Isotope geochemistry and zircon ages of middle to lower crustal rocks in NW Namibia (Kaoko belt)

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The Kaoko belt belongs to a Neoproterozoic belt system of southwestern Africa, which probably resulted from collision between the Congo Craton and the Rio de la Plata Craton. The prevailing rock types, evolved at the western margin of the Congo Craton, are of metaigneous and metasedimentary origin. We focused on an area around a large-scale major structural discontinuity, the Puros Lineament, separating the Western from the Eastern Kaoko Zone. The aim of this study is to understand the evolution of this part of the Kaoko belt by analysing middle to lower crustal rocks using detailed structural mapping, isotope geochemistry and geochronology.

Whole rock geochemistry classifies the granitoid rocks as syenogranite to tonalite. On trace element analysis most igneous rocks show characteristics of a Syn-Collisional and Volcanic Arc tectonic environment. Some are identified as Within Plate granites.

We dated the orthogneisses using the single zircon Pb-Pb evaporation and the conventional U-Pb method. Based on our zircon data we distinguish three different age groups. An early Proterozoic terrain with U-Pb ages between 2010 and 1910 Ma. An early to middle Proterozoic terrain contains migmatized granitoid gneisses with protolith zircon ages ranging between 1701 and 1620 Ma and augengneisses with zircon ages of 1520-1490 Ma. A Neoproterozoic terrain with zircon ages from 738 to 550 Ma represents the last major magmatic events in that area.

Whole-rock $^{147}Sm/^{144}Nd$ ratios for the Mesoproterozoic samples range from 0.096 to 0.123, typical for felsic rocks of that age. A long crustal evolution is reported by present day values for $\varepsilon_{Nd\ (t=0)}$ clustering between 14.1 and 20.1. $\varepsilon_{Nd\ (initial)}$ values ranging from –0.45 to +1.5, similar to ε_{Chur} of that age. This indicates a mantel-dominated source. Calculated T_{DM} model ages are between 1.8-2.2 Ga. The Neoproterozoic rocks with $\varepsilon_{Nd\ (initial)}$= –4.7 to $\varepsilon_{Nd\ (initial)}$= –1.6 point at a more crustal influence.

Zircon ages indicate a long evolution history of the basement with multiple magmatic events within the Kaoko belt. Sm-Nd anlaysis suggest a mantel-derived source for the Mesoproterozoic rocks while the Neoproterozoic rocks record the involvement of older continental crust.

Amoeboid olivine aggregates in carbonaceous chondrites: Records of nebular and asteroidal processes

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Records of nebular processes

Amoeboid olivine aggregates (AOAs) are among the most common type of refractory inclusions in all (except CI) groups of carbonaceous chondrites (CCs). AOAs in primitive (unaltered and unmetamorphosed) CCs are uniformly ^{16}O-enriched ($\Delta^{17}O$ ~ -20‰) and consist of forsterite ($Fa_{<1}$), FeNi-metal, and a Ca,Al-rich component composed of Al-diopside, anorthite, ±spinel, and rare melilite. Melilite is extensively replaced by a fine-grained mixture of spinel, Al-diopside, and anorthite. Spinel is corroded by anorthite. About 2% of > 500 AOAs studied contain low-Ca pyroxene replacing forsterite. These observations and thermodynamic analyses indicate that AOAs are aggregates of solar nebular condensates (forsterite, FeNi-metal, spinel, melilite, Al-diopside, ±anorthite) formed in ^{16}O-rich gaseous reservoir. Although some CAIs were melted prior to aggregation into AOAs, the AOAs escaped extensive melting. Before and possibly after ggregation, melilite and spinel reacted with gaseous SiO and Mg to form Al-diopside and anorthite. Solid or incipiently melted olivine in some AOAs reacted with $SiO_{(g)}$ to form low-Ca pyroxene; this could have occurred in the CAI- or chondrule-forming region(s). Although CAIs in AOAs are mineralogically similar to fine-grained spinel-rich CAIs, their different REE patterns (fractionated Group II in the former and unfractionated at ~10×CI level in the latter) point to formation in different reservoirs, separated spatially or in time.

Records of asteroidal processes

AOAs in primitive CCs (e.g., Acfer 094, CHs) show no evidence for Fe-alkali metasomatic or aqueous alteration, whereas those in CRs, CMs, COs, and CVs contain secondary minerals similar to those in other chondritic components (chondrules, CAIs, matrix) of the host meteorites. For example, phyllosilicates are common in the CM and CR AOAs; AOAs in CV_{oxA} contain nepheline, sodalite, hedenbergite, and fayalitic olivine (Fa_{40-60}), whereas those in CV_{oxB} contain fayalite ($Fa_{>90}$), hedenbergite, and phyllosilicates. Nepheline and phyllosilicates replace anorthite and Al-diopside, whereas ferrous olivine and hedenbergite precipitate along the grain boundaries and in pore space of AOAs. These observations and thermodynamic analyses indicate that secondary mineralizations in AOAs resulted from fluid-assisted thermal metamorphism after aggregation and lithification of the chondrite parent asteroids.