

Crustal Evolution of the Archean Formiga province (APP), southern São Francisco Craton, Brazil.

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The APP is characterized by medium to high-grade terranes (MHT) mainly metamorphosed to amphibolite grade, and associated greenstone belts. The former are made up of orthogneisses with granodioritic composition, granitoids, migmatites and subordinate amphibolites. The greenstone sequences occur as tightly deformed relicts within the MHT, some of them contain graphite rich metasediments. Structurally, these relicts may partially surround the MHT resembling domal features, interpreted as dismantled gneissic domes. The Plumit greenstone is probably an extension of the Province westwards, however it crops out in an overthrust structure within the Late Proterozoic Barbul sedimentary platform cover.

Available isotope data on the MHT and Plumit greenstone evidenced that the crustal evolution took place from 3.2 to 2.6 Ga ago (Rb-Sr and Pb-Pb whole rock isochrons). Coherent low Sr initial ratios (0.7001) and upper mantle-type μ_1 value (8,18) on orthogneiss and migmatite, and U-Pb zircon age on metavolcanics of this greenstone suggest that continental growth by differentiation of the upper mantle occurred from 3.2 to 3.0 Ga ago. This event was followed by reworking processes at c. 2.8-2.6 Ga ago, as also supported by the Sr and Pb isotope evidences. The above geochronological pattern of the investigated area combined with available radiometric data over the southern São Francisco Craton is consistent with the existence of several age distinct fragments which suffered progressive agglutination during the Late Archean.

Additionally the APP exhibits a complex thermal history due to an Early Proterozoic belt (2.4-2.1 Ga.) which developed along its eastern border. Biotite and amphibole K-Ar ages record a widespread thermal overprinting episode over the MHT dated at 2.1-1.9 Ga, and related to the cooling of the Transamazonian cycle. $^{40}\text{Ar}/^{39}\text{Ar}$, on biotites and amphibole yielded plateau ages in the range 2.04-1.88 and at 2.2 Ga., respectively. The latter age may estimate the cooling age of the amphibolite prior to the Transamazonian cycle; the biotite ages the variable intensity of the partial overprinting of this cycle over the Archean rocks. Finally, geological constraints combined with the geochronology demonstrate that during Late Proterozoic times the southern São Francisco Craton (including the Formiga province) acted as a stable foreland for the surrounding Brasiliano belts.

Evolution of the Archaean of Central Africa

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Archaean terrains of Central Africa are exposed as series of basement windows through cover rocks of ages ranging from Proterozoic to Phanerozoic. They consist of the Tanzania craton, the West Nile gneissic complex, the granite-greenstone belt, the Bomu complex, the Ntem complex, the Chaillu massif and the Kasai-Angola craton.

The oldest rocks in that region indicate that the crust in the southern and eastern part was continental while the northern part was oceanic. The continental crust evolved through complex events of sedimentation, volcanism, deformation and regional metamorphism before 3.5 Ga. The relict of continental nuclei is represented by the Kapanga-Sandoa complex in the south of the region, in which the earliest recognizable tectono-metamorphic event has been dated around 3.5 Ga.

The basement complex of Central Africa formed from many crustal elements over a substantial period of time of around 1000 Ma by processes not yet well understood. In spite of local complexities, two main "orogenic cycles" were registered in the whole regions. They are separated by a general fracturing period (3.2 - 3.0 Ga) of the crust and the formation of intracratonic rifts in which greenstone belts evolved.

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Rb-Sr and K-Ar geochronology of the Uauá mafic dyke swarm, north-eastern São Francisco Craton, and their tectonic significance.

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The Uauá mafic dyke swarm (UDS) is intruded into polycyclic Archean to Lower Proterozoic gneissic-migmatite terranes of medium to high grade of metamorphism. The UDS is subdivided into two groups on the basis of field relationships, mineral composition and geochemistry. Both groups have been variably affected by metamorphism and shearing.

