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Were the Deccan Flood Basalts Derived in Part from Ancient Oceanic Crust Within the Indian Continental Lithosphere?

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Abstract

Deep mantle plumes supposedly incorporate deeply subducted eclogitized oceanic crust, and continental flood basalts (CFBs) are now thought by some to be derived from such eclogite-bearing peridotite plumes. Eclogite-peridotite mixtures have much lower solidi (and produce much greater melt fractions for a given temperature) than peridotite. Fe-rich (eclogite- or pyroxenite-bearing) sources have been inferred for many CFBs. However, plumes with considerable amounts of eclogite should have difficulty in upwelling owing to the high density of eclogite. Besides, CFBs are always located along pre-existing lithospheric structures (suture zones, edges of thick cratons) and commonly associated with lithospheric rifting and continental breakup. India's major late Mesozoic CFB, the Deccan Traps, erupted through rift zones and a new continental margin that had developed along ancient suture zones traversing the subcontinent. Many Deccan basalts are too Fe-rich to have been in equilibrium with a peridotite mantle source, and have commonly been considered to be significantly fractionated derivatives of picritic liquids. However, it is possible to view them as relatively less evolved liquids derived from a source with extra fertility (i.e., an Fe-rich source). A new non-plume, plate tectonic model for Icelandic hotspot volcanism involves melting of a shallowly recycled slab of eclogitized Iapetus oceanic crust formerly trapped along the Caledonian suture. The model explains the geochemical-petrological characteristics of Icelandic basalts, and is consistent with passive upper mantle upwelling under Iceland inferred from recent seismic tomography. Based on the petrological and geochemical features of the Deccan flood basalts of the type section, in the Western Ghats, I propose that old, eclogitized oceanic crust trapped in the ancient Indian suture zones could have produced voluminous basaltic melts during the Deccan event.

Key words: Deccan volcanism, flood basalt, Iceland, eclogite, mantle plume.

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Geochronological Constraints on Evolution of Singhbhum Mobile Belt and Associated Basic Volcanics of Eastern Indian Shield

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Abstract

The Singhbhum Mobile Belt (SMB) of the eastern Indian shield represents a roughly east-west-trending arcuate belt of folded supracrustals overlying the granite-greenstone basement of the Singhbhum-Orissa Craton along its northern, eastern and western margins and is bounded by the Chotanagpur Gneissic Complex to further north. The radiometric ages of the basement Singhbhum and equivalent granites and the intrusive anorogenic Mayurbhanj granite pluton constrain the time of evolution of this mobile belt between ~3.12 and 3.09 Ga. Hence, the SMB supracrustals also known as Singhbhum Group, is late Mesoarchaean in age and not Proterozoic as thought earlier. The evolution of the SMB was followed by emplacement of some major basic igneous rocks within or adjacent to the supracrustals. These include Simlipal volcanics at ~>3.09 Ga on the SMB, Mayurbhanj gabbro along with Mayurbhanj granite at ~3.09 Ga along the marginal part of the craton near the SMB, and the Dalma volcanics on the SMB along with the Dhanjori volcanics adjacent to SMB at ~2.80 Ga. The ~ 2.80 Ga old basic volcanics is also associated with emplacement of some small granite plutons occurring along the marginal part of the craton, one of them, the Tamperkola granite intrudes the SMB. The ~>3.09 Ga onward igneous activities along the marginal part of Singhbhum-Orissa Craton took place essentially under anorogenic tectonic setting before being affected by a major metamorphism at ~2.50 Ga, which is recorded on the Dalma volcanics and on some small granite pluton occurs along the marginal part of the craton. The Jagannathpur and stratigraphically equivalent Malangtoli volcanics, occurring within the Singhbhum-Orissa Craton at the west, were erupted at ~2.25 Ga. The boundary between the SMB supracrustals and the Singhbhum-Orissa Craton is demarked by a prominent shear zone known as the Singhbhum Shear Zone, which shows multiple reactivation, the oldest being at ~3.09 Ga, followed by subsequent reactivation during Palaeo- and Mesoproterozoic periods at ~2.2, 1.8, 1.6–1.5, 1.4 and 1.0 Ga respectively. The Singhbhum Group and the adjacent Chotanagpur Gneissic Complex appear to have evolved from a near shore syn-rift and a distal post-rift stable shelf sedimentary assemblages respectively, which were deposited without any stratigraphic break in a marine basin existed in the present north of the Singhbhum-Orissa Craton. Both of these assemblages were deformed and metamorphosed together during Proterozoic at ~2.5 to >2.3 Ga, ~1.6 Ga and ~1.0 Ga.

