Ar GEOCHRONOLOGY AND ISOTOPIC COMPOSITION OF THE LATE OLIGOCENE - EARLY MIOCENE ANCUD VOLCANIC COMPLEX, CHILOE

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The Ancud Volcanic Complex (AVC) forms a portion of the Mid-Tertiary Coastal Magmatic Belt which outcrops in the area of northern Chiloé island. The AVC consists of basaltic to basaltic andesite lava flows and volcanic necks, and rhyolitic pyroclastic flows and vitric domes. Seven of ten K-Ar ages determined for this complex are in the range 20-25 Ma, Late Oligocene-Early Miocene. Volcanic rocks show a wide range of initial Sr and Nd isotopic composition and some basalts have lower initial Sr isotopic ratio than any samples from the active Andean Southern Volcanic Zone (ASVZ), as do some samples from other portions of the Mid-Tertiary Coastal Magmatic Belt. The isotopic and trace-element difference between some samples from the AVC and the ASVZ are consistent with the suggestion that the AVC was not generated by subduction processes similar to those operating below the ASVZ today. The genesis of the AVC and other portions of the Mid-Tertiary Coastal Magmatic Belt have been attributed to the formation of an asthenospheric slab window due to changes in subduction geometry associated with the Late Oligocene increase in trench-normal convergence rates. Asthenospheric upwelling through this slab window has produced rocks with isotopic and trace-element compositions similar to oceanic island basalt, as well as rocks with compositions similar to modern ASVZ magmas, due to interaction of asthenosphere melts with continental lithosphere previously contaminated by slab-derived components. Because of its diversity of rock types, the AVC provides an opportunity to study magma genesis processes associated with the formation of the Mid-Tertiary Coastal Magmatic Belt in greater detail.

THE CRUST ROLE AT PARAMILLOS ALTOS INTRUSIVE BELT: Sr AND Pb ISOTOPE EVIDENCE

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Paramillos Altos Intrusive Belt (PAIB) is located in the thick-skinned fold-and-thrust belt of Malargüe, southwestern Mendoza, Argentina. Geochemical and isotopic studies were carried out to determine the crustal role in their genesis. Different sources in Andean Magmatism have been proposed to account for the geochemical and isotopic patterns. The relative proportions of crust, mantle, sediments and fluids in magma genesis is difficult to assess, although various models attempt to explain the evidence. Sr and Pb isotope ratios at PAIB show different fingerprints for the main units from Early to Late Miocene times. The Sr and Pb patterns of PAIB suggest that different sources were involved in their genesis. The lower crust is considered the contaminant for the older Lower Miocene units. Minor amounts of upper crust are associated with the PAIC-SAS Middle Miocene units. For each unit, the evolution is controlled mainly by fractional crystallization processes. Therefore, PAIB reflects a change in the type and amount of crustal contamination from Early to Late Miocene times. We propose a model that couples a thicker crust with increasing upper crustal contamination and changing isotope ratios, although an additional component from subducted sediment or a subcontinentally eroded lithosphere could not be discarded.

NOBLE GAS INVESTIGATIONS ON VOLCANIC ROCKS AND GEOTHERMAL EMANATIONS IN THE BACK–ARC OF THE CENTRAL VOLCANIC ZONE (CVZ)

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The first comprehensive noble gas isotope survey of the Puna Plateau (21°–27°S) is reported. We sampled geothermal gases and fluids and collected samples from Pliocene to Recent phyric lava flows with different geochemical characteristic.

Geothermal emanations in the Puna Plateau reveal a magmatic component of at least 20–70%. The Puna $^3He/^4He$ ratios in fluid inclusions of olivines ($5.2 < R/R_a < 7.5$) are the highest reported values from South America so far and are comparable to South Atlantic MORB ratios ($7.83 \pm 0.53\ R_a$). They differ significantly from ratios measured in the Western Cordillera. These He isotopic compositions allow to propose a MORB-like source beneath the Puna Plateau. The Ne isotope composition is a further indication that a mantle reservoir very similar to that of MORB exists beneath the Puna. The MORB signatures occur independently of rock chemistry and the area in which the rocks are found.

The range of $^3He/^4He$ values observed may be explained by an ingrowth of radiogenic ^4He in a magma chamber (magma aging). A time span of 10,000 – 80,000 years is calculated to be sufficient to produce the range of measured ratios by this process. High He concentrations in the crushed samples ($0.5 - 18.1*10^{-8}$ cm^3 STP/g) indicate their provenance from a less degassed reservoir, which would be less susceptible to contamination with a radiogenic He source.

The highest $^3He/^4He$ ratios measured in fluid inclusions of olivines indicate that these crystals must have grown prior to magma contamination with K-U(Th)-rich crustal material. Assimilation of crustal melts up to 25%, as is stipulated by Sr-Nd systematics, must have occurred later than olivine crystallisation. Also the presence of quartz in the volcanic rocks from the back-arc indicates no equilibrium between olivine and melt.

FLUID AND HEAT TRANSPORT AT THE TORRES DEL PAINE LACCOLITH (PATAGONIA/CHILE)

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We present data to discuss patterns and mechanisms of fluid and heat transport in the Torres del Paine laccolith (Patagonia/Chile) and its contact aureole.

Contact-metamorphic assemblages yield valuable information on the intrusion temperature and emplacement depth of the laccolith. Exceptional is the presence of prehnite-bearing assemblages in calcareous marls. The upper temperature stability of the assemblage prehnite + anorthite is limited to $T < 425°C$ and low $X(CO2) < 0.06$. The presence of prograde prehnite at the contact indicates that peak metamorphic temperatures were between 400-450°C. This in good agreement with 2D-thermal models and estimated intrusion temperatures of 750±30°C using oxygen isotope thermometry of quartz-fayalite pairs from miaroles. The prehnite-anorthite assemblage further indicates a pressure < 1.2 kbar, suggesting a shallow intrusion level of 2-4 km depth. This is consistent with the abundance of miarolitic cavities and fluid inclusion data.

Oxygen isotope data for granites range from 9.1-9.9‰ for quartz and 5.1-6.0‰ for biotite. The miaroles show a wider range in their quartz values of 8.8-11.1‰. Yet, the similarity of miarolitic and granitic quartzes suggests they formed from a common fluid. Comparison of fluid inclusions in phenocryst and miarolitic quartz also indicates, that the two types of quartzes trapped the same magmatic fluid.

At present, neither field observations and petrological considerations, nor the results of stable isotope and fluid inclusion work, provide evidence for large-scale hydrothermal processes. We suggest, that the low permeability of the host rocks, due to the pre-existing regional anchi-metamorphism, has prevented the development of a large-scale convection cell. In addition, a reduced vertical permeability is indicated by the sub-horizontal bedding of the host rock. We suggest that the fluids from the intrusion escape to the surface through dike swarms connecting to discrete fractures (short-lived fluid pulses).

CRUST-MANTLE CONTRIBUTIONS TO ANDEAN MAGMATISM

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There has been significant debate as to the amount of crustal contributions to Andean magmas. This debate has been fueled by the relatively primitive isotopic ratios of Os and Nd of the Andean magmas. Here we have analyzed for Re-Os isotopes a previously studied suite of Quaternary volcanic rocks from Chile that has been used to argue for significant crustal contributions. The Re-Os isotope system is particularly suitable to determine the crust/mantle contributions to continental margin magmatism because of the large isotopic differences that exist between the mantle and crust.

We have determined Os-isotope ratios for a sample suite from these volcanoes (33-36 S lat.), representing a range of crustal thickness from ca. 60 to 35 km. The samples range in MgO from ca. 8-4% and in SiO_2 from 51-57%. The most evolved eruptive products occur above the thickest crust and have $^{87}Sr/^{86}Sr$ ratios of 0.7054 and epsilon Nd values of -1.5. The $^{187}Os/^{188}Os$ ratios correlate with the other isotopic systems and with crustal thickness. Volcanoes on the thinnest crust have $^{187}Os/^{188}Os$ ratios of 0.18-0.21. Those on the thickest crust have $^{187}Os/^{188}Os$ ratios as high as 0.64. All the Os values are much too radiogenic to represent purely mantle-derived melts (nominally ca. 0.13). The Os-isotopic system mimics the variations recorded by the other isotopic systems but is significantly magnified, demonstrating its power for evaluating crustal contributions to arc-magma genesis. Mixing calculations suggest that the Os isotopic values of the Chilean samples represent mixing of mantle-derived magmas with 20% or more of material derived from mafic lower crust.

ADDITIONAL EVIDENCE TO THE EXISTENCE OF A SUBDUCTED PLATE BENEATH EQUATORIAL ATLANTIC

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The lithosphere surrounding the St Paul Fracture Zone is typically cooler than other areas in the Atlantic Ocean. The analysis of Re-Pt-Os and Os isotopic composition of abyssal peridotites suggest the existence of older lithospheric material in is region. Tomographic evidence, in combination with the geochemical data, supports that a fossil subducting slab is present in this region and corroborated by paleo-reconstructions. Melt inclusion analyses in plagioclase phenocrysts at MAR show boninite compositions. The presence of those Mg-SiO_2 rich melts is an additional line of evidence to support the hypothesis that part of the underlying oceanic mantle in the Equatorial Atlantic is a fossil slab.

RAPID MAGMA TRANSFER BENEATH THE SOUTHERN VOLCANIC ZONE, CHILE

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How fast magma is transferred from the mantle to the surface of Earth is of importance for understanding the processes of partial mantle melting and melt transport. Radioactive disequilibria between nuclides of the U-series can give such time information. Transfer time, from the subducting plate to surface, shorter than a few tens of thousand years has been inferred from ^{238}U-^{230}Th disequilibria in recent arc lavas, whereas ^{226}Ra-^{230}Th disequilibria may suggest even faster magma transport. Here, we present correlation of ($^{226}Ra/^{230}Th$) with ($^{238}U/^{230}Th$) and $^{10}Be/Be$ in recent lavas from south Chile. These correlations strongly suggest that, since the cosmogenic ^{10}Be are inherited from the subducting slab, the excesses of ^{226}Ra over ^{230}Th are also slab-derived. Moreover, the extrapolation of the ^{226}Ra and ^{10}Be correlation to ^{10}Be equal to 0, which is likely for a mantle melt, gives (^{226}Ra) close to (^{230}Th). Such equilibrium between Ra and Th is consistent with a large degree of fluid-induced melting beneath the Andes, whereas the measured disequilibria suggest magma transfer rates on the order of 10 to 100 meters/year through the mantle wedge. Finally, the fact that excesses of ^{226}Ra correlate with ($^{238}U/^{230}Th$) and $^{10}Be/Be$ implies that magma chamber residence time is of the same order of magnitude beneath the stratovolcanoes studied.

THE SUBDUCTION EROSION AND MANTLE SOURCE REGION CONTAMINATION MODEL OF ANDEAN ARC MAGMATISM: ISOTOPIC EVIDENCE FROM IGNEOUS ROCKS OF CENTRAL CHILE

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Isotopic data suggest the incorporation of a greater proportion of crust in Andean magmas erupted in the northern portion of the Southern Volcanic Zone (NSVZ) of central Chile compared to those erupted in the southern portion of the Southern Volcanic Zone of south-central Chile (SSVZ). The NSVZ occurs just south of the current locus of subduction of the Juan Fernandez Ridge. The southward migration of the locus of subduction of this ridge, since the middle Miocene, has resulted in decreasing subduction angle below the NSVZ, the eastward migration of the volcanic front of the Andean arc, and an increase in the crustal thickness below the arc. These factors together have caused changes in the isotopic composition of Andean igneous rocks of central Chile. The data indicate a close chronologic relation between the southward migration of the locus of subduction of the Juan Fernandez Ridge and an increase in the amount of crustal components incorporated in the Andean igneous rocks of central Chile. The observed temporal changes in the isotopic composition of igneous rocks in central Chile are best explained by subduction erosion of the continental margin, and increased mantle source region contamination, taking place up to 7 Ma ahead of the approaching Juan Fernandez Ridge. Ridge subduction, and the resulting progressive decrease in the subduction angle below the NSVZ, together enhance the possibility for a greater amount of subduction erosion west of this portion of the Andean arc compared to further south in the SSVZ, as do the semi-arid conditions in central Chile which result in a low volume of sediment supply to the Chile Trench relative to west of the SSVZ. The geographic correlation between the area of more rapid and/or prolonged subduction erosion west of the NSVZ, and the isotopic evidence for a greater proportion of crustal components in the magmas erupted in this portion of the Andean arc compared to the SSVZ, suggest an important role for the contamination of the mantle source region by subducted continental crust as a process for adding crustal components to Andean magmas. Since the mantle has relatively low Sr, Nd, and Pb concentrations compared to continental crust, differences in the isotopic compositions of magmas erupted in different regions of the Andes may be produced by relatively small differences in the amount of subducted crust added to the mantle source region of these magmas. By comparison, significantly larger amounts of crust must be assimilated by mantle-derived magmas to produce isotopic differences of similar magnitude.

NEW Hf-Nd EVIDENCE SUPPORTS A HETEROGENEOUS PLUME SOURCE FOR THE CARIBBEAN PLATEAU

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Hf-Nd systematics provide us with a valuable tool for tracing mantle sources and signatures in ancient or altered rocks. Hf and Nd are amongst the most resistant of all elements to secondary alteration processes and hence can give us insights into the source compositions of altered plateau basalts that other isotopic systems will not.

Here we use Hf-Nd systematics to probe the depths of the Cretaceous Caribbean Plateau, in order to characterise its isotope systematics, and hence determine the geochemical nature of the mantle plume responsible for its formation.

Much of the plateau is already well characterised in terms of trace elements and isotopes such as Sr, Nd, Pb and Os. Unfortunately, isotope system resetting due to sub-solidus alteration, amongst other factors, has ensured that these isotopes have been inconclusive in resolving many important issues, such as whether the Caribbean plateau is a product of an earlier Galapagos plume phase, and how the apparently unique Gorgona komatiites relate to the rest of the Caribbean plateau.

We present new Hf-Nd isotopic data which reveal that the Caribbean plume must have been compositionally heterogeneous, comprising at least three different source components. We then compare this "Caribbean plume" to other present-day plumes, (e.g. Galapagos) and from this speculate whether initial magmatism from the Galapagos plume could indeed have been responsible for the formation of the Caribbean Plateau.

Pb ISOTOPIC COMPOSITION OF THE ATMOSPHERE OF THE SÃO PAULO CITY, BRAZIL, AND ISOTOPIC CHARACTERIZATION OF SOME POLLUTANT SOURCES

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Lead isotopic compositions of the atmosphere of São Paulo city and the isotopic signatures of the possible pollutant sources, for the period of August/1999 to September/2000, were determined from particulate matter (PM_{10}) collected on clean teflon filters, and rainwater samples at the São Paulo University. The PM_{10} $^{207}Pb/^{206}Pb$ ratios range from 0.786 to 0.875, and $^{208}Pb/^{206}Pb$ from 1.934 to 2.119, defining an array on the Pb diagram. Pb concentrations range from 3.02 to 254.52 ng/m^3, averaging about 15 times lower than the limit of 1.5 µg/m^3 established by the Environmental Protection Agency, USA. Rainwater samples displayed the same isotopic ratios measured on PM_{10} collected on the same day, thus indicating that aerosols are scavenged by rain.

Analyses of possible pollutants such as gasoline and ethanol ($^{207}Pb/^{206}Pb$ = 0.839-0.873), soot from vehicle exhaust pipes ($^{207}Pb/^{206}Pb$ = 0.858-0.890), and particulate material from industrial emissions collected on fiberglass filters ($^{207}Pb/^{206}Pb$ = 0.781-0.861) mostly yielded isotopic compositions falling into an interval defined by 84% of the PM_{10} samples ($^{207}Pb/^{206}Pb$ = 0.840-0.870). However, 15% of the PM_{10} samples are more radiogenic, indicating a significant, unidentified radiogenic source ($^{207}Pb/^{206}Pb$<0.780), evident mainly in samples collected during weekends and from November/1999 to April/2000. One industrial emission sample showed a $^{207}Pb/^{206}Pb$ ratio of ca. 0.79, but a blank filter also presented a similar value, thus impeding confirmation of this industrial emission as the radiogenic source.

We suggest that most of the anthropogenic Pb found in the São Paulo atmosphere comes from industrial emissions, since Pb concentration in vehicular fuels is very low (less than 38 µg/L). Regional background geogenic lead yielded non-radiogenic values ($^{207}Pb/^{206}Pb$ = 0.909-0.932) confirming that this Pb is insignificant in the atmospheric lead budget of São Paulo.

$\delta^{13}C$ AND $\delta^{18}O$ IN BEACHROCKS OF THE STATE OF CEARÁ, NORTHEASTERN BRAZIL

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Beachrocks are found in the intertidal and sublittoral zone along the Ceará state, Northeastern Brazil. They are distributed as discontinuous, gently seaward-dipping fringes. Outcrops in the region of the Lagoinha and Sabiaguaba beaches were studied and sampled along the littoral zone. In both localities, outcrops are composed of marine shell fragments and terrigenous detritus with subangular to subrounded grains. At the Lagoinha beach, carbonate cement display $\delta^{13}C$ and $\delta^{18}O$ values, respectively, in the +1.5 to +3.1‰$_{PDB}$ and -0.5 to +0.4‰$_{PDB}$ range, whereas the $\delta^{13}C$ and $\delta^{18}O$ values for Sabiaguaba beachrock cements range, respectively, from +2.5 to +3.4‰$_{PDB}$ and from +0.3 to +0.7‰$_{PDB}$.

At the Lagoinha and Sabiaguaba beaches, positive $\delta^{13}C$ values of beachrock cements reflect precipitation from ^{13}C-enriched seawater. In addition, C isotope composition is even more enriched in ^{13}C in the Sabiaguaba beachrock carbonate cements than at the Lagoinha beachrock cements. O isotope ratios show a large variation. At the Lagoinha beach, oxygen isotopic values are negative and positive, whereas at the Sabiaguaba beach, O isotope values are all positive. This isotopic behavior indicates homogeneous environmental conditions at the Lagoinha beach, whereas the Sabiaguaba values reflect a variation in environmental conditions to precipitation of the cement.

The narrow O isotopic variation in the Sabiaguaba beachrock suggests that temperature remained about constant during the cement precipitation. At the Lagoinha beach, however, the O isotopic behavior indicates that the environment endured a progressive shift in temperature during cement growth. Temperature estimates for cement precipitation of the Lagoinha beachrock are in the 15 to 19°C range, while for the Sabiaguaba beachrock it ranges from 14 to 15°C. This reflects environmental changes, leading to the following assumptions: (a) carbonate deposition took place at different time intervals; (b) stronger freshwater influx caused post-precipitation change of the O isotope record.

FACIES AND CARBON / OXYGEN ISOTOPES OF THE CALABOZO FORMATION (MIDDLE JURASSIC), ARROYO LA VAINA, MENDOZA, ARGENTINA

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Sedimentological and geochemical-isotopic studies on marine Jurassic (Late Bathonian-Early Callovian) carbonates of the Calabozo Formation, Cuenca Neuquina, were carried out in order to reconstruct the palaeoenvironment of the unit. The studied sections crop out in southwestern Malargüe, Mendoza, at the south margin of Arroyo La Vaina. They correspond to the Upper Section of the Calabozo Formation, while the Lower Section is not exposed.

