

The Paranapanema Lithospheric Block: Its Importance for Proterozoic (Rodinia, Gondwana) Supercontinent Theories.

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Abstract

This work considers the tectonics of the southeastern portion of the South American Platform based on new geological and geophysical grounds. For the last decade, only three (Amazonic, São Francisco and La Plata) of the many other cratonic blocks have been attributed/remarked to the South America portion for most of the usual Rodinia reconstitutions. The possibility of the existence of other blocks has rarely been mentioned. The postulation of the presence of a considerable Paleoproterozoic (pre-Brasiliano) fragment as part of Paraná Basin basement is highly probable. In order to infer the basement structure of Paraná Basin, previous to the sedimentation process, an isostatic modeling was applied to a large-scale gravity survey looking to correlate topographic and gravity anomalies caused by sub-surface loads. The Bouguer anomaly obtained from the gravity survey represents the crustal contribution of crystalline basement, in addition to the sedimentary and volcanic layers of the basin. Following the isostatic modeling and the basin load stripping, the residual anomaly allows observing similarities between the basement gravity signature and outcropping units. Besides, the stress pattern of the two earlier events obtained through the back stripping analysis presents a geographically coincident maximum, and a new E-SE high emerging for the second event, suggesting continuous change of the stress field as a precursor for South American plate rotation. The evident correlation between gravity highs and main attenuation suggests the presence of some pre-existing suture zones. The weakened lithosphere during Ordovician and Carboniferous provided the magma conduits to form in Early Cretaceous tectonic stress field pattern. The resultant mosaic of gravity blocks and the main faults site give support to the presence of this cratonic Proterozoic unit, here on referred to as the Paranapanema Block, which had been neglected in most of the models reported for the reconstruction of Gondwana (and Rodinia).

Key words: South American Platform, Paraná Basin basement, Brasiliano, Rodinia, Gondwana.

Structure, Composition and Evolution of the South Indian and Sri Lankan Granulite Terrains from Deep Seismic Profiling and Other Geophysical and Geological Investigations: A LEGENDS Initiative

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Abstract

We here argue the need for a multidisciplinary, integrated geophysical/geological survey across southern India and Sri Lanka, part of the largest exposed Neoproterozoic high-grade metamorphic terrain in the world. The purpose is to stimulate deep seismic profiling and other geophysical and geological investigations in order to better understand the structure, composition and evolution of a keystone of Precambrian continental crust and the role it played in the amalgamation and subsequent break-up of the Gondwana supercontinent. Of particular importance is that this lithospheric fragment records a 2 billion year long history of magmatism, sedimentation, deformation and metamorphism and now exposes at the surface rocks that once formed at depths of 30 km or more and that record unusually high metamorphic temperatures of up to 1000°C. Modern geophysical data should help to determine what lies underneath these high-T surface rocks and whether the terrain consists of structural distinct subunits separated by (now hidden) sutures. It is likely that the crustal-scale structures generated during the formation of the SGT may extend to other, now dispersed, segments of the Gondwana landmass and their identification in geophysical data will provide a fresh basis for reconstructing the process of supercontinent assemblage and break-up.

Key words: Seismic exploration, southern India, Sri Lanka, crustal structure, LEGENDS initiative.

Cambro-Ordovician Magmatism in SE Brazil: U-Pb and Rb-Sr Ages, Combined with Sr and Nd Isotopic Data of Charnockitic Rocks from the Varzea Alegre Complex

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Abstract

In the central-southern region of Espírito Santo State, southeastern Brazil, several granitoids with a variable composition intruded high-grade metamorphic rocks, in the northern segment of the Ribeira fold belt. A close relationship between hydrous and anhydrous facies is present in some of the plutons, including the Varzea Alegre Igneous Complex, which has an inner domain formed by gabbro, diorite and granite, and an irregular outer ring of charnockitic rocks. These green megaporphyritic charnockites have primary anhydrous mineral assemblage, I-type and metaluminous character, and high-K calc-alkaline signature. U-Pb zircon single crystal ages obtained by TIMS indicate crystallization at about 500 Ma, similar to other late tectonic plutons of this part of the Ribeira belt. Sr and Nd isotopic ratios ranging from 0.7078 to 0.7096 and 0.5114 to 0.5116 respectively, are interpreted to be indicative of a hybrid origin from crustal and mantle-derived magmas. A binary diagram using Sr isotope ratios also demonstrates that the genesis of the charnockites probably included both magma mixing and fractional crystallization processes.