Key words: Singhbhum-Orissa Craton, Singhbhum Mobile Belt, Singhbhum basic volcanics, Chotanagpur Gneissic Complex, Late Archaean crustal growth.

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Geochemistry and Crustal Evolution of Volcano-sedimentary Successions and Orthogneisses in the São Gabriel Block, Southernmost Brazil – Relics of Neoproterozoic Magmatic Arcs

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Abstract

Precambrian metaplutonic rocks of the São Gabriel block in southernmost Brazil comprise juvenile Neoproterozoic calc-alkaline gneisses (Cambaí Complex). The connection with associated (ultra-)mafic metavolcanic and metasedimentary rocks (Palma Group) is not well established. The whole complex was deformed during the Brasiliano orogenic cycle. Both metasedimentary and metavolcanic rocks as well as metaplutonic rocks of the Cambaí Complex have been sampled for geochemical analyses in order to get constraints on the tectonic setting of these rocks and to establish a tectonic model for the São Gabriel block and its role during the assembly of West-Gondwana. The major element compositions of the igneous rocks (Palma Group and Cambaí Complex) indicate a subalkaline character; most orthogneisses have a calc-alkaline chemistry; many metavolcanic rocks of the Palma Group show signatures of low-K tholeiitic volcanic arc basalts. Trace element data, especially Ti, Zr, Y, Nb, of most igneous samples from both the lower Palma Group and the Cambaí Complex indicate origin at plate margins, i.e., in a subduction zone environment. This is corroborated by relative enrichment in LREE, low contents of Nb and other high field strength elements and enrichment in LILE like Rb, Ba, and Th. The data indicate the possible existence of two suites, an oceanic island arc and a continental arc or active continental margin. However, some ultramafic samples of the lower Palma Group in the western São Gabriel block indicate the existence of another volcanic suite with intra-plate character which possibly represents relics of oceanic island basalts (OIB). Trace element data indicate contributions from andesitic to mixed felsic and basic arc sources for the metasedimentary rocks. The patterns of chondrite- and N-MORB-normalized spider diagrams resemble the patterns of the igneous rocks, i.e., LILE and LREE enrichment and HFS depletion. The geochemical signatures of most igneous and metasedimentary samples and their low $(^{87}Sr/^{86}Sr)_t$ ratios suggest only minor contribution of old continental crust.

A geotectonic model for the São Gabriel block comprises east-ward subduction and following accretion of an intra-oceanic island arc to the eastern border of the Rio de la Plata Craton at ca. 880 Ma, and westward subduction beneath the newly formed active continental margin between ca. 750 and 700 Ma. The São Gabriel block represents relics of an early Brasiliano oceanic basin between the Rio de la Plata and Kalahari Cratons. This ocean to the east of the Rio de la Plata Craton might be traced to the north and could possibly be linked with Neoproterozoic juvenile oceanic crust in the western Brasília belt (Goiás magmatic arc).

Key words: Geochemistry, Neoproterozoic, arc magmatism, Brasiliano orogenies, São Gabriel block.

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Tectonic Control of the Triassic Santa Maria Supersequence of the Paraná Basin, Southernmost Brazil, and its Correlation to the Waterberg Basin, Namibia

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Abstract

The Middle and Late Triassic Santa Maria Basin, exposed in southernmost Brazil, and Waterberg Basin, in Namibia, are herein interpreted as part of *en échelon* small basins in southern West Gondwana. The main structures are the Waterberg-Omaruru Fault which can be connected to a NW-strike anastomosed fault zone in Brazil. Based on field structural and stratigraphic analysis two populations of NW-strike fractures, named A-type and B-type, are recognized. A-type fractures (Az = 280°–290°) occur in the Sanga do Cabral Supersequence, underlying units of Santa Maria Basin, as extension of the Waterberg-Omaruru Fault during the Early Triassic. B-type fractures (Az = 295°–345°) are observed in all studied stratigraphic units, from the Triassic Sanga do Cabral Supersequence to the Early Cretaceous Botucatu/Serra Geral formations. Based on the structural analysis we propose that NNE-SSW extension reactivated structures of the Damara Belt, Namibia, with a propagation towards Rio Grande do Sul State forming an anastomosing normal fault system and related-rift basin by Early-Middle Triassic time. The A-type fractures were preferentially active by this phase and the B-type ones are interpreted as secondary link segments within the anastomosing system. During the Gondwana break-up and South Atlantic opening (rift to proto-oceanic phase, Aptian) the B-type fractures were reactivated as normal faults by N50°E–S50°W extension.