Two facies associations are recognized: lower (LFA) and upper (UFA), with storm deposits interbedded between them. LFA is represented by a microfacies succession of: peloidal wackestone, peloidal packestone and intraclastic grainstone. UFA is composed by a microfacies succession of: ooidal grainstone, ooidal packestone and bioclastic wackestone.

The environmental model corresponds to a shallow carbonate ramp with two subenvironments: inner (LFA) and margin ramp (UFA). The latter facies association indicates the end of the Calabozo Formation sedimentation and the beginning of restricted basin conditions, represented by the evaporite sequence of the Tábanos Formation.

To perform isotopic and geochemical studies, only those carbonates showing the lowest post-depositional overprinting, according to the petrography, were chosen.

The high Mn/Sr ratios and Fe contents reflect post-depositional modifications.

The carbon-13 content (0.1‰ to 1.1‰) is within the range estimated for Bathonian and Callovian unaltered marine carbonates. The oxygen-18 values (-9.7 ‰ to –6.5 ‰) are quite depleted and very different from those characterizing coeval unaltered marine carbonates, indicating a diagenetic overprint as a consequence of isotopic re-equilibration with lighter post-depositional fluids.

The small shift to heavier C-13 (1.1‰) and O-18 (-6.5‰) ratios, close to the top of the sequence, indicates the beginning of a change in the environmental conditions. The progressive isolation of the basin, probably related to an eustatic sea level lowering, allowed the establishment of evaporative conditions. This is evidenced by the strong positive covariance to the heavier $\delta^{13}C$ (3.0‰) and $\delta^{18}O$ (-5.5‰) values of the Tábanos Formation.

STABLE AND STRONTIUM ISOTOPIC RECORDS OF MOLLUSCAN SHELLS, LOWER JURASSIC, CUENCA NEUQUINA, SOUTHWESTERN MENDOZA, ARGENTINA

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Strontium, carbon and oxygen isotope ratios of Lower Jurassic (Lower Pliensbachian) biogenic marine carbonates of Cuenca Neuquina, in southwestern Mendoza, are presented. The isotopic variations might be used as a tool in correlating and dating marine sedimentary rocks. With this purpose, the bivalve genera *Gryphaea* and *Weyla* were selected from a biostratigraphically and diagenetically well-constrained section of Puesto Araya Formation, at the south margin of Arroyo Serrucho.

The precise stratigraphic sample placement was established on the basis of ammonite biozones (*Fanninoceras*). To determine the degree of preservation of the calcite shells, scanning electron microscopy, X-ray diffraction and X-ray fluorescence spectrometry techniques were used. The samples show a quite good textural preservation (complex cross foliated and cross foliated fabrics), mineralogical homogeneity (100% calcite), Sr in the determined range for bivalves and Mn and Fe contents between 46-476 ppm and 259-643 ppm, respectively.

The $^{87}Sr/^{86}Sr$ ratios (0.70722 to 0.70729) are in agreement with the values for the Early Jurassic, specifically to the Early Pliensbachian. Some samples show higher values, which could indicate the interaction with radiogenic strontium.

We find a good agreement between the $^{13}C/^{12}C$ ratios (0.9‰ to 2.6‰) for both bivalve genera with the $\delta^{13}C$ values of well-preserved calcitic shells from the Pliensbachian.

The $\delta^{18}O$ values (-16.6‰ to -14.5‰) evidence a post-depositional resetting due to a probable interaction with light meteoric waters, related to an altitude effect subsequent to the Andean uplift.

We could assess that the three isotope systems behaved differently under the same water/rock interaction. While the O, the most sensitive indicator of diagenesis, was completely exchanged, the Sr isotope system not always remained closed and the C retained the primary isotopic signature.

^{14}C RESERVOIR EFFECT AS A SENSITIVE INDICATOR OF SHORE CIRCULATION CHANGES IN THE PATAGONIC LITTORAL OF ARGENTINA

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The calculation of a conventional radiocarbon age is made relating the ^{14}C activity of the analyzed sample to that of the CO_2 of the atmospheric reservoir with which it was in equilibrium. The difference in activities is assumed due to ^{14}C radioactive decay. But in order for the assumptions to apply, the sample could have not been in equilibrium with a reservoir other than atmospheric, such as sea water, rivers, lakes, estuaries, etc., where the ^{14}C concentration is commonly different. These differences cause the so-called reservoir effect (RE). Reservoirs other than atmospheric are usually depleted in ^{14}C, leading to an apparent aging of samples.

As a consequence of the RE, inorganic species of carbon dissolved in ocean water show, at global scale, a ^{14}C-depletion equivalent to about 400y. This phenomenon presents important local variations known as local reservoir effect (LRE), that in the case of variance with time, could be used to assess environmental changes.

The minimal required conditions for the evaluation of the LRE in a temporal section are the availability of marine and terrestrial organisms of well-known age, belonging to the same locality and that the set of sample pairs have been proven to be coetaneous. The difference between their ^{14}C ages is proportional to the RE.

The methodology presented here is based on the calculation of the present LRE. It is worthy to note that the correction of a sample age is only possible when the specific reservoir ^{14}C activity at the moment that the sample was formed is known.

This work showed that ^{14}C activity is very sensitive to changes in coastal circulation patterns, due to the variations of continental water input, coastal morphology, upwelling, coastal drift, etc. These aspects make ^{14}C an excellent tool for characterizing the conditions of a specific area. ^{14}C-LRE has been very useful to compare parameters from the past and present times, or to assess differences between various moments in the past.

We have noticed a trend of increasing LRE with latitude, but it is often masked by local coastal fluctuations.

We will continue calibrating this effect in a more detailed way and also recommend initiating calibration of this effect in archaeological sites where synchronous marine and continental materials can be compared.

ENVIRONMENTAL STABLE ISOTOPES OF THE "SISTEMA DE LAS ENCADENADAS DE CHASCOMÚS", BUENOS AIRES, ARGENTINA

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The Sistema de las Encadenadas de Chascomús, Salado River drainage basin lies in the geomorphologic unit called Pampa Deprimida in the Buenos Aires province, Argentina. The Pampeano Plio-Pleistocene sediments contain the aquifer unit. This system, dynamic and tied to climate conditions, is formed by interconnected shallow lakes connected with the Salado River.

The water level of the lakes depends on the hydrological cycle, the inputs being: precipitation, streams, groundwater inflow and surface runoff, and the outputs: evaporation and stream outflow. During flood periods, precipitation is stored in depressions forming shallow lakes and marshes. Infiltration is high due to regional lack of slope and soil characteristics, and the phreatic is near surface. Groundwater and surface water are strongly interrelated. This paper studies the relation between them by environmental stable isotopes (^{2}H, ^{18}O).

The local meteoric water line (LMWL) is $d^{2}H=8d^{18}O+14‰$ obtained from Ciudad Universitaria station, Buenos Aires city. This LMWL was established from a long record of National Network Collector for Isotopes in Precipitation belonging to the GNIP.

The groundwater isotopic composition for all samples is relatively constant: -5.0‰ and 30‰ for $\delta^{18}O$ and $\delta^{2}H$, respectively, indicating their meteoric origin. Nevertheless, small fluctuations in the obtained values are probably due to evaporation of local precipitation prior to infiltration. Recharge waters reflect the mean precipitation with reasonable fidelity.

The stream and lake waters fit on an evaporation line ($\delta^{2}H=5.9\ \delta^{18}O-1.2‰$), indicating the groundwater contribution. The isotopic results suggest that during summer, when the precipitation-evaporation balance is negative, the surface water hydrochemistry is governed by the evaporation process. These results are in agreement with those presented in a recent work. The origin of groundwater is meteoric and the shallow groundwater constitutes the base flow of surface water, a fact that had been previously assumed by other authors.

ISOTOPIC AND CHEMICAL STUDIES OF GROUNDWATER IN THE LLANURA TUCUMANA GEOTHERMAL AREA, TUCUMAN, ARGENTINA

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The Llanura Tucumana extends along the eastern Andean margin, between 27°S-28°S and 64°50'W- 65°40'W. It is a structural depression infilled by a thick sedimentary sequence, as shown by the preliminary geophysical studies. It is bounded to the west by the Nevados del Aconquija (5500m) and on the east by the Sierra de Guasayán (600m). Both ranges are part of the Sierras Pampeanas System. The southern part of this plain is an important thermal area, which is known through surface manifestations and drilled wells. There are a great quantity of artesian wells which discharge water at temperatures that oscillate between 30°C and 50°C.

This geothermal area has been studied by means of hydrochemistry and Isotope Hydrology. The Tertiary aquifer units are the marine Miocene Guasayán Formation and the continental Pliocene Las Cañas Formation. The latter one has good quality water, although still slightly saline. Overlaying these sediments, the Holocene sequence bears aquifers with high rate of discharge and excellent qualities for most requirements.

The lack of correlation between the isotopic composition ($\delta^{18}O$, $\delta^{2}H$) and chloride and sulfate ions indicates that the salinization mechanism is mainly the leaching of old marine sediments.

As was observed by other authors, it ends up being very difficult to correlate the different aquifer levels of a well with other neighboring ones. This is a consequence of the fact that aquifers are located in sandy lenses presenting variable thickness and scarce lateral development. These characteristics are proper of the Pliocene and also Quaternary units. The same conclusion is reached through this isotopic study.

As established in previous papers, the system is heterogeneous and it was not possible to find a systematic pattern that allows water typifying.

^{3}H and ^{14}C studies are imperative in order to clarify paths and movements of groundwater into the aquifer units.

LEAD ISOTOPIC CHARACTERIZATION OF RESPIRABLE URBAN AEROSOLS AND RELATED SOURCES, SANTIAGO-CHILE

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Morphological characterization of airborne particles of Santiago done by Scanning Electron Microscopy showed three groups of particles: crystalline shapes from geologic sources, agglomerated shapes formed of organic material and submicrometrical mineral particles, and spherical shapes considered anthropogenic activity products.

Samples of aerosols, sediments and leaded petrol of different distributors were collected. Aerosols were sampled at two sites in Santiago: Móvil monitoring station, in the east of the city, and Parque O'Higgins monitoring station in downtown. Mapocho, Maipo, San Francisco and Zanjon de la Aguada river sediments and samples from Disputada and Merceditas ores were studied. All the samples have been analyzed for their $^{206}Pb/^{204}Pb$, $^{207}Pb/^{204}Pb$ and $^{208}Pb/^{204}Pb$ ratios.

Isotopic results plotted in a $^{208}Pb/^{204}Pb$ versus $^{206}Pb/^{204}Pb$ diagram and in a $^{207}Pb/^{204}Pb$ versus $^{206}Pb/^{204}Pb$ diagram define a straight line. This line could be considered as a mixing line; one of the components being the sediments that represent the crustal contribution, and the other a contribution from fossil fuel. The average values of $^{206}Pb/^{204}Pb$, $^{207}Pb/^{204}Pb$ and $^{208}Pb/^{204}Pb$ ratios for sediments are 18.512, 15.583 and 38.335, respectively, and for leaded petrol are 16.515, 15.275 and 35.818, respectively. The $^{207}Pb/^{204}Pb$ and $^{206}Pb/^{204}Pb$ ratios of respirable aerosols align in a straight mixing line, according to the season. When they are plotted with the isotopic average values of sediments and petrol, the contribution of each source can be estimated. The Disputada and Merceditas ores, situated east of the city, mark the sediments with their isotopic signature.

EVALUATION OF THE HYDROGEOLOGICAL INTERCONNECTION BETWEEN THE SALAR DE MARICUNGA AND THE PIEDRA POMEZ BASINS, ATACAMA REGION, CHILE: AN ISOTOPE AND GEOCHEMICAL APPROACH

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The main groundwater reservoirs in the study area are the granular aquifers located in the sedimentary depression of the Salar de Maricunga and the Campo de Piedra Pomez basins. Winter precipitation (snowmelt) and surface water recharge these aquifers. The surface water divide that separates the two basins is the Cordillera de Claudio Gay, which is mainly formed by volcanic and intrusive rocks with no hydrogeological potential. This study uses geochemical and isotope tools to evaluate the hydrogeological interaction between the Campo de Piedra Pomez and the Salar de Maricunga basins, which could be reflected in the Lamas River flow rate.

The geochemical data, especially the high sodium and chloride concentration observed in the Lamas River, in the areas of high flow and high salinity, clearly document that the main source of water to the river is from the southern part of the Lama River basin. The main source of the salinity is of volcanic origin. No geochemical evidence was found to support an interaction between the Campo de Piedra Pomez and the Lamas River basins. The stable isotope data in water did not provide clear evidence to evaluate the main water sources for the river. The carbon isotope data in dissolved inorganic carbon and the high concentration of bicarbonate support the hypothesis of the influence of the Tres Cruces volcano in the water geochemistry of the study region.

TESTS FOR ISOTOPIC EQUILIBRIUM IN STALAGMITES AND TEMPERATURE DEPENDENCE OF $\delta^{18}O$ OF MODERN CALCITE FROM KARST AREAS IN BRAZIL

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Preliminary results are presented of the first systematic studies of the stable isotope composition of O and C of stalagmites from karst areas from southeast (Ribeira karst), south (Botuvera karst) and central Brazil (São Domingos karst), with the purpose to test the viability of these speleothems for paleoclimate studies.

Two kinds of tests were performed on stalagmites from the Ribeira and Botuvera karst areas: equilibrium deposition of ancient calcite and the modern calcite $\delta^{18}O$ dependence of the cave temperature. For the São Domingos speleothems only the first test has been done yet.

Three stalagmites from Santana cave gave strong evidence for isotopic equilibrium between calcite and cave seepage water. This is coherent with the sampling site which has a constant temperature of 18.8°C, 100% relative humidity (RH) along the year and very low air circulation. For the Botuvera area, one stalagmite has shown calcite in isotopic equilibrium. The sampling site also follows 100% RH with 19°C mean annual temperature. Both caves present modern calcite where the $\delta^{18}O$ reflects the cave mean annual temperature, proving the potential of these cave sites for paleoclimate studies based on O and C stable isotope data of ancient calcites. The São Domingos area revealed three stalagmites with non-equilibrium deposits and one with equilibrium deposits. The non-equilibrium deposits are probably caused by evaporative influences due to air circulation at the sampling site which is close to the cave entrance. As criteria for stalagmites in isotopic equilibrium, a variation of less than 0.5 per mil of $\delta^{18}O$calcite combined with a linear correlation coefficient lower than 70% between $\delta^{18}O$ and $\delta^{13}C$ for at least 6 analyses along a single layer of 10 cm length was adopted.

THE USE OF ^{210}Po AS A GEOCHRONOMETER AT CORUMBATAÍ RIVER BASIN, BRAZIL

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In this work, bottom sediments of the Corumbataí river basin located in the central part of São Paulo State were chemically analyzed for the unstable lead (^{210}Pb), with the aim of evaluating the sedimentation rate and related chronological implications. Samples of sediments located upstream (Ajapi-medium course of the Corumbataí river) and downstream (Santa Terezinha-confluence of the Corumbataí river with another hydrographic basin, i.e. the Piracicaba river basin) of the Rio Claro municipality were collected, since it is the main district able to modify the water quality of the Corumbataí river.

The sedimentation rate found for the testimony in sediments collected at the Ajapi district corresponded to 802 mg/cm^2.year, whereas for the testimony collected at the Santa Terezinha district corresponded to 224 mg/cm^2.year; the average sedimentation rate corresponded, respectively, to 4.6 and 2.5 mm/year. Thus, the Ajapi sedimentation rate is higher than that found at the Santa Terezinha district, which is compatible with the field evidence that indicates the occurrence of sand extraction close to the Ajapi district, suggesting that such activities interfere in the natural sedimentation process.

COMUNICACIONES N° 52 (2001):107

CARBON ISOTOPE FLUCTUATIONS THROUGH THE NEOPROTEROZOIC-LOWER CAMBRIAN BIRMANIA BASIN, RAJASTHAN, INDIA

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The results of a carbon isotope study from hitherto unexplored marine sedimentary rocks from the Birmania basin, Northwestern India, are reported. The data document significant isotope variations across the Precambrian-Cambrian boundary. An attempt has been made to identify a carbon isotope chronostratigraphic marker for the Precambrian-Cambrian boundary in the sedimentary succession. The transition is marked by a negative excursion during phosphoritic activity at the base of the Birmania succession which is followed by a positive excursion close to the boundary and a swing back to less positive values in the Early Cambrian. The characteristics of the paleoenvironment during the transition interval are also discussed.

LATE HOLOCENE TECTONIC DAMMING IN THE EASTERN SIERRAS PAMPEANAS, CÓRDOBA, ARGENTINA

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Neogene deformation due to Andean Orogeny has caused block faulting in the Sierras Pampeanas. These dislocations produced Quaternary landscape changes, which are mainly expressed in well-preserved fluvial path modifications. The study of fluvial channel pattern changes associated with Quaternary tectonics has special neotectonic value in this central area of Argentina as a basic method to gain more precise timing of recent movements. Major difficulties for dating neotectonics in the Sierras Pampeanas is a direct consequence of the random distribution of Neogene continental sediments in different isolated basins, which mainly lack good biostratigraphic control for a comprehensive correlation.

Here is presented a radiocarbon study and the ^{14}C age results for a locality on the northwest side of the Eastern Sierras Pampeanas. This place is located in the eastern morphostructural ridge of the Sierras Pampeanas, central Argentina, which is characterised by the greatest number of known fault segments with Quaternary activity, excluding its western border close to the Andes.

A transitory lake paleoenvironment with sedimentary deposits damming up along the Quilpo River related to Quaternary neotectonic activity on the Sierra Baja de San Marcos fault, Eastern Sierras Pampeanas, was confirmed by means of sedimentologic and paleontologic studies.

In situ land snail material collected from the typical pelitic damming-up facies was used for isotopic analysis and radiocarbon dating.

The obtained ^{14}C age of 2,560±120 bp is considered reliable, based in part on the $\delta^{18}O = +0.4‰$ and $\delta^{13}C = -8.2$ values, which are in accordance with deduced paleoecologic conditions for the land snails having lived in a lake system with an important evaporation. The $\delta^{13}C$ value also fits with a continental environment where the bicarbonate content of water was related to organic matter decay produced by plant, and to root activity of both C_3 and C_4 plants.

Discarding ^{14}C -free limestone input in the area, the initial activity of the CO_2 forming the shell would be 100% of atmospheric carbon for that moment.

The Late Holocene radiocarbon age would represent a tectonic damming climax on the Quilpo River due to the youngest known neotectonic reactivation of the Sierra Baja de San Marcos fault of the Eastern Sierras Pampeanas.