Key words: Charnockites, anhydrous magma, geochronology, isotope geology, SE Brazil.

Petrogenesis of A-type Granitoids from the Alto Moxoto and Alto Pajeu Terranes of the Borborema Province, NE Brazil: Constraints from Geochemistry and Isotopic Composition

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Abstract

A-type granitoids (~512 Ma) either intruded into Paleoproterozoic gneiss of the Alto Moxoto Terrane (Prata Complex and Serra da Engabelada Pluton) or into Early Neoproterozoic metavolcanic metasedimentary sequence of the Alto Pajeu Terrane (Serrote Santo Antonio Pluton), constitute a small proportion of Brasiliano (= Pan-African) granitoids in the Central Tectonic Domain of the Borborema Province, northeastern Brazil. The Prata Complex consists of syenogranites, monzogranites, mafic enclaves of diorites and norites. The felsic and mafic members are not genetically related through fractionation. Mingling and mixing were extensive processes within the Prata Complex. The granites evolution appears to have involved fractionation of alkali feldspar, biotite, apatite and sphene without significant wall-rock assimilation. The Serra da Engabelada and Serrote Santo Antonio plutons consist of biotite syenogranites, with rare mafic enclaves. The studied granitoids are dominantly metaluminous, characterized by Fe-rich biotite and Fe-hornblende. High total alkalis, Y, Nb and REE and low CaO, MgO and Sr abundances and high FeO/(FeO+MgO) ratios characterize these granitoids. Chondrite-normalized REE patterns show enriched LREE, moderate to strong negative Eu anomalies and more or less flat heavy REE.

The studied granitoids and diabase from dykes and enclaves show negative $\epsilon\text{Nd}_{(512\text{Ma})}$ values (-14 to -10), high incompatible elements such as LILE, HFSE and REE, suggesting important contribution of Paleoproterozoic crust. The origin of the granites is thought to have involved partial melting of granodioritic or tonalitic lower crust. Such isotopic signature of the diabase from the dykes also reflects a Paleoproterozoic enriched lithospheric mantle in the area. The intrusion of the studied granitoids contemporary with sub-volcanic bimodal magmatism and deposition of many Cambrian "pull-apart" basins in the north and central tectonic Domain of the Borborema Province, suggest intrusion during post-tectonic relaxation of the Brasiliano orogeny following the assembly of West Gondwana.

Key words: A-type granitoids, Cambrian, Borborema Province, post-tectonic magmatism, magma mixing.

From Alluvial Fan to Playa: An Upper Jurassic Ephemeral Fluvial System, Neuquén Basin, Argentina

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Abstract

The Upper Jurassic fill of the back-arc Neuquén Basin includes a lowstand wedge known as the Tordillo Formation. The studied deposits crop out along a N-S oriented belt that runs parallel to the Andean magmatic arc. They are limited to the south by the east-west oriented positive structure of the Huincul arch formed as a result of Upper Jurassic tectonic inversion. The Tordillo deposits were formed in an arid fluvial-dominated system characterised by systematic downstream changes in architectural style. A gravelly and sandy bedload fluvial system is recognised in the southern upstream sector. The reduced thickness and the coarse grain size suggest steep gradients, excess of bedload supply and a low subsidence rate. Thicker and finer-grained deposits prevail to the north and northeast. They were formed under arid conditions in a wadi-sand flat-playa fluvial system. This distal facies association indicates increased accommodation owing to high rates of subsidence relative to coarse siliciclastic sedimentation rates. These low-gradient deposits are characterised by cyclic alternations of mud-dominated and sand-dominated packages interpreted as high- and low-accommodation systems tracts. The overall fining upward stacking pattern of the Tordillo Formation suggests a change towards higher accommodation rates. This is accompanied by frequent development of soil horizons and darker primary and reworked pyroclastic deposits. These attributes indicate a stronger explosive volcanic activity associated with increased precipitation and high water table emplacement towards the end of the Tordillo lowstand wedge.