Key words: Triassic, Santa Maria Supersequence, Waterberg-Omaruru Fault, Waterberg Basin, fracture analysis.

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Paleoproterozoic Crustal Evolution of the São Luís Craton, Brazil: Evidence from Zircon Geochronology and Sm-Nd Isotopes

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Abstract

The São Luís Craton, northern Brazil, is composed of a few granitoid suites and a metavolcano-sedimentary succession. New single zircon Pb evaporation ages and Nd isotope data, combined with other available information, show that the metavolcano-sedimentary succession developed from 2240 Ma to approximately 2200–2180 Ma from juvenile protoliths. The subduction-related calc-alkaline suites of granitoids, spatially associated with the metavolcano-sedimentary sequence, formed in an oceanic island arc setting between 2168–2147 Ma. Most of these granitoids are tonalitic and formed from juvenile, mantle- or oceanic plate-derived protoliths, whereas minor true granites are the product of the reworking of the juvenile island arc material. These arc-related successions represent an accretionary event around 2.20±0.05 Ga, which is coincident with one of the main periods of crustal growth in the South American Platform. This accretionary orogen has subsequently been involved in a collision episode, at ca. 2100–2080 Ma, which is mainly recorded in the nearby Gurupi Belt. The rock associations, inferred geological settings, and the crustal evolution detected in the São Luís Craton are similar to what is described in Paleoproterozoic domains of major geotectonic units of the South American Platform, such as part of the São Francisco Craton, southeastern Guyana Shield, and of the West African Craton.

Key words: São Luís Craton, Paleoproterozoic, geochronology, Nd isotopes, crustal growth.

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Facies and Architecture of a Carboniferous Grounding-line System From the Guandacol Formation, Paganzo Basin, Northwestern Argentina

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Abstract

New outcrops of Middle Carboniferous glacigenic deposits found in the Guandacol Formation (western Paganzo Basin) are described in this paper. The study locality of Los Pozuelos Creek (northwestern Argentina) includes coarse-grained diamictites, rhythmites, laminated pebbly mudstones and shales that represent an expanded column of the Gondwanic glaciation in this region. Thirteen lithofacies recorded at the measured section have been grouped into three facies associations. Facies Association I is composed of coarse-grained massive and stratified diamictites (lithofacies Dmm, Dms, Dmg, Dcs), laminated siltstones with dropstones (Fld) and interstratified sandstones and mudstones (Fl, Sr). These rocks represent both tillites and resedimented diamictites closely associated to small water bodies where laminated siltstones with dropstones and stratified sandstones and mudstones were deposited. Facies Association II comprises couplets of matrix-supported thinly bedded diamictites (Dmld) and laminated mudstones with dropstones (Fld). This facies association results from the combination of three different processes, subaqueous cohesionless debris flows, coeval rainout of ice-rafted debris and settling of fine-grained particles from supension. Finally, Facies Association III is made up of laminated mudstones without dropstones, thin marl levels and scarce fine- to very fine-grained sandstones. This assemblage clearly suggests sedimentation in a deep marine environment below the wave base.

The architecture of the glacigenic deposits has been investigated using photomosaic panels. The geometry of the depositional bodies and facies suggest that Los Pozuelos Creek outcrops exhibit a well preserved three-dimensional example of a grounding-line system. In particular, three different subenvironments of a morainal bank were interpreted: a bank-front, a bank-core and a bank-back. The bank-front assemblage is characterized by coarse-grained, mainly resedimented, diamictites grading laterally to prograding clinoforms composed of interbedded matrix-supported thinly bedded diamictite and mudstones. The bank-core assemblage is formed by a stacking of coarse-grained diamictites where at least five major erosional surfaces, bounding four multistory diamictite bodies, can be recognized. Finally, the bank-back assemblage corresponds to discontinuous intervals of striated lodgement till, and coarse-grained resedimented diamictites showing important post-depositional deformation. The retrogradational stacking of the morainal banks indicate an overall glacial retreat and a glacioeustatic sea-level rise. Erosional surfaces at the base of each morainal bank suggest intervening short term episodes of ice advance.

The new data presented here confirm the existence of "true" tillites in western Paganzo Basin and suggest several (at least four) pulses of glacial advance and retreat during the Namurian glaciation in the region and permit a more refined interpretation of the glacial deposits in the Huaco area.

Key words: Gondwanic glaciation, northwestern Argentina, grounding-line system, morainal banks, Carboniferous.