Original rocks from the 1st group of dykes still preserve ophitic textures, and are mainly composed of aggregates of scarce twinned plagioclase, two pyroxenes, minor hornblende and opaques. The metamorphosed dykes are foliated and folded and are composed of andesine and hornblende along with minor opaques, apatite, quartz and scarce sphene. Similarly as the 1st group the 2nd one (85% of the studied dykes) includes dykes showing preserved ophitic to sub-ophitic textures. These ones usually have hornblende bordering pyroxenes and incipient polygonization of the pyroxene. With the increase in metamorphic intensity the igneous textures are partially modified, and the plagioclase and hornblende-quartz aggregates are largely recrystallized.

Rb-Sr mineral isochrons on the both groups of dykes less affected by metamorphic overprint yielded c. 2.5 Ga (for the 1st group) with low $^{87}\text{Sr}/^{86}\text{Sr}$ initial ratios (-0.701-0.702), and about 2.1 Ga (2nd group) with high initial ratios (-0.703-0.706). Sr-Nd isotopes evidence that these younger dykes may be derived from a more enriched, heterogeneous mantle-source (plus minor crustal contamination) than the older one. Additional K-Ar on amphiboles from the metamorphosed dykes yielded ages in the range 2.14-1.91 Ga. These ages are consistent with the regional cooling history of the Transamazonian cycle, as similarly defined for most of the basement rocks of the Craton.

From the above the ~2.5 Ga dykes may be associated with the Archean-Early Proterozoic transitional evolution, prior to the development of the Lower Proterozoic belts bordering the Archean fragments of the Craton. The ~2.1 Ga dykes are probably associated with the Lower Proterozoic Itabuna magmatic arc, and their emplacement occurred during the connected preceding distension event of the crust. Eventually these dykes together with the oldest ones were variably metamorphosed and sheared due to such a collisional tectonics.

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The tectono-thermal evolution of the Archean Barberton greenstone belt, South Africa

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Significant progress in structural, stratigraphic and geochronological studies over the last 10 years within the ~3.1-3.5 Ga Barberton greenstone belt (BGB), has enabled tighter constraints to be made on the tectono-thermal evolution of the belt. Rocks in the BGB span a local tectono-thermal history of at least 400 Ma, and have been affected by regional thermal perturbations for over 1500 Ma. Early events (3490-3450 Ma) are recorded as MOR-like tectono-thermal processes. These are followed by two arc-trench-like related processes separated by ~200 Ma. Collisional-like processes occurred between ~3230 Ma and 3080 Ma. Thereafter, the terrain was probably extended, thermally disturbed, and mineralized with gold during a more regional tectonic extensional period during the onset of formation of the Witwatersrand basin at ~3070 Ma.

Early, D₁-related deformation is recognized predominantly in the southern parts of the BGB and has been constrained in age by U-Pb zircons to be between 3427 ± 3 and 3229 ± 3 Ma in the north-central part of the belt. D₂ only affects Overwacht and Fig Tree Group rocks. Along the eastern and western edges of the BGB, D₂-related deformation becomes more apparent and today dominates geology map patterns of the belt. This deformation is responsible for the open synclines, tight antiforms and related thrusting, as well as a significant strike-slip component. In the western part of the BGB, early D₃ deformation is >3164 ± 12 Ma while late D₃ deformation is >3084 Ma. All the main stratigraphic Groups of the BGB are affected by D₃ deformation with the coarse clastics, quartzites and conglomerates of the stratigraphically highest Group, the Moodies Group, syn-tectonic in their origin. Structural studies have shown gold mineralization in the BGB to be late D₃ in timing, consistent with U-Pb zircon/rutile ages which constrain the main gold mineralizing event in Barberton to be between 3126 ± 21 and 3084 ± 18 Ma. Late, D₄-related deformation re-folds earlier F₃ folds and is also associated with strike-slip faults.