Key words: Argentina, Neuquén Basin, Jurassic, fluvial sedimentology, facies models.

Amphibole $^{40}\text{Ar}/^{39}\text{Ar}$ Geochronology from the Okcheon Metamorphic Belt, South Korea and its Tectonic Implications

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Abstract

An understanding of the Okcheon Metamorphic Belt (OMB) in South Korea is central to unraveling the tectono-metamorphic evolution of East Asia. Amphibole-bearing rocks in the OMB occur as calcsilicate layers and lenses in psammitic rocks, in the psammitic rocks themselves, and in the mafic volcanic layers and intrusives. Most amphiboles fail to show $^{40}\text{Ar}/^{39}\text{Ar}$ plateau ages; those that do have ages ranging from 132 to 975 Ma. The disturbed age pattern and wide variation in $^{40}\text{Ar}/^{39}\text{Ar}$ ages can be related to metamorphic grade, retrograde chemical reactions, excess Ar and amphibole composition. The oldest age (975 Ma) can be interpreted either as an old igneous or metamorphic age predating sedimentation or a false age caused by excess Ar. The youngest age of 132 Ma and the disturbed age pattern found in amphiboles from rocks located close to Jurassic granitoids are the result of retrograde thermal metamorphic effects accompanying intrusion of the granitoids. Some medium- or coarse-grained amphiboles in the calcsilicates are aggregates of fine-grained crystals. As a result, they are heterogeneous and prove to be readily affected by excess Ar. A disturbed age pattern in amphiboles from the calcsilicates occurring in the high-grade metamorphic zone may also be the product of excess Ar. On the other hand, the disturbed pattern of amphiboles present in the calcsilicates from the low-grade metamorphic zone could arise from both excess Ar and mixed ages. However, amphiboles from psammitic rocks and some calcsilicates in the high-grade metamorphic zone and in intrusive metabasites display real plateau ages of 237 to 261 Ma. The temperature conditions in the high-grade metamorphic zone were higher than the argon closing temperature for amphibole, and the amphiboles in this zone give plateau ages only when they are homogeneous in composition, lack excess Ar, and have not been thermally affected by intrusion of the granitoids. The unmodified $^{40}\text{Ar}/^{39}\text{Ar}$ ages prove rather younger than the age of the Late Paleozoic metamorphic event of 280 to 300 Ma, but they are close to muscovite K-Ar ages of 263 to 277 Ma. These $^{40}\text{Ar}/^{39}\text{Ar}$ amphibole ages are interpreted as the time of cooling that followed the main regional, intermediate-P/T metamorphic climax. The results demonstrate that interpretation of $^{40}\text{Ar}/^{39}\text{Ar}$ amphibole ages in an area subjected to several metamorphic events can be accomplished only by undertaking a thorough tectono-metamorphic study, accompanied by detailed chemical analysis of the amphiboles.

Key words: Okcheon Metamorphic Belt, amphibole-bearing rocks, $^{40}\text{Ar}/^{39}\text{Ar}$ amphibole age, excess Ar, cooling age.

Alkaline Magmatism Versus Collision Tectonics in the Eastern Ghats Belt, India: Constraints from Structural Studies in the Koraput Complex

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Abstract

Linear domains of deformed alkaline rocks and carbonatites have recently been identified as representing sites of ancient suture zones. In peninsular India, the western margin of the Proterozoic Eastern Ghats Belt (EGB) is characterized by a series of alkaline plutons that are aligned close to the contact with the Archaean Craton. Most of the complexes were deformed and metamorphosed during a subsequent orogenic event. Unlike other plutons in the belt, the alkaline complex at Koraput reportedly escaped deformation and granulite facies metamorphism forming an anomalous entity within the zone. Multiply-deformed country rocks hosting this complex underwent syn- D_{1CR} granulite facies metamorphism followed by D_{2CR} thrusting, with pervasive shearing along a NE-SW trending foliation. A second granulite facies event followed localized D_{3CR} shearing. Within the Koraput Complex, strain partitioning was responsible for preserving igneous textures in the gabbroic core, but aligned magmatic amphibole needles and plagioclase laths occasionally define a S_{1AC} fabric. Along the margins, S_{1AC} is rotated parallel to a NE-trending, east-dipping S_{2AC} fabric in the gabbro, fringing syenodiorite and nepheline syenite bands. Locally, D_{3AC} shearing follows D_{2AC} deformation; S_{2AC} and S_{3AC} parallel S_{2CR} and S_{3CR} in the country rocks. High-grade metamorphism represented by recrystallization of amphibole and plagioclase, and breakdown of amphibole and biotite to garnet, pyroxene and K-feldspar in the complex follows D_{3AC} . Unlike earlier reports, therefore, the Koraput body is also deformed and metamorphosed. The aligned alkaline complexes in the EGB probably represent deformed alkaline rocks and carbonatites formed by rifting related to an earlier episode of continental break-up that were deformed during subsequent juxtaposition of the EGB with the Archaean Craton. This supports the contention that the western margin of the EGB and its contact with the Archaean Craton is a suture zone related to the Indo-Antarctica collision event.