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Gold Mineralization in Kottathara Prospect, Attappadi Valley, Kerala, India: a Preliminary Appraisal

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Abstract

The Kottathara gold prospect of Attappadi Valley in Kerala is located within the Southern Indian Granulite Terrain comprising charnockite and gneisses with enclaves of high-grade supracrustals. The gold mineralization associated with the basic members of the Attappadi supracrustals and the quartz veins traversing them are confined within the Bhavani Shear Zone. Primarily the gold-quartz lode is emplaced in rheologically preferred zones along the contact of the basic members with the enclosing gneisses subsequent to a period of retrogression and shearing. Ore-mineralogical studies reveal that gold got remobilized and this remobilization is identified with the regional Bhavani Shear. SEM studies indicate that gold occurs in free state and also within sulphides especially pyrite. Variation in grain morphology is clearly discernible in gold occurring within oxidised and in non-oxidised zones.

Sequencing of deformational events with associated emplacements of known ages suggests the age of gold mineralization of Attappadi area as between 2 Ga. and 2.5 Ga. The secondary mobilization has to be <2.0 Ga or younger possibly of younger Pan-African age related with the Moyar-Bhavani Shear System. The inherent gold content of the komatiitic metapyroxenites together with the auriferous quartz lodes assigns a lithological control on gold mineralisation. Subsequent folding and remobilization due to the regional shear constrained the geometry of the lode zones implying structural control.

Key words: Gold mineralisation, early Proterozoic, structural-cum-stratigraphic control, Attappadi Valley, South India.

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Morphology and Chemistry of Placer Gold from Attappadi Valley, Southern India

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Abstract

We report the morphological, textural and chemical characteristics of gold grains in stream gravels from the Siruvani River in Attappadi Valley, southern India. The placer gold deposits contain both primary grains with jagged grain contours and secondary grains with smooth grain margins. The primary and secondary gold grains are also distinguished by marked contrast in microtextures with the latter displaying a range of corrosion textures including striations, etch pits and chemical corrosion cavities that coalesce to form honey-comb patterns. Some of these cavities are filled with fine clay derived from lateritic weathering front. While the primary grains are characterized by high silver content (up to 35.77 wt.%) with marginal overgrowths of high purity gold, the secondary grains show exceedingly high fineness (1000 Au/Au+Ag) levels (up to 984) with no marked compositional variation indicating selective extraction of Ag and/or reprecipitation of Au. From morphological and chemical characteristics, we propose that the high purity gold grains were not derived directly from primary sources, but underwent chemical refinement in the weathering front before they were transferred to the fluvial systems. Our findings have important implications for gold exploration in the Attappadi Valley.

Key words: Placer gold, morphology, chemistry, lateritic weathering front, Attappadi Valley.

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Mineralogical Characterization of Graphite Deposits from Thodupuzha-Kanjirappally Belt, Madurai Granulite Block, Southern India

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Abstract

Graphite from deposits occurring in the high-grade metamorphic rocks and their larteritized equivalents of the Thodupuzha-Kanjirappally Belt in Madurai Granulite Block, southern India is structurally fully ordered (crystallite size, $Lc_{(002)}$ ranging from 469 to 749 Å), possess high degree of graphitization (DG value ranging from 105 to 267 Å) and reflect crystallization at high temperature (700±100°C). Raman spectra of graphite display profiles corresponding to high crystallinity and high structural ordering. The high temperature crystallinity characteristics of graphite were not obliterated during retrogression of granulites to amphibolite facies gneisses. Preliminary carbon stable isotope results show a spread in isotope values from –11.8 to –26.8 ‰, which suggest more than one sources for carbon. The lighter carbon isotope values are suggestive of biogenic origin, whereas the heavier ones are probably fluid precipitated graphite.

Key words: Graphite, XRD, Raman spectra, carbon isotopes, southern Indian granulites.

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Storm Event Beds in a Paleoproterozoic Rift Basin, Aravalli Supergroup, Rajasthan, India

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Abstract

Storm event beds in the Paleoproterozoic riftogenic sedimentary succession of Aravalli Supergroup are described from a 12.8 m-thick sandstone-mudstone interbedded unit in Zawar area, Rajasthan, India. The storm event beds include different primary structural assemblages indicating deposition from waning storm current. Sequential arrangement of beds with characteristic primary structural assemblages suggests deposition under a transgressive phase, and overall retrogradational evolution of the storm-succession provides evidence in favour of faster downsagging of the basin floor. The Pb-Zn sulphide ore bearing sedimentary succession of Zawar records repeated downsagging and exhumation of the basin floor in the frame of continental rift tectonics.

Key words: Storm event beds, Paleoproterozoic, Aravalli Supergroup, retrogradational, rift-basin.