HOLOCENE TEPHRA-FALL DEPOSITS OF SOUTHERN AND AUSTRAL ANDES VOLCANIC ZONES (33-54°S): ERUPTION RECURRENCE

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Using more than 90 ^{14}C dates to identify and limit the age of 56 eruptions that produced mappable tephra-fall deposits along the Southern Andes Volcanic Zone (SVZ) and Austral Andes Volcanic Zone (AVZ) (33-54°S), it was estimated the recurrence time of the Holocene explosive volcanic activity. The eruptions that formed these deposits were classified in four categories on the basis of their tephra-fall volumes. Small eruptions are considered those with compacted volumes < 0.15 km^3 (VEI ~3). Medium eruptions are those with volumes between 0.15 and 1 km^3 (VEI=3-5). Large eruptions are considered to be those that produced deposits between 1 and 10 km^3 (VEI=4-5), and very large eruptions are those with volumes well over 10 km^3 (VEI=5-8). Results indicate that 27% (15) of the eruptions are within the small category; 39% (22) of them are medium category; 21.5% (12) are considered large, and only 12.5% (7) fall in the very large eruption category. Although the deposits considered here are believed to represent a fairly complete record of eruptions of VEI>3, many groups of explosive eruptions may well have escaped notice. For the estimation of the recurrence of the eruptions producing tephra-fall, it is assumed that the volcanic activity can nearly be modelled with a Poisson distribution, from which we obtain a value of the recurrence period of 900 years for the eruptions of very large magnitude; the large eruptions resulted in a recurrence time of 750 years, whilst medium magnitude eruptions had a period of 500 years and minor eruptions on the order of 300 years. Finally, a period of recurrence of 200 years is obtained for the entire studied segment, including both the SVZ and AVZ.

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CARBON ISOTOPE FLUCTUATIONS AND SEDIMENTATION AGE OF PRECAMBRIAN MARBLES OF THE SERIDÓ BELT, NORTHEASTERN BRAZIL

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The age of the metasediments of the Seridó Group, Borborema Province, in northeastern Brazil, has been a matter of debate for over three decades. While some workers assume a Paleoproterozoic age for this Group, some radiometric dating have pointed to a Neoproterozoic age. This study deals with $\delta^{13}C$ fluctuation in marbles intercalated in metaclastic rocks of the Jucurutu and Seridó Formations that are the basal and topmost units, respectively, of the Seridó Group, in an attempt to contribute to a resolution of this debate. $\delta^{13}C$ chemostratigraphic profiles allowed to recognize two stratigraphic levels, in both, the Jucurutu and Seridó Fms. In the Jucurutu Fm., one of the lenses near Jucurutu town displays $\delta^{13}C$ values in the +8.5 to $+10‰_{PDB}$ range, while another one near Messias Targino town, intercalated in paragneisses, shows $\delta^{13}C$ values from +2.5 to $+3.7‰_{PDB}$. In the Seridó Fm., a lens to the north of São Mamede town displays $d^{13}C$ values in the +8.8 to $+10.6‰_{PDB}$ range. Near Currais Novos town, Seridó marbles exhibit a relatively homogeneous $\delta^{13}C$ behavior, varying from –4 to $-4.5‰_{PDB}$. This C isotope behavior could be ascribed, perhaps, to episodic carbonate sedimentation, Jucurutu Fm. carbonates with higher $\delta^{13}C$ values being probably older while carbonate lenses of the Seridó Fm., with negative $d^{13}C$ values being, probably, younger. Therefore, the interval in $\delta^{13}C$ composition for marbles in the Seridó Belt varies through time from +10 to $-4.5‰_{PDB}$.

C isotope patterns obtained in this study, once compared to the secular $\delta^{13}C$ variation curve, allow us to infer a Neoproterozoic age for the Seridó Group, between 0.62 and 0.58 Ga, since this time interval is the only one in the variation curve with oscillations of $d^{13}C$ values from +9 to $-4.5‰_{PDB}$.

^{21}Ne SURFACE EXPOSURE DATING OF GIANT LANDSLIDES AT SIERRA LAGUNA BLANCA, ARGENTINA: EVIDENCE FOR TECTONIC CONTROL ON SLOPE OVERSTEEPENING

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We report ^{21}Ne surface exposure ages of eight superimposed landslide deposits and one tectonically uplifted terrace on the western piedmont of Sierra Laguna Blanca, southern Puna Plateau, Argentina (26°30'S, 67°10'W). Quartz was separated from granitic and phyllitic host rocks sampled from large boulders on the surface of the deposits. The analysis of the Ne isotopic composition revealed substantial contributions from nucleogenic ^{21}Ne and/or non-atmospheric compositions of trapped Ne in several samples, rendering the distinction of cosmogenic ^{21}Ne difficult. However, using appropriate assumptions for these components, we can nevertheless estimate the concentrations of cosmogenic ^{21}Ne with reasonable confidence.

The ^{21}Ne production rate in quartz at the sampling locations (26.5°S, ~4000m altitude), as scaled from the sea level, high latitude value of 19 atoms g^{-1} a^{-1}, is around 200 atoms g^{-1} a^{-1}. Resulting exposure ages are 431^{+18}_{-26} ka for the stratigraphically oldest landslide and between 317^{+38}_{-45} and 152^{+17}_{-24} ka for the seven younger deposits, indicating that landsliding activity at Sierra Laguna Blanca clustered during that period but ceased after ~150 ka BP. No landslides were thus generated during recent epochs of enhanced humidity. Therefore, we regard slope oversteepening due to tectonic uplift of the basement block to be a more likely explanation for the repeated collapse of the mountain front than climatic influence. The termination of landsliding may be connected to the propagation of thrusting away from the mountain range into the piedmont area. This is supported by the exposure ages of the terrace samples (~130 and ~85 ka, respectively). We infer that landsliding activity at Sierra Laguna Blanca is closely related to the tectonic evolution and the position of active thrust faults.

STABLE ISOTOPE COMPOSITION OF THE RIO DE LA PLATA ESTUARY: AN ATTEMPT TO RELATE TO METEOROLOGICAL VARIABLES

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The Río de la Plata estuary is the collector of a vast drainage basin of about 3.1×10^6 km^2. Its major tributaries are the Paraná, Paraguay and Uruguay rivers. The main course of the Paraná river starts at the "Planalto do Brasil", located in central east Brazil. Pilcomayo and Bermejo rivers contribute to the Paraná water from the high Andes range. Paraguay river releases water coming from the Mato Grosso. The Uruguay river, directly, and the Iguazú river through the Paraná, also contribute water from the Brazilian east coastal hills to the estuary. Less significant are other rivers like the Salado, Negro, etc.

The objective of this work is to study the variations in isotopic composition of the Río de la Plata river and its correlation with the ITCZ, ENSO and other meteorological phenomena. The methodology consists in the monthly collection of a 2 liter sample in the estuary and the measurement of ^{18}O and ^{2}H concentration. An aliquot is reserved for further tritium analysis.

In this first report 40 isotope analyses for the Río de la Plata estuary are presented. Cyclical variations of oxygen isotopes, with minima in winter and maxima in summer, are observed. ^{2}H excess also changes cyclically, probably with a longer period of time.

We are gathering data for a more detailed and longer record in order to establish a fine correlation of the isotopic composition with the ITCZ seasonality and the ENSO phenomena.

C-ISOTOPIC DATA FROM SOME CRITICAL SECTIONS IN NW AND CENTRAL INDIA AND THEIR IMPLICATION ON THE VENDIAN - TOMMOTIAN TRANSITION

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In contrast to the biostratigraphically well-constrained Himalayan region, the Vendian - Tommotian transition in the peninsular India has not been properly understood due to an absence of suitable rocks for geochronological investigation and lack of recognizable body-fossils. We present the C-isotopic data from Vindhyan (central India) and Marwar basins (NW India) to evaluate such a transition in peninsular India and to compare the findings with the western Gondwana. The C-isotopic data for the Lower Vindhyan carbonate sequence along the western margin of the basin indicate homogeneous $\delta^{13}C$ values (+1.7 to +2.3‰$_{V\text{-}PDB}$) in an approximately 20 m section. Our findings are consistent with a Mesoproterozoic age for the Lower Vindhyan, in contrast to the recently proposed Lower Cambrian age, based on the 'SSF' evidence (contested by some research groups). The possibility of the Upper Vindhyan to record the Vendian - Tommotian transition needs to be investigated properly. The C-isotopic data for the Bilara Group (calcareous facies of the Marwar Supergroup) along three different sections indicate generally negative $\delta^{13}C$ values and extreme fluctuations. The Dhanapa Formation (lowest unit of Bilara Group) shows an upsection increase from -4.3 to -2.3‰$_{V\text{-}PDB}$. The overlying Gotan Fm. rocks show ~0‰$_{V\text{-}PDB}$ values near the base and negative excursions as low as -6‰$_{V\text{-}PDB}$ in the middle. The uppermost Pondlu Fm. rocks also show generally negative values and significant oscillations in a subsurface section, and near zero values recorded below the overlying Nagaur Group. Such repeated oscillations can be correlated with the globally observed Neoproterozoic - Cambrian transition. At variance to such observations, the transition is rather sharp in NW Argentina (SE of Salta) where a 100 m thick carbonate sequence ($\delta^{13}C$ -3.4‰ $_{V\text{-}PDB}$ at the base to -1.6‰$_{V\text{-}PDB}$ near the top) has recorded the transition approximately 15 m below the top, marked by a negative excursion. Variation in the nature of the Neoproterozoic - Cambrian transition between different basins underlines diverse depositional tectonics and faunal characteristics.

CARBON ISOTOPES AND CHARCOAL IN SOILS: VEGETATION CHANGES AND CLIMATE INFERENCES IN THE SOUTHEASTERN BRAZIL

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We report $\delta^{13}C$ data of soil organic matter (SOM) and ^{14}C dates on charcoal from five soil profiles collected under natural vegetation in the Paraná (Londrina) and São Paulo (Piracicaba, Anhembi and Jaguariúna) states, southeastern Brazil. Carbon isotopes are used to evaluate vegetation changes during the late Pleistocene and Holocene. Charcoal distribution in the soil and its dating are used to infer linkage between forest fires and climate changes and to establish the chronology. The presence of charcoal in the soils of Anhembi and mainly Jaguariúna is a clear indication that these study areas have been affected by forest fires. The extremely high charcoal content in some soil horizons indicates that these events were much more severe during some periods, maybe indicating much drier conditions. In the Jaguariúna soils the highest abundance of charcoal was found in the top soil and dated between ca. 4000 and 9000 BP. $\delta^{13}C$ of SOM for Londrina and Piracicaba show a significant change after the shallow interval, from -21.6‰ to -15‰, probably indicating a predominance of C_4 vegetation in both sites around the early to mid Holocene. The $\delta^{13}C$ values around -23‰ observed in the 0-300 cm soil interval in Anhembi indicate a predominance of C_3 plants at the study site during the Holocene and probably late Pleistocene. The $\delta^{13}C$ values obtained at the Jaguariúna indicate a change from -22‰ to -17‰ in the soil interval 200 to 340 cm indicating a major contribution of C_4 plants during the early Holocene and maybe late Pleistocene. At the Jaguariúna backslope site the trend to more enriched $d^{13}C$ values from 40-50 cm layer (-20.7‰) to 240 cm depth (-18.8‰) shows a more significant influence of C_4 plants during the middle to early Holocene, suggesting drier conditions. Pollen records in the south and southeast regions of Brazil also indicate the influence of a drier climate during a similar period.

STRATIGRAPHY AND STABLE ISOTOPE GEOCHEMISTRY OF THE CARBONATE SEQUENCE FROM THE PARAGUAY BELT

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In the Paraguay Belt the Vendian-Varangian glaciation rocks are characterized by a glaciomarine sequence, that occur at the border of the basin, and by glacial derived turbidite deposits, that occur in the deeper parts of the basin.

In the present study, we present new carbon isotope data across 1300 m of carbonates from the northern Paraguay Belt that are stratigraphically placed above glacial sediments. The whole sequence may be divided into three different horizons that shows a general increase in $\delta^{13}C_{PDB}$ values from the base to the top: 1) a lower horizon in which the $\delta^{13}C_{PDB}$ values are negative; 2) an intermediate horizon dominated by slightly positive carbon isotope values; and 3) an upper horizon in which the carbon isotope values vary from -1‰ to +9.3‰. Compared to the carbonate sequences from the Brasília Belt (Bambuí Group), the amount of high $\delta^{13}C_{PDB}$ values in the Paraguay belt is much less prominent.

Rocks from the lower horizon lay directly above the glacial diamictites and present variable $\delta^{18}O_{PDB}$ values. Besides presenting negative $\delta^{13}C_{PDB}$ values, they also display a negative carbon isotope peak that may reach values as low as –10‰. The intermediate horizon is best represented in the Provincia Serrana area and is characterized by homogeneous $\delta^{13}C_{PDB}$ values throughout the sequence. This horizon is dominated by dolostones and present $\delta^{18}O_{PDB}$ values ranging between + 1.9‰ and +2.7‰. The upper horizon is dominated by dolostones and present variable $\delta^{13}C_{PDB}$ and $\delta^{18}O_{PDB}$ values. The highest $\delta^{13}C_{PDB}$ values were found on samples from a narrow layer from the Provincia Serrana area. Although the Guia area also has positive values (+3.8‰), they were not as high as those from the Provincia Serrana. At the end of the profile, and just below the contact with the upper siliciclastic unit, there is an abrupt decrease in the $d^{13}C_{PDB}$ values down to –2.0‰.

C, Sr AND Pb ISOTOPIC CHEMOSTRATIGRAPHY IN PRECAMBRIAN CARBONATE SEQUENCES IN THE EASTERN TRANSVERSAL DOMAIN OF THE BORBOREMA PROVINCE, NORTHEASTERN BRAZIL

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Marble lens from two adjacent tectonostratigraphic terranes in the Transversal Domain, Borborema Province, NE Brazil, have been isotopically studied (C, Sr and Pb). The studied marbles are part of the Sertania Complex (Alto Moxoto terrane) and Surubim-Caroalina Complex (Rio Capibaribe terrane). In both complexes, marbles are mineralogically similar, consisting mainly of calcite and dolomite, besides variable amounts of piedmontite, chondrodite, quartz, feldspar, muscovite, and opaque minerals. Carbon isotope values of marbles from the two complexes have a large range in $\delta^{13}C$, which vary from 0‰ to +10‰. A plot of $\delta^{13}C$ vs. stratigraphic height shows an isotopically heavy plateau, around +10‰, at the same stratigraphic position in the two complexes, followed by lighter values, around +5‰. Higher values coincide with samples where silicate minerals, formed during metamorphism, are present. $^{87}Sr/^{86}Sr$ ratios for the Surubim-Caroalina Complex marbles are higher (0.70801 - 0.70828), although with overlapping values, than in those from the Sertania Complex marbles (0.70763 - 0.70824). The measured $\delta^{13}C$ values and the $^{87}Sr/^{86}Sr$ ratios, when compared with values for the secular variation curve, suggest a deposition age around 900 Ma. A Pb-Pb isochron obtained on calcite samples from the Surubim-Caroalina Complex marbles yields an age of 887 ± 20 Ma, and for the Sertania Complex marbles yields an age of 822 ± 130 Ma. These ages are interpreted as deposition ages, and are coincident with the late stages of a deformational event at 0.96 Ga in the region.

C AND Sr ISOTOPIC COMPOSITION OF PROBABLE VENDIAN-TOMMOTIAN CARBONATE SEQUENCES IN NW ARGENTINA

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Vendian-Tommotian sequences in the Tucuman, Salta and Jujuy provinces, Argentina, comprise sandstone, slate, conglomerate and limestone (Las Tienditas/Volcan Fms.) with abundant trace fossils in the clastic facies rocks. The Precordillera basin, San Juan, represents a carbonate sequence of the Lower to Middle Cambrian La Laja Fm. The Pie-de-Palo Range, characterized by carbonates intercalated with greenschist/amphibolite facies metaclastic rocks, forms a part of the Precordillera basement. The $\delta^{13}C$ in carbonates of the Las Tienditas Fm. show a gradual decrease from the base (+3.4 $‰_{PDB}$) to the top with a minimum of -1.6‰ at ~15m from the top. Carbonates in a 700m thick section within the La Laja Fm. are marked by slightly positive $\delta^{13}C$ at the base (marly) with a negative anomaly (-2.0‰) at ~20 m above, followed by a small positive anomaly (+0.5‰) ~100 m from the base. Above this point, values are ~ -0.5‰ with a negative anomaly (-2.0‰) recorded at ~240m above the base.

Seawater $^{87}Sr/^{86}Sr$ values define a non-monotonic increase (0.70870 - 0.71082) through carbonates in the Las Tienditas Fm. while the La Laja Fm. carbonates vary from 0.70926 to 0.71030, with higher values at the base. C and Sr isotopes thus suggest that the Las Tienditas carbonates record the Precambrian-Cambrian transition (~15m from the top of the studied section). The same is also evident at ~30 m from the base of the La Laja Fm. The narrow range of $\delta^{13}C$ variation (-1.4 to +1.3‰) and $^{87}Sr/^{86}Sr$ in the 0.709-0.710 range for the Caucete Group carbonates of the Pie-de-Palo Range, although not unequivocal, appear to be in consonance with a Vendian to Tommotian age, reinforced by the presence of Didymaulichnus and Gordia.

C AND O ISOTOPIC COMPOSITION OF LATE CRETACEOUS-PALEOCENE CARBONATE SEQUENCES IN ARGENTINA AND CHILE

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Only in a few localities in South America has the K-T transition been recorded in carbonate rocks (Pernambuco-Paraiba coastal basin, northeastern Brazil; Yacoraite and Neuquén basins, Argentina; and Navidad and Magellan basins, Chile). In the Yacoraite basin, this transition was recorded in a 2 meter-thick marly layer in the Tunal Fm. that overlies theYacoraite Fm. (Cabra Corral, Salta Province), and at Maimara (Jujuy Province) where Tertiary sandstones overlie limestones of the Yacoraite Fm. At Topocalma Point, the K-T transition has been recorded in a 30 cm-conglomerate bed (in the top of sandstones and coquina beds), covered by a fossiliferous sandstones. At Algarrobo Point, Maastrichtian afossiliferous gray marls are separated from Tertiary marls, with abundant trace fossils, by a thin conglomerate bed. In the Magellan basin, glauconitic sandstones, with calcitic cement, and limestone concretions of the Punta Rocallosa Fm. (Maastrichtian) are overlain by sandstones, claystones and limestones of the Maastrichtian-Paleocene Chorillo Chico Fm. The K-T transition has been recorded in the lower portion of the Chorillo Chico Fm.

In the Yacoraite Fm. (Maimara and Cabra Corral), δC^{13} ranges from +1 to +2‰$_{PDB}$, with an important incursion at the K-T transition (-4‰$_{PDB}$). In the Tunal Fm. marls, δC^{13} varies from –3 to –1‰$_{PDB}$. At Rocallosa Point, δC^{13} ranges from –4 to –33 ‰$_{PDB}$, and the lowest value, in the Chorillo Chico Fm., marks the Late K-T transition. At Punta Topocalma Fm., δC^{13} is negative with a minimum of -30 ‰$_{PDB}$ at the transition. $\delta^{18}O$ fluctuations in the Yacoraite and Magellan basins, if primary, suggest a marked cooling for the K-T transition, followed by a temperature increase.