$^{40}\text{Ar}/^{39}\text{Ar}$ studies on mineral separates from granitoid rocks surrounding the BGB, and from mafic-ultramafic rocks and sediments from within the belt, have enabled constraints to be made on thermal conditions pertaining to the Barberton region. Amphiboles (with blocking temperatures of ~650 °C) from Overwacht Group volcanics provide evidence of seafloor metamorphism at 3489 ± 68 Ma i.e. soon after the extrusion of the rocks. Muscovites and biotites (with blocking temperatures of ~300 °C) from several granitoids adjacent to the BGB have $^{40}\text{Ar}/^{39}\text{Ar}$ reset ages of ~2600 Ma. Similarly, sediments such as barite from within the BGB (with blocking temperatures of ~200 °C) show $^{40}\text{Ar}/^{39}\text{Ar}$ reset ages at ~2700 Ma and more commonly at 2025-2090 Ma, coincident with large-scale, regional, thermal perturbations in the Kaapvaal Craton. Thus, rocks of the lower (Overwacht Group) part of the BGB stratigraphy have not been exposed to temperatures >650 °C since time of their formation (i.e. 3490-3440 Ma) but have been overprinted by thermal anomalies >200 °C up to 2025-2090 Ma ago.

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Metamorphogenic, shear zone related light carbon isotopes from the Archean Sukumaland Greenstone Belt, NW-Tanzania.

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The Sukumaland Greenstone Belt is situated S of Lake Victoria and forms part of the Tanzanian Craton. The belt consists of an association of Nyanzian basalts, gabbros, banded iron formations, felsic tuffs and flows and carbon-rich sediments, topped by Kavirondian sediments. Numerous granitoids intrude the above sequence.

Carbon rich horizons (total organic carbon 0.1 to 3.5%) show an extreme spread in isotopic composition. A first group of moderately sheared, partly silicified, very fine-grained sediments, very low in metamorphic grade, displays $\delta^{13}\text{C}_{\text{org}}$ in the range of -24 to -29 ‰. A second group of extremely sheared sediments of low metamorphic grade exhibit uncommon $\delta^{13}\text{C}_{\text{org}}$ between -37 and -56 ‰.

The extremely low $\delta^{13}\text{C}$ values can only be explained by fixation of ^{13}C -rich carbon from methane in the sediments. Methane fixation is known to occur directly via methylotrophic bacteria or indirectly via CO₂ due to the oxidation of CH₄, by common autotrophs. A new model is proposed in the paper.

A relative depletion in ^{13}C can occur, if a considerable amount of metamorphogenic methane-derived light isotope carbon is added to the organogenic carbon in the sediments via an intersecting polyactuated shearzone.

The originally ^{13}C enriched CH₄, derived from sediments related to the above mentioned first group, underwent open system isotopic fractionation by selective removal of ^{13}C incorporated in CO₂ or graphite due to continuously changing fO₂ conditions during migration, leading to a shift in $\delta^{13}\text{C}$ from originally heavier than -30 ‰ to finally lighter than -60 ‰.

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The mechanisms of recycling of the Archean continental crust: example of the Closepet granite; South India.

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The Closepet granite (South India) is generally considered as a typical crustal granite emplaced at 2.51 Ga and derived through partial melting of the surrounding Peninsular gneisses (3.2 to 2.7 Ga). In the field the granite appears as a composite body made up of at least 2 groups of intrusions: i) an early SiO₂-poor group (clinopyroxene and porphyritic granites) located in the central part of the body. These granites display a narrow range in both $^{87}\text{Sr}/^{86}\text{Sr}$ (0.7019-0.7030) and E_{Nd} (-1.47 to -4.73). ii) A later SiO₂-rich group (equigranular grey and pink granites) located along the interface between the SiO₂-poor group and the Peninsular gneisses. They progressively grade to migmatized Peninsular gneisses, thus indicating their anatectic derivation. Their isotopic characteristics vary in a wide range ($^{87}\text{Sr}/^{86}\text{Sr}$ from 0.7033 to 0.7106 and E_{Nd} from -7.31 to -8.91).

Field and geochronological evidences show that the two groups are broadly contemporaneous and mechanically mixed. This observation supported by the chemical data that display well defined mixing trends in both E_{Sr}-E_{Nd} and Harker's diagrams. This continuous chemical variation of two magmatic bodies is interpreted in terms of interaction and mixing of two unrelated end-members derived from different source regions (enriched peridotitic mantle vs Peninsular gneisses). The proposed petrogenetic model involves the intrusion of mantle derived magmatic inputs into mid-crustal levels along a transcurrent shear zone; they supplied additional heat and fluids that initiated the anatexis of the surrounding crust. During this event, large scale mixing occurred between mantle and crustal melts thus generating the composite Closepet granite.