Key words: Eastern Ghats Belt, alkaline magmatism, Koraput Complex, deformation, granulite-facies metamorphism.

Geochemistry and Origin of Neoproterozoic Granitoids of Meghalaya, Northeast India: Implications for Linkage with Amalgamation of Gondwana Supercontinent

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Abstract

Many granitic bodies intrude the basement gneisses in Meghalaya Plateau, Northeast India. Rb–Sr whole-rock isotopic ages of the granitoids range from 881 to 479 Ma while the ages of the basement orthogneisses vary from 1714 to 1150 Ma. All the plutons are dominantly metaluminous and show geochemical variation. Oxygen isotopic compositions in the granitoids and gneisses are concordant ($\delta^{18}\text{O}$: + 5.78‰ to + 8.70‰). However, the gneisses from high-grade terrain have low $\delta^{18}\text{O}$ value of +2.52‰ to +5.31‰. Initial $^{87}\text{Sr}/^{86}\text{Sr}$ (I_{Sr}) ratios of the plutons vary from 0.70459 to 0.71487 and tend to increase with progressive younging in age. The geochemical characters suggest derivation of the granites from lower crustal source. The fractionated rare earth patterns observed in the granitoids can be obtained by partial melting of gneisses or diorites. Some gneiss samples have experienced interaction with hydrothermal fluids resulting in lowering $\delta^{18}\text{O}$. The isotopic ages of granite plutonism in Meghalaya are similar to the plutonic and tectonothermal events in other parts of India, southwestern Australia and document final amalgamation events of the Gondwana Supercontinent.

Key words: Neoproterozoic granite, oxygen isotope, petrogenesis, Meghalaya, Northeast India.

Deformation Style of Slickenlines on Mélange Foliations and Change in Deformation Mechanisms Along Subduction Interface: Example from the Cretaceous Shimanto Belt, Shikoku, Japan

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Abstract

Accretionary complexes record the histories of changes in physical properties of sediments from unlithified sediments to lithified rocks through the deformation processes along subduction interface. The trench sediment suffered various deformation of particulate flow, pressure solution deformation and cataclastic faultings from ductile to brittle regime during accretion in subduction zone. Tectonic *mélange* is a characteristic rock in on-land accretionary complexes. The dominant deformation mechanism of tectonic *mélange* formation is pressure solution on the basis of microscopic observation. However, brittle slickenlines are also commonly observed on *mélange* foliations at the outcrop scale. Although the slickenlines as a brittle failure is common on the surface of the pressure solution foliation, the relationship of their kinetic are still uncertain. Detailed observations of slickenlines suggest that they are formed by reactivation of the *mélange* foliations, which indicates that the slickenlines are developed after formation of block in matrix texture characterized in *mélange*. In addition, *mélange* foliations are cut by faults related to underplating of oceanic materials. Therefore, formation of slickenlines occur before underplating in a relatively deep portion along subduction interface. On the basis of P-T conditions reported from other parts of the Cretaceous Shimanto Belt, the *mélange* formation and underplating is inferred to have occurred around the seismic front or within the seismogenic zone. The change in deformation mechanisms from pressure solution to brittle failure may be the first change in physical properties from plastic to brittle around seismic front.

Key words: *Mélange*, accretionary complex, deformation mechanism, Shimanto Belt, Japan.