COMUNICACIONES N° 52 (2001):119

APPLICATION OF HYDROCHEMISTRY AND ISOTOPIC HYDROLOGY TO IDENTIFY RECHARGE AREAS AND CHARACTERIZE NITRATE CONTAMINATION IN THE SANTIAGO AQUIFER

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In the framework of the project ARCAL XXXI – RLA/8/023-9004, carried out under the auspice of the International Atomic Energy Agency, satisfactory conclusions on groundwater hydrochemistry, main recharge mechanism and areas, and nitrate groundwater contamination have been reached. An original sampling campaign along with a recollection of a large amount of hydrochemical and isotope data allowed a comprehensive interpretation of the whole hydrogeological system. Sulphate content in groundwater exceeds by 1.5 times the admissible limit of 5.2 meq/l (according to the Chilean potable water rule) over 70% of the aquifer domain. High nitrate content above the local admissible limit (10 meq/l NO_3/N) has been found in well-defined areas throughout the entire aquifer system, with measured values as high as up to 8 times the limit. An environmental isotope survey (^{18}O and ^{2}H) allowed to determine different sources of groundwater recharge, deep percolation from the Maipo river being one of the most important, while infiltration of local precipitation (rain and/or snow) showed to be significant mostly for peripheral areas of the whole aquifer system. Despite this, preliminary results of ^{13}C isotope in groundwater seem to provide an additional possible interpretation where deep infiltration of local precipitation in the Maipo valley superimposes the main recharge mechanism. Further investigation to confirm this hypothesis needs to be carried out. Use of $^{15}N_{NO3}$ and $^{18}O_{NO3}$ helped to determine main probable sources of nitrate in groundwater. Preliminary results point out that irrigation with sewage water is one of the most probable causes of high nitrate content in the Santiago aquifer.

SPATIAL VARIABILITY OF ^{137}Cs AND ^{40}K IN GRASSLAND SOIL

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The activity of ^{137}Cs radioactive isotope produced from the Chernobyl accident and ^{40}K, a natural isotope, in a natural soil-plant system was studied in an alpine area of northeast Italy.

The affinity of bomb-derived fallout ^{137}Cs and naturally-occurring fallout ^{40}K for soil and sediment particles make them valuable tracers, and they have been used in a range of environmental investigations.

The aim of this study was to evaluate the present spatial distribution of ^{137}Cs and ^{40}K, vertical and lateral migration of radioelements, and to determine change of radioelements by means of a multitemporal study.

To predict the transfer of radiocaesium in a wide variety of ecosystems it is therefore essential to know the spatial and temporal variation of these factors; GIS tools (ILWIS - ITC 1998) were applied.

^{137}Cs and ^{40}K soil activity did not show homogeneous patterns of distribution. We also observed a particularly different behaviour for both radioisotopes. This behaviour in soil would be mainly influenced by the physical-chemical characteristic.

The model predicts radiocaesium mobility in soil as a function of the physical-chemical soil characteristics (clay content, porosity, pH, exchangeable soil elements, organic matter). Radiocaesium uptake by plants depends on the interactions of a large number of factors acting on both plant physiology and soil chemistry levels.

ISOTOPIC STRONTIUM, CARBON AND OXYGEN STUDY ON NEOPROTEROZOIC MARBLES FROM SIERRA DE UMANGO, ANDEAN FORELAND, ARGENTINA

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The Umango Hill (La Rioja Province, 29°00'S-68°40'W) is one of the mountain blocks of the Sierras Pampeanas Occidentales. The crystalline basement is composed of basic igneous rocks and a siliciclastic-limestone sequence, both affected by amphibolite facies metamorphism. The metamorphic complex carries relics of granitic orthogneisses (~1000 Ma) and granitic intrusions of several ages (~520 Ma for the oldest). The siliciclastic-limestone sequence belongs to the Neoproterozoic-Early Palaeozoic and was interpreted as a platform covering the Mesoproterozoic cratonic basement. The metamorphism and deformation of the complex took place during the Early Palaeozoic.

Compositional and isotopic data of strontium ($^{87}Sr/^{86}Sr$), carbon ($\delta^{13}Cv_{PDB}$) and oxygen ($\delta^{18}Ov_{PDB}$) of the marbles from the siliciclastic-limestone sequence are presented. The results are interpreted and correlated with the temporal variation curves of $^{87}Sr/^{86}Sr$ and $\delta^{13}C$ from Neoproterozoic marine carbonates.

Petrographic studies allowed identification of three types of marbles (Calcitic, Calcitic-dolomitic and Dolomitic) and Calc-silicate rocks. All these rocks are affected by prograde metamorphism that varies from upper greenschist up to upper amphibolite facies.

The samples containing high percentages of calcite (>85%) are those which have higher contents of Sr (498-1927 ppm) and the lowest contents of Mn (40-580 ppm). The samples containing Mn/Sr ratio between 0.03 and 0.76 might have constituted "closed systems" and could have kept the original isotopic composition, which corresponds to the seawater from which they were deposited.

The $^{87}Sr/^{86}Sr$ vs. Mn/Sr and $\delta^{18}O$ values of some samples lay close to the "Primary System" end. For these samples the $^{87}Sr/^{86}Sr$ ratios are between 0.7072 and 0.7075. In the curve of $^{87}Sr/^{86}Sr$ (Neoproterozoic time) the values for selected samples from Umango Hill fall between 640 and 580 Ma. The ^{13}C content of the analyzed samples varies between -2.0‰ and +10.2‰ and the ^{18}O between -25.7‰ and -4.7‰. The strongly positive $\delta^{13}C$ values are characteristic of the late Cryogenian interval (730-590 Ma).

PYROCLASTIC LAYERS FROM LAKE MASCARDI, ARGENTINA: TOWARDS THE DEVELOPMENT OF A TEPHROCHRONOLOGY IN NORTHERN PATAGONIA

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Paleoenvironmental and paleoclimatic studies have been recently carried out on the Quaternary sequence of Lake Mascardi, Argentina, within the framework of an Argentinean - Swiss cooperative project, and mainly focused on the multidisciplinary study of lacustrine sedimentary cores from Lake Mascardi, a proglacial lake formed during the late Pleistocene retreat of the glaciers. Several ash falls originated in Andean volcanoes and derived from eastward wind driven plumes were "instantaneously" deposited as tephra layers in Lake Mascardi during post-glacial times, providing excellent stratigraphic and chronological markers. Volcanoes Calbuco, Osorno and perhaps Puyehue-Cordón Caulle are possible sources of plumes which, moving towards the east and southeast, originated ash-fall deposits in the studied area.

These chronological markers allow to establish the synchronicity or diachrony of geological and climatic events along the dispersion area of a given pyroclastic deposit. Thus, tephra layers are a powerful tool to correlate and compare paleoclimatic records from both sides of the Andes. The sedimentary sequence in core PMAS93 provides a high-resolution chronology unique at this latitude.

Ten tephra layers from Lake Mascardi have been characterized whereas three others are proposed as reworked deposits of previous ash falls. Trace element concentration ratios allowed further separation of the studied tephras into four groups. The range of Cs/La, Th/La and La/Yb is small and coincident with reported results for Quaternary lavas from SVZ volcanoes. The chondrite-normalized REE patterns further confirm trace element grouping and show a clear affinity among the different ash layers suggesting a common source that has been identified as the Osorno volcano. Some of the tephras, however, can also be associated to the Calbuco and Puyehue volcanoes. Our results show that these individual tephras can be recognized and separated combining petrography, shard morphology and geochemistry. Four tephras are considered to be potentially good markers.

These preliminary data combined with a well-established chronology indicate that Lake Mascardi provides an excellent site to develop a detailed tephrochronology for this region.

UPPER PLIOCENE-LOWER PLEISTOCENE $^{40}Ar/^{39}Ar$ AGES OF PUDAHUEL IGNIMBRITE (DIAMANTE-MAIPO VOLCANIC COMPLEX), CENTRAL CHILE (33.5°S)

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The Pudahuel Ignimbrite is a characteristic pyroclastic flow deposit in the Central Depression within the Maipo, Mapocho and Cachapoal valleys and, on the eastern side of the Andes, at the Yaucha and Papagayos rivers. Near Santiago, the Pudahuel Ignimbrite reaches 40 m in thickness, which decreases 60 km to the west to 5 m. The deposit is composed of lapilli-size pumice and crystals in a cineritic matrix. Facies of both laminar and turbulent flow regime can be distinguished, the latter prevailing near topographic barriers and on river plains. There, traction structures, like cross-bedding, and important amounts of lithic clasts are characteristic. Pumices are rhyolitic in composition and have few 0.5-2 mm long biotite crystals. Two $^{40}Ar/^{39}Ar$ step-heating experiments on biotite from pumices of two localities, Maipú (Santiago) and Bollenar (Melipilla), show *plateau* ages of 2.3±0.3 Ma (RW-371) and 2.2±0.3 Ma (RW-1009). In both cases, the first step of the experiment indicates loss of Ar from the crystal rims, which was removed from the *plateau* calculation only in the second case. For the RW-371 sample an inverse isochron age of 1.4±0.8 Ma (MSWD: 0.98) was obtained. Previously, the Pudahuel Ignimbrite was dated at *ca.* 450 ka using zircon fission-tracks. Although inconsistent with our new ages, the Pleistocene age seemed coherent with the discovery of an *Antifer* (deer) bone within the ignimbrite close to Santiago. Nevertheless, the *Antifer* genus is recognized in Argentina in the Pliocene-Quaternary. Another consequence of the new possible Pliocene ages is that, since the ignimbrite does not show brittle deformation, the age of a N-S compressive event recognized in the Central Depression is constrained. Thus, the Pudahuel Ignimbrite (Diamante-Maipo Volcanic Complex) is part of a Plio-Quaternary silicic magmatic belt formed by the NNW alignment of volcanic centres and complexes like the Calabozos Caldera (35.5°S), Puelche Volcanic Field (35.7°S), Laguna del Maule Volcanic Field (36°S) and Domuyo volcano (36.7°S) in Argentina. This belt is superimposed on rocks which are deformed by the Tertiary Malargüe fold-and-thrust belt. To the south of 38°S, and with the same orientation, another coeval magmatic belt is formed by alkaline basaltic centres.

NEODYMIUM AND STRONTIUM ISOTOPIC STRATIGRAPHY OF THE NEO-ARCHEAN RIO JACARÉ SILL -BAHIA, BRAZIL AND ITS RELATION TO PGE MINERALIZATION

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This work presents stratigraphically-plotted Nd and Sr isotopic data together with evidence of mineral and whole rock geochemistry disturbance in smooth fractionation trends of the Rio Jacaré Sill. The sill is an Archean layered intrusion of the Mirante Complex which is nestled in the Contendas-Mirante belt in the central part of the São Francisco Craton in the State of Bahia-Brazil. The sill is divided in three zones: a Lower Zone (LZ), Transition Zone (TZ) and Upper Zone (UZ). TZ is the repository of PGE-bearing magnetite ore bodies and they present field evidence of magma mixing. Isotopic profiles show near vertical straight-line segments with constant IRs due to fractional crystallization. Compositions similar to the isochron initial ratio were interpreted as indicative of the arrival of more primitive influxes. Reversals and disturbance in these trend lines were related to mixing of fractions of batches of magma after the fractional crystallization. Decrease in $\in_{Nd}$ values and an increase in $Sr_{(o)}$ pointed to country rock assimilation. Thus we concluded that isotopic Nd and Sr systematics confirmed that both LZ and UZ have undergone fractional crystallisation and that TZ corresponds to mixing between an evolved residual magma from the LZ and a primitive component from the UZ. We concluded that PGE-bearing magnetite deposits are related to isotopic initial ratio changes promoted by magma mixing/contamination episodes after fractional crystallisation periods during the crystallization history of the Rio Jacaré Sill.

COMUNICACIONES N° 52 (2001):125

METAL SOURCES IN JURASSIC TO MIOCENE ORE DEPOSITS OF ECUADOR

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In this study we discuss more than 200 lead isotope compositions of ores as well as magmatic and metamorphic rocks of Ecuador. The interest of carrying out a large- scale isotope survey in the Northern Andes derives from a geotectonic evolution characterized by multi-accretionary episodes which is not recognized in the Central Andes.

Ore deposits of Ecuador can be subdivided into VHMS deposits formed within discrete geotectonic domains (i.e., island arcs, marginal basins) before complete assemblage of the Ecuadorian crust (pre-accretionary deposits), and epithermal-/porphyry-deposits associated with continental magmatism and formed after accretion of the different geotectonic domains (post-accretionary deposits). Temporally, this subdivision corresponds to pre-/syn- and post-Eocene ore deposits.

The lead isotope signatures of the pre-accretionary VHMS ore deposits and associated magmatic rocks vary according to the setting, reflecting a geotectonic control on the ore lead composition. Isotopic signatures are internally consistent within but differ among geotectonic domains. This may be a result of variable magmatic homogenization of leads of various origins.

Post-accretionary ore deposits of Ecuador are emplaced within a crust resulting from the juxtaposition of the different domains previously formed. These deposits are spatially associated with magmas characterized by relatively homogeneous isotopic signatures. Different from pre-accretionary ore deposits, post-accretionary mineralization displays isotopic signatures which scatter outside the compositional field of associated magmas, indicating a mixed lead contribution from magmatic fluids/rocks and local basement rocks. Such isotope systematics fit into the model of a multiaccreted Ecuadorian crust. In Ecuador, mantle-derived melts reached shallow crustal levels through terrane sutures and crustal scale fractures related to the Huancabamba deflection. At these levels local hydrothermal systems were established in which the isotopically homogeneous magmatic lead was variably mixed with lead leached from basement rocks of the different terranes resulting in the observed isotopic scatter of the Middle-Late Tertiary ore deposits.

METALLOGENIC EVENTS IN THE COASTAL CORDILLERA OF COPIAPÓ REGION, NORTHERN CHILE (26-28° S)

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From Early Jurassic to Early Cretaceous (ca 100 Ma) a subduction-related magmatic arc system was developed in the Coastal Cordillera in the Copiapó region (26-28° S), with production of volcanic and plutonic rocks. During late stages of emplacement and cooling of intrusive bodies different types of hydrothermal ore deposits were formed. On the basis of the deposit ages, four main metallogenic events can be recognized in this segment of the Coastal Cordillera: 1. Early Jurassic (188-172 Ma), represented by Cu-Au and Au deposits, 2. Late Jurassic (167-153 Ma) that includes Cu-Fe-Au and Fe deposits, 3. Late Jurassic - Early Cretaceous (141-132 Ma) which comprises Cu-Au, Cu-Fe-Au and Au deposits, and 4. Early Cretaceous (130-98 Ma), represented by Fe, Cu-Au and Cu-Fe-Au deposits. The latter stage includes three discrete substages: Early Cretaceous (130-125 Ma) with Cu-Au, Cu(W) and Au deposits, Early to "Middle" Cretaceous (121-117 Ma) that included Fe and Cu-Fe-Au deposits, and Early to Late Cretaceous (103-98 Ma), represented by Cu-Fe-Au and Cu-Au deposits. An age of 78 Ma in an Fe deposit (mina Chago) could be associated with the late stage of a Late Cretaceous hydrothermal event, contemporaneous with dikes of 80-100 Ma of the Jesús María district and San Vicente-Viñita mine, southern Copiapó.

COMUNICACIONES N° 52 (2001):127

SULFUR AND LEAD ISOTOPE CHARACTERISTICS OF THE PONTES E LACERDA GOLD DEPOSITS, SW AMAZONIAN CRATON BRAZIL

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This work deals with the characterization of the S and Pb isotope signatures in sulfides from the Pontes e Lacerda gold deposits (PLGD) located in the SW sector of the Amazonian craton. Among 23 hydrothermal gold deposits are known in the Pontes e Lacerda region related to mylonitization and hydrothermal alteration (K/Ar ages ca. 970 Ma). The ores consist of quartz, pyrite, chalcopyrite, galena, sphalerite and gold.

The sulfur isotope results show $\delta^{34}S$ values in the range from +1.0‰ to +5.5‰ in galenas from mineralized quartz-vein. Pyrites collected in host rocks show $\delta^{34}S$ values in the range from +6.9‰ to +10.0‰ and suggest an influence from the sedimentary rocks. Pb isotopic results in galenas plotted on plumbotectonic diagrams fall within the 1000-800 Ma age interval, broadly consistent with the K/Ar ages and may represent the age of the mineralizing solution precipitation. Pb isotope ratios indicate a much more radiogenic signature for the pyrites (from the host rocks) than that for galenas (from the Au-bearing qtz-vein) and probably are a result of the U-bearing minerals in the pyrite grains or the presence of U in the pyrite lattice.

The PLGD isotopic data suggest a heterogeneous source and reflect a complex history where ore solutions interacted with the host rocks. The PLGD must have formed in the course of the Aguapeí-Sunsás event in the SW part of the Amazonian Craton and the studies reported here state for an important metallogenic epoch in the Pontes e Lacerda region in the Mesoproterozoic time.

C AND S ISOTOPE CHARACTERISTICS OF BITUMEN, CALCITE, Fe AND Cu SULFIDES IN THE METALLOGENIC ANALYSIS OF THE OCOITA METALLOTECT

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The "Ocoita" metallotect is a group of mineral occurrences characterized by the simultaneous presence of migrabitumen and Cu-Fe sulfides. It was defined in the Copiapó Region (within the Qda. Paipote quadrangle). The deposits occur in a belt of Early Cretaceous porphyritic andesites (ocoitic lavas) of the Pabellón Formation, a member of the Chañarcillo Group.

An early, iron-rich hydrothermal pulse, mobilized the migrabitumen, originally derived from the distillation of marine organic matter (average δC^{13} = -24.98 ‰), and precipitated it together with pyrite and chlorite in higher levels. A second, copper-rich, hydrothermal pulse replaced the early pyrite, precipitating bornite-chalcopyrite-tetrahedrite in the contraction cracks and gas vesicles of the bitumen. In the late stages of mineralization, co-precipitation textures (bitumen-copper sulfides) developed, indicating that the organo-metallic complex acted as a catalyst in the formation and transport of copper complexes during the reduction stages of the copper-enriched hydrothermal fluids.

The isotopic composition of the Fe sulfides in the early hydrothermal stage (δS^{34}= +0.6 ‰) show a magmatic source for the sulfur. However, the sulfur isotopes of the Cu sulfides (δS^{34} = -6.4 to -44.7 ‰) point to an increasing participation of biogenic sulfur, therefore, showing the direct role of bitumen in the scavenging of metals from the Cu-rich hydrothermal fluid.

Measurements of carbon isotope in the late calcites (δC^{13} between -8.53 and -2.31 ‰) yield values expected for carbonates related to the oxidation of organic matter.

COMUNICACIONES N° 52 (2001):129

ISOTOPIC FRACTIONATION OF $\delta^{13}C$ AND $\delta^{18}O$ IN HYDROTHERMAL CARBONATES FROM THREE ARGENTINEAN DISTRICTS

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Up to the present, all the studied Argentinean calcareous onyx deposits, in Salta, San Luis and Mendoza provinces, have Miocene to Pliocene ages and show two precipitation stages, the first one represented by calcite (calcareous onyx) and the second one by aragonite. The Calcareous Onyx deposits are hydrothermal low-sulfidation type with typical filling vein structures which have a characteristic sub-horizontal disposition.

In the San Luis district, a 250°C calcite formation temperature was determined and the carbonate precipitation is thought to be produced by adiabatic boiling conditions of the solutions, which explains the calcite fibrous character as well as the development of some distinctive textures of these deposits.

Between both stages of precipitation an isotopic fractionation of $\delta^{13}C$ and $\delta^{18}O$ took place. It is represented by an 18-25% increase in $\delta^{13}C$ values in all deposits and by the 3.6% increase of the $\delta^{18}O$ values in the Salta district. At the same time a 5% decrease in the $\delta^{18}O$ values in the San Luis and Mendoza districts is evidenced.

It stands out that the studied deposits have elevated values of $\delta^{13}C$ (from 3.29 up to 7.84 o\oo pdb) and $\delta^{18}O$ (from 25.33 up to 34.32 o\oo SMOW), which is an uncommon feature for most of the well-known hydrothermal deposits elsewhere.

The temperature decreases produce the more compact polymorphous (aragonite) formation as a consequence of ^{13}C increase in the solutions of the second stage.

It is assumed that the water source is mainly of meteoric origin, and that $\delta^{13}C$ fractionation is the most important indicator of temperature variation, while the $\delta^{18}O$ fractionation is mainly attributed to isotopic equilibrium reactions between meteoric waters and ^{18}O-enriched continental sedimentary rocks in a convective closed system.

NEW K-Ar AGES OF THE PRIMARY TIN MINERALIZATION IN THE RONDÔNIA TIN PROVINCE, BRAZIL[a]

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The main primary tin mineralizations in the Rondônia tin province are thought to be related to the three youngest rapakivi suites identified in this province: the São Lourenço-Caripunas Intrusive Suite (ca. 1.31 Ga), the Santa Clara Intrusive Suite (1.08-1.07 Ga) and the Younger Granites of Rondônia (1.00-0.97 Ga). The Santa Clara Intrusive Suite (SCIS) and the Younger Granites of Rondônia (YGR) occur side by side at the central-eastern part of the Rondônia tin province. Both suites have petrographic, geochemical and metallogenic similarities. The suites are composed of dominant early-stage intrusions showing metaluminous to slightly peraluminous character, and volumetrically smaller late-stage intrusions comprising two compositional rock groups: a metaluminous to peralkaline group and a peraluminous group. Sn-polymetallic deposits are closely associated with these late-stage peraluminous rocks in both suites. K-Ar ages of ca. 965 Ma on micas of greisen and quartz vein from the YGR are slightly lower than the ca. 974 Ma crystallization age of the late-stage peraluminous granites of this suite, and may represent the age of the hydrothermal tin mineralization that took place soon after the crystallization of these granites. K-Ar ages between 1006 to 976 Ma on micas of greisen and quartz vein from SCIS are at least 70 Ma younger than the ca. 1074 Ma crystallization age of the late-stage peraluminous granites of this suite, and probably indicate an Ar loss due to thermal effect caused by the emplacement of the neighbouring YGR. The Ar loss around this time is also observed on biotites of granites from the SCIS and of augen gneiss from the basement complex. Thus, the precise age of the hydrothermal tin mineralization related to the SCIS remains an open question, although the field evidence, and the presence of dominant magmatic water suggest an age slightly younger than the age of these granites.

COMUNICACIONES N° 52 (2001):131

DUAL ORIGINS OF EPIGENETIC HYDROTHERMAL Ba AND Pb-Zn DEPOSITS IN THE CHAÑARCILLO GROUP, ATACAMA REGION, CHILE: AN EXAMPLE IN THE QUEBRADA GALENA

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Two contrasting styles of Ba and Pb-Zn deposits and occurrences are described in the Quebrada Galena area within the Lower Cretaceous back-arc carbonate and lesser volcanic rocks of the Chañarcillo Group, in the Atacama Region. The Maria Cristina Zn-Pb-(Ba) deposit displays carbonate-hosted massive sulfides (sl-py-gn-mc-mt) and barite at the contact of a diorite porphyritic intrusive body. The deposit paragenesis follows a calcic skarn model with a prograde stage of garnet (andradite to $Ad_{30}Gr_{70}$), diopside and epidote skarn and potassic alteration of the intrusion, and a retrograde stage of hydrous silicates, carbonate, quartz, sulfides and barite. $^{40}Ar/^{39}Ar$ dating of hornblende from the main diorite intrusion in the Quebrada Galena and of K-feldspar from the hydrothermally-altered porphyritic intrusion in the Maria Cristina mine suggest an age range between 94 and 90 Ma for this skarn-type mineralization. The Mamiña barite deposit contains a stratiform barite lens, the largest of a belt hosted by an algal-laminated limestone and stratiform breccia unit. The lens consists of rhythmically banded and lesser breccia barite ore, intergrown with coarse-grained euhedrally zoned ferroan calcite and dolomite cements. The paragenetic study points to a late diagenetic setting of the barite and ore-stage carbonate cements, with several stages of brecciation including a late post-mineralization stage. Fluid inclusions in barite indicate saline fluids (6-24 wt% $NaCl_{eq}$) with homogenization temperatures between 135 and 245°C. Other Ba and Pb-Zn ore occurrences in the belt exhibit characteristics similar to one or both of these ore styles. Further study of the latter deposits, and of the structural control and timing of the barite mineralization might indicate whether the moderate temperature brines might be related to the same tectono-thermal event which formed the skarn mineralization.

Pb ISOTOPE INVESTIGATIONS ON Cu-Au DEPOSITS FROM CARAJÁS PROVINCE, AMAZONIAN CRATON, BRAZIL

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Recent discoveries of large Cu-Au deposits in Carajás, the most important mineral province of Brazil (Fe, Cu, Au, Mn, Ni etc.), have demonstrated the vocation of this region for such deposits, which are, in general, associated with Archean volcanosedimentary sequences and, in some cases, with Archean and/or Paleoproterozoic granitic intrusions. This work presents a brief discussion about three Cu-Au deposits from Carajás Basin based on new Pb isotope data on zircon and sulfides. In the first deposit (Bahia), no granitic intrusions have been recognized up to now, while the second deposit (Águas Claras) is close to a Paleoproterozoic granite. The third deposit (Pojuca) is intruded by Archean and Paleoproterozoic granites. The main conclusions concerning the evolution of these deposits are: 1 – The primary Cu-Au mineralization is Archean and associated with volcanosedimentary sequences correlated with the Grão Pará Group (ca. 2.76 Ga), as demonstrated in the Bahia deposit. 2 – These sequences lie on a continental basement formed by the Xingu and Pium complexes (2.86-3.03 Ga), the source of the inherited zircon crystals and probably the radioactive elements detected in the volcanic rocks. 3 – A sedimentary sequence (Águas Claras Formation) covering the Grão Pará Group was crosscut by 2.7 Ga gabbroic dikes and sills, which establishes a minimum age for this formation. 4 – Archean (2.56 Ga) granitic intrusions affected the sequences and promoted the remobilization of the mineralization, like in the Pojuca deposit. These granites input radioactive elements in the country rocks, including the associated mineralization. 5 – Shear zones, coeval or younger than the Archean granites, could also be responsible for the remobilization of the mineralization, like in the Águas Claras deposit. 6 – Paleoproterozoic granites intruded some deposits promoting the remobilization of the mineralization and inputting some typical elements such as Mo and W.

COMUNICACIONES N° 52 (2001):133

$^{40}Ar/^{39}Ar$ GEOCHRONOLOGY OF THE EL TENIENTE PORPHYRY COPPER DEPOSIT

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32 new total fusion ^{40}Ar-^{39}Ar dates from hydrothermal sericite and biotite at El Teniente range from 12.26 to 4.39 Ma, with 28 ages concentrated in the 5.58 - 4.39 Ma interval. Two peaks are clearly visible in the age distribution at 5.3 ± 0.1 and 4.7 ± 0.1 Ma. These peaks are statistically distinct and probably correspond to two separate hydrothermal/mineralization events. Molybdenite Re-Os ages of 5.6 and 4.8 Ma may provide support for this hypothesis.

The two thermal pulses are recognized in most of the lithologic units at El Teniente (andesites, Sewell Diorite, Teniente Porphyry, and the Braden Breccia), suggesting that these lithologies had already been emplaced at ca. 5.3 Ma. Some of the lithologies reveal only the younger thermal peak, such as the Central Diorite with total fusion dates of 4.66 ± 0.05 and 4.80 ± 0.07 Ma, and the latite dikes dated at 4.80 ± 0.09 and 4.39 ± 0.17 Ma. Whether these rocks are actually young or were overprinted by more recent thermal events cannot be resolved by our data at this time. The 4.39 Ma date comes from a weakly seriticized late latite dike, possibly representative of a late hydrothermal episode within the deposit. This age correlates with a molybdenite Re-Os date of ca. 4.4 Ma.

Step-heating dating of hydrothermal biotite from the Sewell Diorite produced a plateau age of 4.69 ± 0.05. A previous K-Ar date of 7.1 Ma from the same sample is interpreted as an artifact of excess ^{40}Ar.

If accurate, total fusion ^{40}Ar-^{39}Ar dates of 12.26 ± 0.37 for a seriticized porphyritic facies of the Sewell Diorite (Blanco Porphyry) and 10.07 ± 0.31 Ma for the Northern Diorite, may represent Late Miocene hydrothermal activity.

The occurrence of at least two distinct hydrothermal events within El Teniente may account for its richness and anomalously large volume. The formation of super-giant porphyry copper deposits in the Chilean Andes appears to require the superposition of temporally distinct magmatic-hydrothermal mineralizing systems within a single orebody.

INSIGHTS INTO ANDEAN METALLOGENESIS FROM THE PERSPECTIVE OF Re-Os ANALYSES OF SULFIDES

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We chose to analyze Re-Os isotopes in sulfides from twelve porphyry copper ore deposits that are spatially and temporally separated. Comparisons of source of metals from low concentration sulfides and chronologic data from high concentration molybdenites highlight important processes within and among these Andean deposits.

The low concentration sulfides contain between 5-30 ppt Os and 1-30 ppb Re. The molybdenites have ^{187}Os concentrations that range from 5-2000 ppb, and Re concentrations that range from 60-3600 ppm.

There is a strong relationship between the copper tonnage in Andean ore deposits and the Os initial ratio of sulfide minerals. The larger deposits have sulfide minerals with lower initial Os ratios than the smaller, less significant deposits. In order to substantiate this trend, more analyses from different deposits are included. The correspondence still exists with the addition of the five deposits, and can be interpreted that larger deposits use regional tectonic and structural features that allow sampling of deeper more primitive magmatic sources.

Re concentrations of the molybdenites vary significantly within deposits and between deposits. There is no relationship among the tectonic positions or temporal occurrences within deposits and the Re concentrations found in the molybdenites. In general, the molybdenite ages correspond with, or are slightly older than alteration and whole rock ages for most of the deposits. Interestingly, there are three mineralization episodes that span 1.2 Ma in El Teniente, and two periods in Pelambres (0.35 Ma) and Andina (~0.9 Ma). Given that most hydrothermal systems are not thought to last over such long geologic time scales, these data indicate that multiple pulses of temporally *separate* mineralization events overprint an area and characterize some of these deposits. The low concentration data also support this finding because multiple sources of Os are present within a deposit (i.e. Chuquicamata, Escondida).

THE SALAMANGONE PALEOPROTEROZOIC Au-DEPOSIT, LOURENÇO DISTRICT, AMAPÁ, BRAZIL: U-Pb, Sm-Nd, Rb-Sr, Pb-Pb AND K-Ar ISOTOPIC SIGNATURES

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The Salamangone deposit occurs in the Lourenço Gold District, Amapá. It is associated with Paleoproterozoic metamorphosed supracrustal rocks and a calc-alkaline complex. The deposit lies within a metaluminous to weakly peraluminous, calc-alkaline tonalitic-granodioritic pluton. The Au-mineralization consists of an epigenetic quartz-vein system, enriched in Au and As, and structurally controlled by a ductile-brittle shear zone. U-Pb zircon analyses of tonalite gave a crystallization age of 2.16 Ga, whereas Sm-Nd T_{DM} model ages for tonalite and granodiorite gave 2.24 and 2.34 Ga, respectively, $\varepsilon_{Nd}(T)$ varies from +2.88 to +3.02. Additional whole rock Rb-Sr isochron ages on granitoids yielded values in the range of 2.17 to 2.28 Ga, with $^{87}Sr/^{86}Sr$ initial ratios of 0.702. A Pb-Pb isochron age of arsenopyrite crystals from the quartz veins gave an age of 2.0 Ga, consistent with the main mineralization stage. The geochemical signature and isotopic data of granitoids and Pb-Pb age data of quartz-vein sulfide suggest that the Lourenço region, as well as the neighboring areas in French Guiana, represents a vast area largely floored by accreted juvenile arc terranes without evidence of Archean crust contamination. In this scenario the Salamangone gold deposit seems to be an orogenic mesozonal gold deposit related to the development of a calc-alkaline magmatic arc, both produced within the Maroni-Itacaíunas Province during a major Paleoproterozoic orogenic event.

CARBON AND OXYGEN ISOTOPES OF HYDROTHERMAL CALCITE ASSOCIATED WITH THE "LAVAS OCOÍTICAS" BETWEEN COPIAPÓ AND ILLAPEL

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In northern Chile, between latitudes 27° and 33° S, a sequence of porphyritic lavas, know as the "Lavas Ocoíticas" extruded at the end of the Neocomian. In the area of Copiapó the "Lavas Ocoíticas" host numerous metallic deposits and occurrences, and have been designated as the Metallotect "Ocoita Pabellón" which is characterized by the occurrence of "migrabitumen" (both in veinlets and in vesicles) and copper sulfides. The "Lavas Ocoíticas" often display an irregular amygdaloidal texture. The amygdules are filled with hydrothermal minerals, including chlorite, calcite, zeolite, clay minerals, silica and sometimes bitumen. Geochemically the lavas are characterized as calc-alkaline andesites rich in K. They are enriched in LREE relative to HREE (La/Yb>5), have a high content of K_2O, Rb, Ba and Th, and a low content of Ta and Nb, characteristic of magmas related to subduction. Furthermore a low concentration of Nb is an indicator of crustal contamination.

In this communication we present new C and O isotope data obtained from hydrothermal calcite in both the northern area (Copiapó), where it is associated with bitumen, and in the southern area (Illapel) where hydrothermal alteration or metamorphism seems to have obliterated the bitumen.

The isotopic characteristics of calcite, present both as veinlets and vesicles in the "Lavas Ocoíticas," have a range of +5.4‰ to +19.3‰ for the $\delta^{18}O$, and -1.8‰ to -13.5‰ for $\delta^{13}C$.

Results of fluid inclusions indicate that calcite formed at relatively low temperature between 193° and 318°C. The recalculated fluid composition $\delta^{18}O_w$ (using the medium value 214°C) varies between -3,4‰ (for $\delta^{18}O_{calcite}$ = 5,4‰) and $\delta^{18}O_w$ = 10,5‰ (for $\delta^{18}O_{calcite}$ = 19,3‰). These values are consistent with derivation from magmatic or metamorphic fluids. Pending fluid inclusion studies may confirm this initial interpretation.

Rb/Sr ESTABLISHES AN AGE OF 61 TO 67 Ma FOR COLOMBIAN EMERALDS

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The rubidium-strontium method of dating has been used to determine the age of some Colombian emeralds from the Muzo, Chivor, Coscuez and Yacopi mines. These deposits are found within the eastern and western borders of the Eastern Cordillera, specifically in the Guavio Region and Vasquez-Yacopi Tcrritory, and are hosted by a Lower Cretaceous marine black shale series, for the eastern zone, and sandstones - limestones - black shales for the western zone. The mineralization is contained within hydrothermal breccias, veins and pockets filled with carbonates, quartz and pyrite.

Despite of low radiogenic strontium enrichment, the high spread in $^{87}Rb/^{86}Sr$ ratios obtained using the leaching technique has permitted to establish two isochron ages. Emeralds from the western zone are suggesting an age of around 67 Ma with a low initial ratio of 0.713, while from the eastern zone, a poor isochron is revealing an age of ca. 61 Ma and a higher initial ratio of around 0.746. These discordant initial ratios could be attributed to the nature of the source and/or the local lithostratigraphy. Previous data for mineralization obtained by Cheilletz and collaborators show two distinct age groups: 65 Ma on muscovite from the eastern zone, and 32-38 Ma on micas from the western zone. Thus, the Rb/Sr ages between 61 and 67 Ma obtained on emeralds from both zones suggest that the mineralization occurred during this age interval and the thermal event detected by $^{40}Ar/^{39}Ar$ in the western zone has not affected the Rb/Sr system in emeralds.

RESERVOIR SOURING AND SULPHUR ISOTOPES: A CASE STUDY

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Reservoir souring is one of the main problems that can occur during the exploitation of a given oil field. H_2S sources must be recognized in order to solve or mitigate their pernicious effects. Causes include microbial sulfate to sulfur reduction (BSR), thermochemical sulfate to sulfur reduction (TSR), thermal hydrolysis, hydrolysis of metal sulfides and desorption of H_2S from formation sediments.

A research survey in a soured oil field was carried out to determine the origin of H_2S using, in a first step, sulfur isotopes in the produced gas. We present here the data and information of this case study.

The reservoir is located in the Neuquén Basin, the main oil-gas producing region of Argentina. The main productive reservoirs are in the Mendoza Group (Late Jurassic-Early Cretaceous), including the Mulichinco Formation, Agrio Formation and the Avilé member within this unit. It has been exploited for more than 15 years. The H_2S content, ranging from 3 - 4000 ppm, constituted a problem since five years ago.

We have discarded processes other than TSR and BSR. We have considered that BSR and TSR are mutually exclusive, due to the temperature ranges that they occur, which for BSR are between 0 to 60-80°C and for TSR from 100° to 150-200°C. The reservoir temperature is around 60°, so the conditions for TSR are not fulfilled.

Through the spatial distribution of H_2S and the disperse and highly fractionated isotope values, we can conclude that the source of souring of the oil field is bacterial sulfate reduction.

The supporting evidence is: 1) the history of explotation, 2) the highly dispersed sulfur isotope values of the produced H_2S, compatible with sulfate reduction by BSR, 3) the isotopic composition of water, *i.e.* injection water, production water, and oxygen scavengers (bi-sulfite), 4) the relative differences in the volume of sulfur sources, 5) the existence of a sulfate source feeding the process, 6) the distribution pattern, and 7) the presence of fatty acids in formation waters.

COMUNICACIONES N° 52 (2001):139

ISOTOPIC COMPOSITIONS OF SULPHATES AND NITRATES FROM THE CHILEAN NITRATE DEPOSITS: EVIDENCE FOR CONCENTRATION AND FRACTIONATION OF PARENTAL BRINES

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Isotopic compositions of nitrates ($\delta^{15}N$ and $\delta^{18}O$) in *caliche* samples from the Chilean nitrate deposits are similar to recent values reported for atmospheric N deposition in arid areas of the world. $\delta^{34}S$ and $\delta^{18}O$ of sulphate minerals present in the nitrate ores show similar values to those of continental evaporites in the area of Atacama, which suggest volcanic and hydrothermal sources. The sulphate isotope compositions display positive correlation trends (between $\delta^{34}S$ and $\delta^{18}O_{SO4}$) reflecting a reservoir effect due to fractionation related to precipitation. This effect has been clearly observed for sulphur and oxygen between sedimentary and bedrock *caliche* samples. Ore-grade bedrock *caliche* (mostly nitratine-halite mixtures filling veins) shows lower values than sedimentary caliche (acting as wall rock). Saline compounds of different origins present in the Neogene Atacama Desert were transported by the hydrological system towards the lower endorheic areas. There, brines were concentrated and fractionated by repeated processes of evaporation and precipitation. As a result, saline minerals (mostly nitrates, chlorides and sulphates) precipitated, filling the porosity of previous rocks.

Sr-Nd-Pb ISOTOPE COMPOSITIONS OF FELSIC INTRUSIONS IN THE EL TENIENTE AND LAGUNA LA HUIFA AREAS, CENTRAL CHILE

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Late Miocene to Early Pliocene magmatism in the El Teniente and Laguna La Huifa areas (34°S) is related to Cu-Mo mineralization (e.g.: El Teniente deposit). The high-Al TTG-like porphyritic suite linked to this mineralization is the result of significant mafic crustal re-working involving the melting of newly underplated Andean crust.

The position of this Na-rich magmatism coincides with the location of the main Miocene plutonic-volcanic arc, and lies ~250 km inboard of the present trench position and ~50 km to the west of the Quaternary volcanic front.

New $^{87}Sr/^{86}Sr$ and $^{143}Nd/^{144}Nd$ isotopic ratios from these porphyries range from 0.703957 to 0.704028, and from 0.512808 to 0.512834, respectively. In addition, new lead isotope compositions range from 18.573 to 18.592 for $^{206}Pb/^{204}Pb$, from 15.590 to 15.602 for $^{207}Pb/^{204}Pb$, and from 38.434 to 38.469 for $^{208}Pb/^{204}Pb$ ratios.

These porphyritic plutons have less radiogenic $Sr_{(7Ma)}$ values ($\approx$ 0.7040) and higher $eNd_{(7Ma)}$ values (+3.4 to +3.9) than those exhibited in Quaternary volcanic rocks at the same latitude, but are almost identical to modern lavas erupted through the thinnest SVZ crust. The Pb isotopes, are clearly more radiogenic than Nazca Plate Basalts (NPB), but less radiogenic than those from the Juan Fernández Ridge (JFR).

Overall, the new isotopic evidence appears to favor a general petrogenetic model of partial melting of young mafic Andean lower crust for felsic intrusions from El Teniente and Laguna La Huifa. Furthermore, these data seem to be inconsistent with the idea of an origin by partial melting of recycled oceanic crust (e.g.: NPB or JFR).

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COMUNICACIONES N° 52 (2001):141

PRELIMINARY STUDIES OF STABLE ISOTOPE DATA IN THE PANCANTA-LA CAROLINA TUNGSTEN DISTRICT, SAN LUIS, ARGENTINA

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In the southern part of the igneous-metamorphic basement of the Sierras de San Luis (Eastern Pampean Ranges), in the Pancanta area, are located the tungsten deposits. The distribution of W-bearing quartz-vein mineralization was controlled by shear zones heterogeneously spread within the La Escalerilla Granite (early Devonian), Las Verbenas Tonalite (early Ordovician) and metasedimentary rocks (San Luis Formation). In the granite the W-bearing quartz-vein mineralization is in contact with thin sheared tonalite bands. The close spatial relation between the granite and the W-deposits seems to indicate the influence of the granite hydrothermal activity on the ore-fluids. The calculated $\delta^{18}O$ values of 6.0 per mil and 9.4 per mil from biotite and quartz, respectively (El Porvenir mine), resemble those for fluids in felsic magmas. The calculated δD values of -88 per mil from biotite (El Porvenir mine) lie below the fields for waters in felsic magmas. On the other hand, both calculated $\delta^{18}O$ and δD values from biotite (El Porvenir mine) lie within the field of late potassic alteration.

The calculated $\delta^{34}S$ value = 6.0 per mil from pyrite in the Pancanta mine, will closely reflect those of the hydrothermal fluids at the temperatures of interest, with a significant input of metasedimentary sourced sulfur in the ore fluids.

The oxygen and hydrogen stable isotope data suggest that the ore fluids, with D-depleted, were possibly sourced from contributions of fluids equilibrated both with degassed felsic magmas and highly evolved meteoric waters. Nevertheless, the stable isotope data are still insufficient to allow a definitive interpretation.

STABLE ISOTOPE EVIDENCE FOR FORMATION FROM MAGMATIC FLUIDS OF THE MINERALIZED BRECCIAS IN THE LOS BRONCES AND EL TENIENTE COPPER DEPOSITS, CENTRAL CHILE

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The giant Miocene and Pliocene Río Blanco-Los Bronces and El Teniente breccia copper deposits of central Chile (33-34°S) are among the largest in the world. Hypogene copper, the most significant ore in these deposits, is concentrated in the matrix of breccias. Measured $\delta^{18}O$ and δD of quartz and tourmaline co-existing with chalcopyrite in the matrix of the Donoso breccia range from +6.9 to +12 and -73 to -95, respectively. Fluid inclusion temperatures imply $\delta^{18}O$ from +5.6 to +9.1 and δD between -51 and -80 for the fluids from which these minerals precipitated. In El Teniente, measured $\delta^{18}O$ and δD in quartz, tourmaline and anhydrite from both the Braden pipe and the Marginal breccia suggest similar compositions for the breccia-forming fluids. The presence of highly saline, high-temperature fluid inclusions and these stable isotope data indicate a magmatic origin for the fluids that generated the Donoso copper-rich tourmaline breccia in Río Blanco-Los Bronces and mineralized biotite and tourmaline breccias in El Teniente. Magmatic fluids derived from cooling plutons were responsible for both brecciation and mineralization in these breccias. Our data preclude participation of any significant volume of meteoric water, as in porphyry copper systems, in the formation of both the mineralized breccias and the copper-poor rock-flour breccias such as the Braden pipe, as well as at any stage of vein-related alteration and mineralization in these deposits.

MAGMATISM AND MINERALIZATION AGES FROM NORTHEAST AREA OF LA SIERRA DE SAN LUIS, ARGENTINA

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Three igneous rock groups, characterized as pre-, syn- and post-kinematic, have intruded the crystalline basement of Sierra de San Luis, Argentina.

The ore deposits are associated with Devonian to Carboniferous epizonal granite stocks and batholiths in an area underlain by metamorphic rocks. These granitoids are characterized as post-kinematic magmatism.

Model lead ages on the ore deposits (338.8 – 292.1 Ma) are strongly supported by K-Ar ages of the intrusive rocks.

The bulk of the north Sierra de San Luis ore deposits are genetically related to Late Carboniferous granite plutons. The ore bodies are tungsten veins with greisen envelopes, lead veins, epithermal fluorite veins and REE and Th deposits. A generalized scheme of ore bodies related to granites is proposed. The ore deposits and their lithotectonic setting are characteristic of the Gondwana metallogenic Epoch in the Sierra de San Luis.

The ages from the post-kinematic magmatism of the northern part of the Sierra de San Luis varies between Late Ordovician and Late Permian Periods. This magmatism would be represented by the Las Chacras-Piedras Coloradas and Renca batholiths, La Totora, Los Alanices, El Telarillo, La Población and El Hornito plutons.

The ages from the granitoids establish that the considered group composes one suite of characteristic post-kinematic intrusions, whose composition varies from intermediate to acid.

The Pb-Pb age (326 - 292 Ma) for the Las Aguadas district is comparable with the K/Ar age of the Los Cóndores deposit (334 ± 10 Ma). These ages are concordant with the El Hornito and Los Alanices intrusion ages.

The final magmatism stages from the post-kinematic intrusions would give origin to the Metallogenic Gondwanic Cycle. With this acid magmatism would be the beginning of the Gondwanic Metallogenic Epoch.

NEW K-Ar AGES OF VOLCANIC ROCKS AND ASSOCIATED MINERALIZATION IN CAÑADA HONDA DISTRICT, SAN LUIS, ARGENTINA

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Tertiary Volcanic Belt in San Luis, Argentina, is located in the southeastern extreme of the Central Andean «flat slab» segment extending from 28° to 33° S Lat. The ore deposits and the volcanic rocks with which they are related were generated on the inner side of an arc environment as a consequence of the subduction zone shallowing. Volcanism took place in late Miocene-late Pliocene period, between 9.5 and 1.9 Ma. Lavas and volcaniclastic rocks cropping out at isolated volcanic centers over an 80 km WNW-ESE-trending belt become progressively younger toward the eastern end of the belt. Mesosilicic magmas belong to normal to high-K calc-alkaline and shoshonitic magma types showing at both regional and local scales a K enrichment with decreasing ages.

Most of the sulphide-rich base metals, gold and silver epithermal deposits and the Diente Verde gold-rich porphyry copper are associated with eroded volcanic centers and a subvolcanic porphyry in the western part of the belt. Intersections of NNE-SSW, E-W and NW-SE structural trends appear to control the emplacement of volcanic rocks and associated mineralization along the belt.

New and existing radiometric ages permit to define a late Miocene volcanic epoch for Cañada Honda district. The 9.5 ± 0.5 Ma age for Diente Verde volcanic cone and the 8.49 ± 0.2 Ma age for Cerro del Valle dome indicate that Cañada Honda is the oldest volcanic center in the belt. An illite from hydrothermal alteration related to La Reynela low sulfidation epithermal vein was dated at 7.3 ± 0.2 Ma. This age indicates that the mineralization event occurred after the main magmatic episode in Cañada Honda district and predates the waning volcanism represented by El Morro eruptions to the east. This evidence suggests the probable existence of different magmatic pulses and associated mineralization periods, accompanying the eastward migration of the volcanic front.

GEOCHRONOLOGICAL STUDIES IN THE CHUQUICAMATA DISTRICT, CHILE: A REVIEW

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The dating and discrimination of significant events in the complex Chuquicamata porphyry copper system have been challenging. The work by others and us indicate that the first mineralizing (Chuqui) porphyries were emplaced at ca.35 Ma, followed by potassic alteration and various hydrothermal pulses to ca. 33 Ma. This system evolved within a dynamic ductile to brittle shear system. After 1-2 km of exhumation, a discrete mineralizing (quartz-sericitic) event was superimposed at ca. 31 Ma. Relatively slower exhumation followed, allowing for the development and preservation of important supergene blankets (19 to 15 Ma) and exotic copper deposits. The unmineralized Fortuna igneous complex, juxtaposed across the NS (Falla Oeste) fault system, is relatively older than the Chuqui porphyries.

Historically, in the 1960s, Pb-alpha on zircon approximately dated the Paleozoic and Mesozoic hosts to the Chuqui porphyries, and the Eocene Fortuna. In the 1970s and 1980s, conventional K/Ar dated the main potassic alteration at 35 to 33 Ma, and the quartz-sericite alteration at 31-28 Ma. In the 1990s, Rb-Sr accurately dated the major homogenization of the Chuqui system at 35 ± 2 Ma and confirmed that Fortuna is older. $^{40}Ar/^{39}Ar$ defined two thermal pulses and documented thermal overprint by the younger event. U-Pb dating is hindered by the presence of xenocrystic zircon with Paleozoic ages. Recently, ELA-ICP-MS dating of zircon distinguished 3 intrusive phases at 34.8, 33.4 and 33.3 Ma, compatible with a 34.9 Ma age by Re-Os in molybdenite. Re-Os in Cu-Fe sulfides confirms the ca. 31 Ma age of the quartz-sericitic stage. Fission-track data on zircon and apatite, and (U-Th)/He dating, point to extremely fast cooling to <100°C after the quartz-sericitic event, and improve exhumation histories. Fission-track data on apatite and ESR of quartz in fault gouge suggest that the Falla Oeste was active into the Pliocene and Pleistocene, respectively.

ORDOVICIAN METAMORPHISM AT THE SOUTHWESTERN MARGIN OF GONDWANA: P-T CONDITIONS AND U-Pb SHRIMP AGES FROM LOMA DE LAS CHACRAS, SIERRAS PAMPEANAS

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Loma de Las Chacras, on the western margin of the Sierra de Valle Fértil, consists of metasediments and metabasites metamorphosed to medium-to-high grade, and previously was considered to represent the easternmost outcrop of the Precordillera terrane. Petrographic study and thermobarmetric calculations from microprobe compositional data suggest maximum P-T conditions, corresponding to the paragenesis: Grt rim (in contact with leucosome) + Bt-2 (matrix) + Pl rim (in contact with Grt) + Ky + Kfs + Qtz, estimated at 12.1 ± 1 kb and 769 ± 18°C. The fall from the peak of metamorphism is dated at 463 ± 2 Ma by SHRIMP U-Pb analyses of zircon rims overgrowing detrital cores. This is consistent with other evidence for Early–Mid Ordovician metamorphism of the Famatinian orogenic belt. The zircon cores have Mesoproterozoic to Cambrian ages, indicating inheritance from a Gondwana source. Thus the suture between Late Cambrian Gondwana and the Precordillera terrane lies to the west, along the Bermejo valley between Sierra de Valle Fertíl and Sierra de Pie de Palo. Our wider studies of the Famatinian metamorphism show a regular transition to increasingly lower pressure conditions eastwards into the Gondwana margin.

COMUNICACIONES N° 52 (2001):147

TRIASSIC VOLCANIC UNITS IN COASTAL REGION OF ANTOFAGASTA, NORTHERN CHILE

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A 150 metre thick sequence of rhyolitic tuffs, and an associated rhyolitic dome (Cerro Camaleón), outcrop in Antofagasta region, northern Chile. The rhyolite is crystal rich and zircon bearing. Zircons were collected from samples of both units.

The U-Pb data define two discordia. Three zircon fractions were separated for the sample BF-225, however one fraction shows lead loss and therefore was not used for discordia definition. Discordia lower intercepts are 233 +9.6/-12 and 220 +19/-17 Ma, while upper intercepts are 1007 +150/-140 and 1116 + 170/-120 Ma, respectively.

These data place this volcanic episode, previously assigned to the Jurassic, in the Middle to Late Triassic period, which provides the first geochronological evidence of Triassic volcanicity to be found in the Coastal Range of Antofagasta, and can be correlated with outcrops at Cerro Quimal and Quebrada Cifuncho in Taltal.

MIDDLE CRETACEOUS CRUSTAL ANATEXIS ASSOCIATED TO CONTRACTIONAL DEFORMATION ON EDEN'S SHEAR ZONE

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The Puerto Eden's igneous and metamorphic complex (PEIMC) represents the westernmost outcrop of the Eastern Andean Metamorphic Complex (EAMC), situated at 49°8'20"S - 74°23'20"W. It is composed of amphibolite facies schists, melanocratic and leucocratic diatexites, and orthomylonites intruded by schlieren-bearing porphyritic biotite monzogranite, tabular garnet-tourmaline and white mica-garnet leucogranites, pegmatitic felsic dikes, andesitic dikes, and biotite-hornblende granodiorites belonging to the South Patagonian Batholith (SPB). Structural and microstructural features on the schists, migmatites and orthomylonites, which are developed within the leucodiatexite body, suggest a reverse movement of the eastern block with a small dextral component under medium- to high-temperature conditions. Geochemically the granitic rocks are typical volcanic arc granites, and the leucogranites probably represent anatectic granitic segregation from the underlying EAMC. A similar origin is proposed for the previously formed leucodiatexites in which their biotite schlieren and centimetric ellipsoidal enclaves of quartz probably represent remnants of the schist's quartz veins from paleosome before migmatization. The data set of K-Ar age determinations on schists, migmatites and granitoid bodies ranges between 102 ± 2 and 109 ± 3 Ma. The K-Ar ages and a previous ca. 150 Ma contact metamorphism event in Puerto Eden, suggest that the K-Ar ages from the schists and schlieren-bearing bodies could represent reset ages. The K-Ar ages of biotite-hornblende and white mica isotropic granitoids are interpreted as minimum ages of crystallization. This indicates either a very slow cooling over ca. 45 Ma or more probably a magmatic event associated with crustal anatexis close to 110 Ma. This peraluminous magmatism could be related to a decompression dehydration-melting of white mica within a contractional regime associated with a convergent orogenic belt. Both ages registered in the studied area can be correlated with magmatic and deformational episodes in the geological history of the Andean Patagonia.

GEOTECTONIC SIGNIFICANCE OF THE MARAYES VIEJO BASALT BASED ON K-Ar DATING, WESTERN PAMPEAN RANGES, SAN JUAN PROVINCE, ARGENTINA

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The intracratonic basin of Marayes-El Carrizal, extends along the western edge of La Huerta range, in the Western Pampean region, San Juan province. It is filled by a sequence of continental clastic sediments of Middle to Upper Triassic age. The only igneous component recognized in this sequence is the Marayes Viejo Basalt (BMV), considered as a dike that intrudes the sedimentary rocks. Recently, the authors identified another igneous body, the Marayes Viejo Porphyry (PMV), whose radiometric age permits assigning it to the Neopaleozoic. Apophyses of this porphyry cut the BMV.

Field observations demonstrate that the BMV was deposited as a flow on the crystalline basement of La Huerta range. Its eruptive nature is corroborated by the analysis of the contact surfaces. The overlying sedimentary sequence covers it in concordance, in some cases filling irregularities in the surface of the flow. According to petrographic and chemical analysis, the BMV corresponds to a trachybasalt derived from magma of alkalic to calc-alkalic character, erupted in an active continental volcanic arc setting.

The result of the whole-rock K-Ar dating presented here, gives an age of 255 ± 13 Ma, corresponding to the uppermost Lower Permian – Upper Permian. The date correlates with the age of the PMV and other ages from rhyolitic intrusive bodies of La Huerta range, and confirms the presence of the Gondwanic magmatic cycle in the Western Pampean Ranges.

The dates obtained suggest an active subduction during Permian time for the western margin of the Pampean Ranges. The basaltic-andesitic magmatism in the area can be genetically related to magmatic activity that is post-compressive stage (San Rafaélica phase ± 280 Ma), but prior to the extensional stage that formed the Marayes-El Carrizal basin.

EVOLUTION OF MAGMATISM FROM THE UPPERMOST CRETACEOUS TO OLIGOCENE, AND ITS RELATIONSHIP TO CHANGING TECTONIC REGIME, IN THE INCA DE ORO-EL SALVADOR AREA (NORTHERN CHILE)

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We present geochronological and petrological data for extrusive and intrusive rocks in the Inca de Oro, El Salvador, Potrerillos and Salar de Maricunga sheets, III Region, Chile (26°-27° S). Additionally, we include published data for the El Salvador and Potrerillos districts. The dataset includes K/Ar, Ar/Ar and U-Pb mineral ages, which have been carefully selected for quality. The area is underlain by Carboniferous-Permian granitic basement rocks, which are covered by Triassic to lower Upper Cretaceous volcanic and sedimentary successions, including both marine and continental sequences. The period studied in this paper includes extrusive and intrusive rocks of Maastrichtian to Oligocene age, which are of particular interest since they record the "preparation" of the lithosphere prior to, during, and after the mid-Eocene Incaic deformation and associated porphyry copper event. Shortening in the early Late Cretaceous (95-85 Ma) deformed large areas of northern Chile, and marked the transition from the dominance of intra-arc extension to that of shortening punctuated by periods of extension. We recognise seven tectono-magmatic periods from the latest Cretaceous to Oligocene, comprising (1) a volcanic-sedimentary event contemporaneous with an extensional tectonic regime in the Late Cretaceous, associated with graben formation, followed by (2) an important compressive event at the beginning of the Tertiary. The middle Paleocene (3) was again dominated by voluminous volcanic activity (collapse calderas) in an extensional regime. During the earliest Eocene (4) the magmatic activity in the area shows a gradual transition from pyroxene-bearing to amphibole-bearing lithologies, culminating in the intrusion of pre-Incaic hornblende granodiorites (5) in the late early Eocene. During the middle to late Eocene Incaic deformation (6), minor hornblende-bearing intrusions hosted porphyry-Cu mineralisation. Restricted post-Incaic (7) intrusions were emplaced during the early Oligocene. The data show that periods of extension were characterised by dominantly extrusive magmatism (Periods 1 and 3), whereas during periods of compressional stress (Periods 2, 4 to 7), intrusive activity was dominant and volcanism almost non-existent.

COMUNICACIONES N° 52 (2001):151

PRELIMINARY ISOTOPIC DATA FROM SOME AMPHIBOLITES OF THE METAMORPHIC BASEMENT OF THE COLOMBIAN CENTRAL CORDILLERA

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Various amphibolite bodies are exposed in the northern sector of the Colombian Central Cordillera, around the cities of Medellín and El Retiro in the Antioquia Department. They are associated with other medium- and high-grade metamorphic rocks such as paragneisses, schists, quartzites, migmatites, and granulites.

It is possible to recognize several kinds of amphibolites: amphibolites, garnet-bearing amphibolites, and diopside-bearing amphibolites. The former are the most widespread type in the metamorphic unit, whereas the garnet- and diopside-bearing types occur in places generally related to metasedimentary rocks. Metamorphism has obliterated the primary textures and most of the amphibolite bodies show evidence of two deformation phases. A third deformational phase is observed in places. Mineral paragenesis indicates low to high amphibolite facies. Amphibolites show evidence of retrometamorphic recrystallization.

Geochemical data suggests that protoliths correspond to tholeiitic basalts and gabbros. El Retiro amphibolites have a #Mg ≈ 32 and those from the Medellín area exhibit a #Mg ≈ (40-56). Whole rock Sm-Nd data yielded an isochronic age of 984 ± 210 Ma, MSWD=1.8, with positive $\hat{I}_{Nd}$(T=985Ma) between +6 and + 8, which indicates a mantle-derived source for the protoliths. The crystallization age is only valid if magmatism of both places were contemporaneous. One of the samples shows $\hat{I}_{Nd}$(T=985Ma) ≈1, due to continental crust contamination. The same sample has provided a model age of 1400 Ma, which is consistent with the age of crustal residence obtained for the metasedimentary rocks associated with these amphibolites.

Isotopic characteristics and other lithogeochemical data suggest different mantle sources for the amphibolites of Medellin and El Retiro.

We suggest that the amphibolites were formed in a back-arc basin where volcanism had been contemporaneous to sedimentation, but alternatively they could have been formed at an oceanic spreading center with some continental sedimentary contribution.

K-Ar GEOCHRONOLOGIC EVIDENCE FOR A TRIASSIC METAMORPHIC EVENT IN THE MAIN CHILOÉ ISLAND, SOUTH-CENTRAL CHILE

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The Bahía Mansa Metamorphic Complex in the main Chiloé island is composed of metasedimentary and minor metavolcanic rocks. Previous K-Ar and $^{40}Ar/^{39}Ar$ dates on muscovites from pelitic schists collected west of Ancud indicated 220±5 and 232.5±2.7 Ma, respectively. Three new K-Ar ages on muscovite and muscovite with traces of biotite from metapelitic rocks collected in the vicinities of Castro gave 236±6, 245±8 and 230±5 Ma. These ages represent cooling ages related to the main deformation and metamorphism event (D_2) in the greenschist facies during the Early to Middle Triassic. All the K-Ar ages represent cooling ages related to the Ar closure temperature in muscovite near 350° C and they are temporarily close to the maximum temperature of metamorphism, in the greenschist facies. Regionally, all available K-Ar ages for the Bahía Mansa Metamorphic Complex in Chiloé show partial correlation with the cooling ages reported for the same metamorphic complex to the north. Available K-Ar and $^{40}Ar/^{39}Ar$ ages for the Bahía Mansa Metamorphic Complex in the main Chiloé island suggest accretion to the Gondwana continental margin during Triassic time. Concordant U-Pb dating of detrital zircons has suggested a maximum depositional age of about 388 Ma (Early to Middle Devonian) and also erosion of sediment sources of Devonian, Ordovician and Grenville ages.

COMUNICACIONES N° 52 (2001):153

A NEOGENE AGE FOR TRAIGUÉN FORMATION, AYSÉN, CHILE, AS REVEALED BY SHRIMP U-Pb DATING OF DETRITAL ZIRCONS

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The volcanosedimentary marine deposits of the Traiguén Formation crop out extensively in the archipelagos of Aysén. This unit has been considered to be Early Cretaceous to Miocene in age, based on sparse fossils and contact relations with plutons. It has been observed to uncomformably overlie Early Cretaceous components of the North Patagonian Batholith near the SW corner of its extension, and to be intruded by 20 Ma plutons in its northwestern outcrops. U-Pb SHRIMP ages of detrital zircons as young as 26 Ma indicate that deposition of the Traiguén Formation occurred during the latest Oligocene to earliest Miocene. Peaks in the distribution of ages within the 60 analyzed detrital zircon grains occur at 70, 200, 280, 360, 500 and 1250 to 1400 Ma. These results indicate that during deposition of the sampled level of the Traiguén Formation, Early Cretaceous components of the North Patagonian Batholith were not shedding detritus into the Traiguén basin. Most of the zircons appear to have been recycled from the Chonos Metamorphic Complex that crops out to the west of the Traiguén Formation, with the exception of the 70 Ma zircons that probably come from the Península Gallegos – Isla Clemente Granite.

THE TIPA SHEAR ZONE (NW-ARGENTINA): EVIDENCE FOR EARLY DEVONIAN MOVEMENT VERIFIED USING Sm-Nd DATING OF GARNET AND WHOLE ROCK SYSTEMS

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Between the Famatina-System and the Pampean Ranges (NW-Argentina) four large ductile shear zones have been recognized. They all strike NNW-SSE, are steeply dipping towards the east and show E-W directed compression. Timing of mylonitization is important in order to understand Paleozoic geotectonic processes on the western Gondwana margin.

The studied area is situated near Tinogasta (Dep. Catamarca), in the Sierra de Copacabana and the Sierra de Fiambalá (TIPA shear zone). Most common rock types are peraluminous S-type granites. In order to date the age of the deformational event, garnet-WR analyses were carried out using the Sm-Nd system. Examination of thin sections as well as field observations clearly show a syntectonic (deformation-induced) garnet growth. Garnet-WR analyses of two mylonitic samples yield ages of 416 ± 3 Ma and 420 ± 27 Ma respectively, those of a deformed garnetiferous pegmatoid vein give 409 ± 3 Ma and a slightly deformed granitic gneiss yields 413 ± 5 Ma. U-Pb zircon data show that the deformed granitic protoliths crystallized at around 495 and 460 Ma, whereas post-tectonic granite intrusions took place at around 350 Ma. At this time, as well the U-Pb system opened in apatites of pre-tectonic rocks and mylonites and thus indicates a thermal overprint on the order of 425 to 500°C during that time (350 – 330 Ma). We interpret the obtained Sm-Nd garnet-WR ages as dating the mylonitization in early Devonian time. This event could be correlated with the final closure of a back-arc basin by collision of the Famatinian island arc with the hinterland.

K-Ar AGES OF ROCKS FROM LAGO ALUMINE, RUCACHOROI AND QUILLEN, NORTH PATAGONIAN ANDES, NEUQUEN, ARGENTINA

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This study presents new K-Ar ages of granitic rocks from the Patagonian Batholith in the North Patagonian Andes (38°00'- 39°30' SL), from localities near Alumine lake and from Ñorquinco lake to Quillen valley, in the Neuquén Province, Argentina.

The age determinations were obtained by the K-Ar method on biotites and amphiboles. The samples collected in a 50 km transect through the outcrops from Alumine valley to Paso Icalma have given values of Mid Cretaceous age, ranging from 100 ± 10 to 111 ± 5 Ma. The rock extracted from an outcrop near Paso Icalma has an age of 87 ± 7 Ma.

The samples of the granitic rocks from near Rucachoroi lake and Quillen valley, have yielded ages from 209 ± 12 to 241 ± 41 Ma, that permit to assign them to the Triassic.

According to the results obtained in the present research, there are two clusters of ages. The first one comprised by the Rucachoroi-Quillen granitic rocks belong to the Triassic; and the second one, the granitic rocks from Alumine valley to Paso Icalma, correspond to the Early Cretaceous. The latter ones, with values from 100-110 Ma, represent an important magmatic event which has not been mentioned until the present for the area under study. The sample of Paso Icalma, located to the west of the area, has a younger age, 87 ± 7 Ma, and corresponds to a Late Cretaceous episode.

The values presented for the Rucachoroi and Quillen granitic rocks, would be reflecting a close relationship with the break-up of Gondwana.

Therefore, the rocks located to the north of Pulmari river are predominately of Cretaceous age, whilst those outcropping to the south of this river are of Triassic age, not discarding that it could be little outcrops of both events in the area studied.

Sr, Nd, Pb - ISOTOPIC COMPOSITION OF METASEDIMENTARY AND MAGMATIC ROCKS OF THE LATE PALEOZOIC AND MESOZOIC BASEMENT IN CHILE AND W ARGENTINA (~ 36°30-40°S; 70°30' - 73°W) - IMPLICATIONS FOR THE SOURCE REGIONS OF THE PRE-CENOZOIC BASEMENT

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Geochemistry and isotopic composition (Sr, Nd, Pb) of late Paleozoic granite, late Mesozoic intrusions and their weak to high grade metasedimentary host rocks define two groups of rocks with regard to their sources. The late Paleozoic granite are typical crustal melts and define together with the isotopically very similar metasedimentary rocks an old crustal source derived from Proterozoic cratonic material. The isotopic compositions of these rocks are comparable with those of the Paleozoic basement of the Central Andes and the Sierras de Córdoba. One group of late Mesozoic intrusions indicates either a high proportion of magma from a depleted mantle source in a well-homogenized hybrid magma or a special regional type of mantle source. The negative correlation of Nd - Sr isotopic ratios of a second group of the late Mesozoic intrusions shows clear evidence for mixing of magmas comparable in composition to the first group with the old crustal source. The generally positive correlation of their $^{207}Pb/^{204}Pb$ and $^{208}Pb/^{204}Pb$ ratios with Sr_i also points to the mixing with the old crustal source. Both assimilation of crustal material and development only by crystal fractionation are working processes in the late Mesozoic intrusions. Isotopic dating of the late Mesozoic intrusions is in progress.

AGE DISTRIBUTION OF PLUTONS ACROSS THE SOUTHERN PATAGONIAN BATHOLITH: NEW U-Pb DATA ON ZIRCONS

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The Patagonian batholith is one of the longest continuous igneous complexes in the world. It extends along the Patagonian and Austral Andes. The Northern Patagonian batholith (NPB) shows a regular age distribution with Early Cretaceous plutons on both margins and younger plutons in the central core, where the Liquiñe Ofqui Fault Zone provided pathways for magma ascent. A similar pattern of age distribution has been proposed for the Southern Patagonian batholith (SPB). However, for the latter, the existent database was produced by different geochronological methods with a sparse sample distribution, and restricted to three cross sections within the batholith. We present high-precision radiometric ages (U-Pb TIMS and SHRIMP analyses) from the northern portion of the SPB. The new data confirm the observation that oldest rocks, with an age range between 140 and 150 Ma, were emplaced at the eastern margin. Very earliest Cretaceous granitoids, ca. 137 Ma, are also present in the western border of the batholith. Early Cretaceous granitoid ages of ca. 120 Ma are present in the eastern margin of the SPB, and the proposed Late Cretaceous peak of intrusive activity is registered in our age dataset (ca. 86 Ma), as well as Paleocene and Miocene granitic rocks, in the central portion of the SPB. The ages presented are consistent with the zonation of NPB, however a structural control for magma ascent is not yet determined. The zircon fission-track ages imply the presence of a large Miocene intrusion or at least the presence of a large regional heat source, sufficient to heat rocks to temperatures well in excess of 300°C. In conclusion, the U-Pb data indicate a range of plutonic activity in the SPB from 150 to 16 Ma, and a history of discrete, successive episodes, resulting in a longitudinal zonation similar to that noted in the NPB is strongly suggested.

EXOTIC CRUSTAL FRAGMENTS ON THE PACIFIC MARGIN OF GONDWANA

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The recent hypothesis that the Antarctic Peninsula consists of accreted terranes has been investigated using U-Pb microprobe (SHRIMP) dating of detrital zircons in metasedimentary rocks and inherited zircons in granites. The age distribution patterns of these zircons are used to assess the contribution of Gondwana sources to the different terranes. (1) The Eastern Domain is thought to be a parautochthonous part of the Gondwana continental margin. Eastern Domain zircons have complex age patterns dominated by peaks at 555, 625 and 670 Ma with minor peaks at 500, 535 and 595 Ma, suggesting derivation from a number of Pan-African orogenic belts within Gondwana. (2) The Central Domain is a suspect microcontinental arc terrane, separated from the Eastern Domain by a major crustal suture. It is dominated by Triassic-Early Jurassic S-type granites and later Mesozoic–Cenozoic cordilleran I-type granitoids. The former plutonic rocks contain inherited zircons with age patterns dominated by two peaks at 470 and 530 Ma, with minor components scattering between 260 and 560 Ma. These represent active arc construction on continental crust without the full range of Gondwana sources. (3) The Western Domain is characterised by turbiditic metasedimentary rocks, and may represent the subduction-accretion complex of the Central Domain, or another, separate, crustal fragment. A sample of Western Domain sandstone has a zircon age distribution with distinct peaks at 470 and 530 Ma, which coincide with the peaks shown by the Central Domain orthogneiss, and a number of younger peaks, including a major one at 265 Ma. A similar predominance of Permian inheritance is common in the accretionary complexes of Chile and New Zealand. These patterns are consistent with suggestion that the Western and Central domains were allochthonous terranes that collided with the Eastern Domain in earliest Cretaceous times.

U-Pb SHRIMP AND Rb-Sr AGES OF THE SONSÓN BATHOLITH, COLOMBIA.

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The Sonsón batholith is part of the Central Cordillera. For this batholith the K-Ar ages are incongruous. One prior study obtained an age of 69 ± 3 Ma, while another obtained ages of 170 ± 10 Ma and 160 ± 4 Ma.

In order to solve this controversy, we carried out Rb-Sr, Sm-Nd and U-Pb isotopic studies and obtained ages that will serve as a basis for understanding the genesis of this intrusion in the Andean context.

The samples collected of the Sonsón batholith, as well as from smaller intrusions associated with it (Norcasia, El Hatillo and Manizales stocks), correspond to the typical facies of each intrusion.

For the Sonsón batholith two Rb-Sr isochron ages were calculated:

1. 73 ± 9 Ma and initial $^{87}Sr/^{86}Sr$ ratio of 0.70494
2. 64 ± 15 Ma and initial $^{87}Sr/^{86}Sr$ ratio of 0.70509

Zircons from this intrusion yielded an U-Pb SHRIMP age of 60.7 ± 1.4 Ma, interpreted as the age of crystallization of the batholith.

The $e_{Nd(60Ma)}$ values range mostly from +0.5 to –3.02. The exception is the Norcasia stock, with a very positive (+3.0) value, representing therefore, the most primitive end-member of this magmatic activity.

The T_{DM} model ages between 0.4 and 1.02 Ga, $e_{Nd(T)}$ and initial Sr ratios indicate mixing between a mantle-derived component and a crustal melt derived from Precambrian–Paleozoic basement.

A DISCUSSION ON DISCORDANT WHOLE ROCK Rb-Sr AND FINE FRACTION K-Ar DATES FROM TRINITY PENINSULA GROUP AT BOTANY BAY, WEST ANTARCTICA

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The Trinity Peninsula Group is a flysch-like turbidite and greywacke sequence accumulated in a subduction-related accretionary prism, that was affected by incipient metamorphism and has a widespread distribution in the Antarctic Peninsula. This sequence was sampled for isotopic analyses at Botany Bay, Antarctic Peninsula. A first analysis from the data yields an errorchron (281 ± 51 Ma) suggesting lack of complete isotopic equilibrium. We reprocessed the data with expanded uncertainties and they yielded an isochron of 283 ± 11 Ma (Ir: 0.71448, MSWD 1.7, probability of fit 0.18), with a similar age and initial ratio. Four K-Ar ages were obtained from fine fractions that are not concordant. Three of them yielded older ages (390 ± 10, 381 ± 14 and 346 ± 13 Ma) and only one gave an age that agrees within the error with the Rb-Sr whole-rock isochron (268 ± 10 Ma). We consider that the older K-Ar dates are inherited ages and, on the other hand, we interpret the Rb-Sr and K-Ar Early Permian dates as the age of the very low-grade metamorphic event that affected the sequence of TPG at Botany Bay. The different behavior of both isotopic systems could be related with the fact that they did not achieve thermodynamic equilibrium during metamorphism, so they were only partially re-homogenized.

A WIDESPREAD DEVONIAN METAMORPHIC EPISODE IN NORTHERN PATAGONIA, ARGENTINA

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The crystalline basement of the North Patagonian Massif is composed of a supracrustal sequence of middle- to high-grade schists, mica quartzites and quartzites, that have been included in the Cushamen Formation. Rb/Sr data show that most of the samples form a positively correlated array and are aligned in a family of parallel reference lines, each of them with its own initial ratio. This could be in accordance with a set of rocks with different initial ratios, metamorphosed at the same time, but without a complete re-homogenization on a regional scale. The data lie along a 345 Ma reference isochron. It thus appears that the Rb-Sr system in the whole rock has been strongly affected by a regional metamorphic event at ca. 350 Ma, as has been earlier suggested. The analytical results screened gave two isochrons. The first is for the type locality (Cushamen, Chubut). Age: 362 ± 10 Ma, IR: 0.70599, MSWD: 1.05, Probability of fit: 0.37. The second for La Angostura, Chubut. Age: 371 ± 33 Ma, IR: 0.71091, MSWD: 0.20, Probability of fit: 0.89. We suggest that the lack of an important fluid phase hindered the possibility that the Sr redistribution took place on a kilometer scale. Although the episode is not well constrained, these ages, in our opinion, reflect the peak of a metamorphic event for the Cushamen Formation. Also, these ages can be associated with previous results on metamorphic units, close to the Cordillera, which also mark a lower limit for the deformative episode previous to the sedimentation of the Tepuel Group. Therefore, we consider these conditions representative of a widespread metamorphic event in northern Patagonia for Early-Middle Devonian times, probably associated with a collisional-accretional episode in the entire area.

THE MINA GONZALITO GNEISS: EARLY ORDOVICIAN METAMORPHISM IN NORTHERN PATAGONIA

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U-Pb SHRIMP data obtained from the Mina Gonzalito gneiss, in the eastern margin of the North Patagonian Massif, indicate that metamorphic zircon rims grew during the high-grade metamorphic event at 469 ± 4 Ma (probably Arenig). This is significantly earlier than is currently assumed and shows that the metamorphism was contemporaneous with that experienced by the Famatinian belt on the western margin of Gondwana rather than with the late stages of the Brasiliano-Pan African cycle. The age distribution pattern of inherited zircons, in the range 500-1100 Ma, is closely similar to that of the supposed protolith, the local low-grade metasedimentary sequence (El Jagüelito Formation). Both show dominant provenance from late Brasiliano igneous rocks, such as the granites of the basement to the Sierra de la Ventana. Thus deposition of the El Jagüelito Formation also postdated post-tectonic Brasiliano plutonism. Northern Patagonia must have been contiguous with the Río de La Plata craton by latest Neoproterozoic times.

COMUNICACIONES N° 52 (2001):163

CHRONOLOGICAL STUDY OF THE PRE-JURASSIC BASEMENT ROCKS OF SOUTHERN PATAGONIA

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Rb-Sr and U-Pb zircon (both conventional and SHRIMP) data are reported for metapelites and a variety of granitoids from the pre-Jurassic outcrops of the Deseado Massif, southern Patagonia. Rb-Sr isochron data for phyllitic metapelites associated with a 540 Ma amphibolite at Estancia Dos Hermanos follow a rough trend corresponding to 950 Ma with an initial $^{87}Sr/^{86}Sr$ ratio of 0.706. SHRIMP data for detrital zircons have ^{238}U–^{206}Pb ages concentrated at c. 580, 640, 800 and 1100-1200 Ma, suggesting sedimentation of the protolith in latest Precambrian times from a variety of Neoproterozoic sources. Data for evolved muscovite-bearing granites at Tres Hermanas and El Sacrificio define a single anatectic igneous episode at 420 ± 5 Ma (latest Silurian/earliest Devonian), whereas the El Laurel tonalite appears to be slightly younger (405 ± 6 Ma). A leucogranite at Bajo de La Leona, c. 50 km SSW of Dos Hermanos, gave a U-Pb zircon SHRIMP age of 346 ± 4 Ma (Carboniferous). Thus granite magmatism in southern Patagonia is generally younger than the Cambrian and Ordovician belts related to collisional events in the proto-Pacific margin of the Río de la Plata craton. Devonian/Carboniferous S-type magmatism occurred in the Sierras Pampeanas, but its tectonic setting is still rather obscure. Another parallel may be found in the sparse Silurian and Carboniferous granite magmatism of the northern Antarctic Peninsula. Further data of this sort will hopefully help to resolve the terrane structure and evolution of the region.

U-Pb, ^{40}Ar-^{39}Ar AND FISSION-TRACK GEOCHRONOLOGY OF THE EARLY CRETACEOUS CALEU PLUTON AND ITS VOLCANIC ENVELOPE, COASTAL RANGE OF CENTRAL CHILE: TECTONIC AND METAMORPHIC IMPLICATIONS

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Ten samples from the Caleu pluton were selected for dating. Nine of them were collected to provide cooling ages and one sample to date the emplacement of the pluton by the single grain U-Pb method. From the nine samples, five were dated by step-heating ^{40}Ar-^{39}Ar method on minerals (hornblende, biotite, plagioclase), and seven by apatite fission-track techniques. The most reliable ^{40}Ar-^{39}Ar results, corresponding to cooling temperatures of the pluton from 500-550° to 250-300°C, are in the 93.5 - 96.5 Ma range. Most of the apatite fission-track ages of the pluton are in the 90-96 Ma range. Five samples were selected to analyze primary and metamorphic minerals of the Veta Negra Formation at the Chacana section by the ^{40}Ar-^{39}Ar method. Ages around 119 Ma were obtained for the age of the volcanism. The metamorphic ages obtained in adularia from amygdales and in strongly sericitized plagioclase are in the 97-102 Ma range, which are slightly older than those (93-94 Ma) obtained further south, at the Bustamante Hill section. The nearly similar ages obtained for the metamorphism and for the Caleu pluton emplacement and subsolidus cooling indicates that the metamorphic and plutonic events are product of the same thermal event. It seems that the metamorphic conditions are not only due to burial but also to an additional thermal input. The cooling and metamorphic ages allow to calculate slow subsidence and fast exhumation rates in the studied Lower Cretaceous terrane. A tectonic scenario that relates magmatism, metamorphism, subsidence and exhumation is discussed.

ORDOVICIAN METAMORPHISM IN THE SIERRAS PAMPEANAS: NEW U-Pb SHRIMP AGES IN CENTRAL-EAST VALLE FÉRTIL AND THE VELASCO BATHOLITH

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Little is known about the timing and characteristics of regional metamorphism during the Famatinian orogeny in the southern proto-Andes (26°-37°S). A key transect in this study is at 30°30´-31°40´S, where Grenvillian basement units of the Precordillera Terrane (PT) are separated by the Bermejo valley from high-grade rocks of the Sierra de Valle Fértil. New U-Pb SHRIMP data of central-eastern Sierra de Valle Fértil and Sierra de Velasco are presented to characterise metamorphism on the eastern side of the transect, i.e. the Gondwana margin. Well-developed zircon overgrowths in two garnet ± cordierite migmatites from Valle Fértil define very similar ages of 465.9 ± 4.4 and 466.5 ± 7.7 Ma. This new metamorphic zircon was formed during a thermal peak that reached anatectic conditions. Inherited ages obtained from the zircon cores of the migmatites range from 500 to 2000 Ma, indicating derivation from Proterozoic to Cambrian sources. Zoned tips and cores from a blastomylonitic cordierite granite in the Sierra de Velasco produced a precise age of 481.4 ± 2.4 Ma, interpreted as the crystallization age of the granite, while distinct low-U metamorphic overgrowths produced an age distribution centred at 469.0 ± 3.9 Ma. This is the first isotopic evidence indicating that a mid-Ordovician metamorphic overprint affected a major unit of the Famatinian granites. Metamorphic ages decrease to the west, from the Velasco (469 Ma), central-eastern Valle Fértil (466 Ma), southwestern Valle Fértil (463 Ma) to Pie de Palo (460 Ma), but as analytical errors overlap in most cases, further studies are needed to confirm this observation. The estimated metamorphic age range (Upper Arenig–Llandeilo) is probably associated with the complex accretion of the PT to Gondwana, which involved the sequential closing of the Famatina basin, crustal thickening, and early exhumation of the magmatic arc and eastern basement sectors of the PT.

Sm-Nd, Rb-Sr AND K-Ar AGE CONSTRAINTS OF THE EL MOLLE AND BARROSO PLUTONS, WESTERN SIERRA DE SAN LUIS, ARGENTINA

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Within the Early Paleozoic Famatinian orogeny of Southern Sierras Pampeanas (Sierra de San Luis and Sierra de Córdoba), the post-orogenic granitoids are characterized by circular intrusions. The published Rb-Sr and K-Ar ages from plutons in the Sierra de San Luis range between 408 and 320 Ma. The El Molle and Barroso monzonitic plutons are two main exposures of a post-orogenic intrusive complex located in the western area of the Sierra de San Luis basement, and are also distinguished by a circular feature. From these plutons we obtained new Sm-Nd, Rb-Sr and K-Ar dates in order to contribute to the understanding of the magmatic and metamorphic evolution of the final stages of the Famatinian orogeny in the Sierra de San Luis. The Sm-Nd whole rock – mineral isochron yielded an age of 348 ± 25 Ma, with initial $^{143}Nd/^{144}Nd$ 0.51199 ± 0.00001, MSWD 0.3 and T_{DM} between 958 and 1137 Ma. The Rb-Sr whole rock isochron gave an age of 378 ± 48 Ma, with initial $^{87}Sr/^{86}Sr$ 0.7071 ± 0.0002, and MSWD 2.0. The K-Ar biotite date obtained from one of the granitoid rocks was 380 ± 7 Ma, whereas another K-Ar biotite date from a shear zone that cuts the pluton yielded 364 ± 7 Ma. Although these isotopic results are not totally consistent, we consider that up to now an age of about 380 Ma is the best approximation to the crystallization age, and is within the time interval of the post-orogenic granitoids of Sierra de San Luis. The younger limit for the pluton age is set by the K-Ar biotite age of 364 ± 7 Ma from a shear zone that affects the pluton, whereas the Sm-Nd isochron age of 348 ± 25 Ma is interpreted as representing another equivalent local shear zone metamorphism.

CONSTRAINTS ON THE AGES OF FAMATINIAN IGNEOUS INTRUSIONS AND SUBSEQUENT DEFORMATION IN THE SIERRA DE FIAMBALÁ (CATAMARCA/NW-ARGENTINA)

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Confined to the east by the Pampean Ranges and delimited in the west by the rocks of the Famatinian system, in between, we propose a separate zone, the so-called Las Termas belt. This unit, best exposed in the Sierra de Fiambalá near Tinogasta, comprises turbiditic metasedimentary rocks (meta-greywackes and metapelites) and calc-silicate rocks (carbonate platform sediments), and was intruded by mafic to acid igneous rocks. The sedimentary rocks, we guess, are equivalent to that of the Late Precambrian La Aguadita Formation. Igneous bodies intruding the belt should correspond to Early Ordovician and post-Devonian magmatic activity. The belt is characterized by NNW-SSE trending, long-lasting ductile shear zones. Initial work concentrates on allocating the age of the igneous bodies and on the temporal fixing of the movements along the numerous ductile shear zones. Zircon fractions of the Puntilla orthogneiss s.str. yield a lower intercept age of 467 ± 3.6 Ma, which is interpreted as the time of intrusion of the granite-gneiss. The loss of radiogenic lead in small, short prismatic zircons, as well as in separately assorted pyramidal apices, may deliver some age information of the subsequent metamorphic/deformational overprint of the rocks during the Late Silurian. The upper concordia intercept at 1268 ± 46 Ma accounts for a mixing of components, which represents the inheritance of radiogenic lead of different ages and origins. A fine-grained mylonite of the Las Termas belt was suggested to represent total isotopic rehomogenisation during deformation within the Rb-Sr mineral system. Apatite and K-feldspar yield an age of 392 ± 9 Ma, which clearly dates the deformation along the shear zone, whereas biotite and WR show a slightly younger age of 357 ± 8 Ma. The present state of age investigation supports well our concept of a separate Las Termas belt.

Rb-Sr AGES FROM LA HORQUETA FORMATION, SAN RAFAEL BLOCK, ARGENTINA

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Paleontological and geological evidence allow interpreting the San Rafael Block (SRB) as a southern extension of the Precordillera. In the eastern part of the SRB have been identified a Grenvillian basement and an Ordovician carbonate sequence at Ponón Trehué. Also Ordovician turbiditic deposits at Cerro Bola were recognized. However, the relation of other pre-Carboniferous units of the SRB with the Precordillera, e.g. La Horqueta Fm., Rio Seco de los Castaños Fm., and El Nihuil doleritic and gabbroic rocks, is controversial due to the scarce geological, paleontological and geochronological data. We present here, as part of a research project on pre-Carboniferous units of the SRB, new Rb-Sr geochronological data from the La Horqueta Formation that contribute to constrain the timing of the main deformation and low-grade metamorphism of this unit. At the Los Gateados section, in the northern part of the SRB, six whole rock samples of mica schists were analyzed. The Rb contents vary between 57 and 151 ppm, and Sr contents from 50 to 83 ppm. The isochronic Isoplot/Ex Model 3, yielded an age of 371 ± 62 Ma, with an IR: 0.7165 ± 0.0034 and MSWD: 3.7. At the La Horqueta section, near the Diamante River, seven whole rock samples were analyzed. Rb contents of the phyllites vary between 116 and 290 ppm, and Sr between 25 and 57 ppm. The Rb-Sr whole rock analysis using the Isoplot/Ex Model 1, yielded an age of 379 ± 15 Ma, with IR: 0.7151 ± 0.0026 and MSWD: 1.4. The good alignment allows admitting the straight line as a true isochron. The results obtained in this work indicate that the low-grade metamorphism and folding of the La Horqueta Formation is Devonian in age, in agreement with previous geochronological data obtained by the K-Ar method, and could be related to the Precordilleran-Chanic tectonic event.

U-Pb AND K-Ar GEOCHRONOLOGY FROM THE CERRO EMPEXA FORMATION, 1ST AND 2ND REGIONS, PRECORDILLERA, NORTHERN CHILE

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The Cerro Empexa Formation (CEF) is a regionally distributed andesitic volcanic and continental sedimentary unit exposed in the Precordillera of the 1st and 2nd Regions of northern Chile. The formation has generally been considered to lie within the Lower or "mid" Cretaceous, however, this assignment is based on scant, unreliable geochronologic data. Furthermore, there are conflicting interpretations as to whether the unit predates or postdates the first major Mesozoic shortening event affecting northern Chile. Because of the formation's presumed mid-Cretaceous age and its stratigraphic position over older back-arc sedimentary successions, the unit has been interpreted to represent products of the first eastward jump in the Andean magmatic arc from the arc's initial position in the Cordillera de la Costa.

Our mapping and field observations indicate exposures previously assigned to the CEF include two andesitic volcanic units separated by a major unconformity. The CEF proper lies above this unconformity. Two zircon fractions from an ignimbrite in the type section of the CEF (Higueritas syncline) were analyzed by the conventional U-Pb method and yielded concordant results with a weighted mean $^{206}Pb/^{238}U$ age of 68.2 ± 0.4 Ma. In the Cerros de Montecristo, 175 km south of the type section, two zircon fractions from a different ignimbrite also yielded concordant results with a weighted mean $^{206}Pb/^{238}U$ age of 65.6 ± 0.4 Ma. In the Cerros de Paqui, an andesite dike intruding the lower levels of the formation, and interpreted to be comagmatic the upper lavas, yielded a K-Ar hornblende age of 69 ± 3 Ma.

The data presented here, including high-precision U-Pb zircon geochronology, demonstrate a latest Cretaceous age (69-65 Ma) for the lower part (lower member and lower levels of the upper member) of the Cerro Empexa Formation. The unit does not represent a mid-Cretaceous magmatic arc as has been suggested, but instead represents reestablishment of Andean magmatism in the latest Cretaceous following an important Late Cretaceous shortening event.

GEOLOGY OF THE HILLS IN THE REGION OF THE CITY OF SANTIAGO DE CHILE: NEW ISOTOPIC CONSTRAINTS

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New Sr- and Nd-isotope ratios obtained from two subvolcanic samples of basaltic composition from the San Cristóbal and Santa Lucía hills (Lower to Middle Miocene) and one sample of dacitic composition from the Manquehue hill (Middle to Upper Miocene) fall in the range of 0.703710 to 0.703786 and 0.512841 to 0.512937, respectively. Since these values are similar to some OIB from the Nazca plate and E-MORB from the Chile Ridge, it is suggested that crustal contamination was not significant in the evolution of their parental magmas. New Pb-isotope data for the same samples show that they are enriched in ^{207}Pb ($^{207}Pb/^{204}Pb$ = 15.581-15.593) and have higher $^{206}Pb/^{204}Pb$ (18.446-18.472) and $^{208}Pb/^{204}Pb$ (38.317-38.366) ratios than N-MORB from the East Pacific and Chile ridges, but lower than OIB from the Nazca plate; it is suggested that material derived from the subducted oceanic crust, notably from pelagic sediments, played an important role as mantle source contaminants. On the basis of their isotopic features, petrography and age, it is concluded that the Lower to Middle Miocene basaltic rocks were generated in an extensional environment and the Middle to Upper Miocene dacitic rocks would mark the beginning of the compressional phase that affected this Andean region between the Miocene and the Quaternary.

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$^{40}Ar/^{39}Ar$ DATES IN THE CENTRAL CORDILLERA OF COLOMBIA: EVIDENCE FOR AN IMPORTANT REGIONAL TECTONOMAGMATIC EVENT IN THE UPPER TRIASSIC

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$^{40}Ar/^{39}Ar$ step-heating ages obtained for five medium-grade metamorphic rocks and three intrusive granitoids from the northern part of the Cordillera Central of Colombia indicate the existence of an important Upper Triassic tectonomagmatic event.

Most of the dates are plateau ages in micas and amphiboles, ranging from 230 to 210 Ma. Age values around 230 Ma are reported for two amphibolites occurring SE of Medellin and a biotite from the Abejorral gneiss, they are considered as resulting from a regional medium-grade metamorphism. A similar interpretation can be given for two amphiboles from the Pueblito basic alkaline rocks, traditionally associated to the Cauca ophiolitic complex. However, they yielded somewhat older ages, that could alternatively be interpreted as due to the crystallization process of the magmatic rocks.

Two $^{40}Ar/^{39}Ar$ dates were obtained on micas from the La Honda and El Buey stocks. Since their age values resulted close to 220 Ma, they may be considered as later magmatic activities. Two additional ages were obtained on deformed muscovites from the Horizontes monzodiorite, and their somewhat younger ages, close to 210 Ma, can be interpreted as related to the crystallization of this intrusion in the final stages of the same tectonomagmatic event.

In conclusion, the already available results, although in a preliminary way, seem to define an important tectonomagmatic event that affected the Central Cordillera of Colombia. It may be regionally correlated with events of similar age reported in some of the metamorphic belts of the Cordillera Real of Ecuador and northern Peru.

EVIDENCE OF PROTEROZOIC CRUST UNDER THE COASTAL CORDILLERA OF CENTRAL CHILE: GRENVILLE AGE XENOCRYSTIC ZIRCONS IN CRETACEOUS VOLCANIC ROCKS

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In the central Andes, Proterozoic basement rocks outcrop in isolated areas from beneath a Mesozoic and Cenozoic cover in southern Peru, northernmost Chile, Bolivia, and in northwestern Argentina. Their role in Andean magmatism and metallogenesis is well documented. In the southern Central Andes, Proterozoic rocks are so far known to outcrop in Argentina, east of the continental divide. In the course of U-Pb dating of the bimodal volcanic and subvolcanic host rocks for Mesozoic manto-type copper deposits, we have encountered xenocrystic zircon with Proterozoic and Paleozoic ages.

In the Punta del Cobre Cu-Fe (Au) District (27°30'S / 70°15'W), 22 km south of Copiapó, xenocrystic zircon in the Lower Cretaceous host-dacite yields ca. 1 Ga ages.

In the El Soldado Cu District, (32°38'S / 71°04'W), 120 km northwest of Santiago, scarce and strongly resorbed zircon crystals in the Lower Cretaceous host-rhyodacite yield ages of 0.5 to 1.3 Ga. The Early Cretaceous bimodal volcanic and subvolcanic rocks, which consist of primitive calc-alkaline basalts and rhyodacites, display geochemical evidence of crustal contamination. Our results suggest that, during their formation and ascent, the felsic magmas picked up zircons in the Proterozoic and Paleozoic crystalline basement of the Coastal Cordillera.

The presence of Proterozoic (Grenville age) basement underlying localities as close as 30 km from the Pacific coast has implications for the extent and age of the Chilenia Terrane and gives further credence to correlation models that juxtapose eastern North America (Laurentia) and southwestern South America (Gondwana) during the Late Proterozoic.