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Origin of quartz diorites (Damara Orogen, Namibia) – Constraints from major and trace elements and Sr, Nd isotopes

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Quartz diorites are essential components of granite batholiths, although of volumetrically minor importance. Generation of quartz diorites along destructive plate margins often requires the presence of a mantle component either in the form of direct contributions from the lithospheric mantle or by remelting of crust due to heating from the underlying upper mantle. In intracontinental settings their generation is more ambiguous. Among the plutons of dominantly granitic composition of the Damara orogen (Namibia), only few include medium-sized plutonic complexes containing quartz diorites.

Quartz diorites at Goas-Okongava (539±10 Ma), Bandombaai (540±3 Ma) and probably Koigabmond and at Tsomtsaub (541±3) intruded close to the onset of high-grade metamorphism at ca. 540 Ma which is constrained by numerous high-precision U-Pb monazite and Sm-Nd garnet-whole rock ages. All quartz diorites are metaluminous with some variation in SiO_2 (51-65 wt%) and MgO (2.3-6.6 wt%). They are LREE-enriched with minor negative Eu-anomalies. Their initial Nd and Sr isotopes are highly variable ranging from εNdi: -2 to -15 and 87Sr/86Sri: 0.705-0.713.

MgO-SiO_2 covariation indicates an important role of fractional crystallization. The fractionated mineral assemblages consist of varying amounts of amph, bt and minor plg. For individual sample suites, isotope compositions correlate with major element abundances (i.e. MgO, SiO_2) indicating that fractional crystallization is accompanied by crustal assimilation (AFC). The most primitive samples with ca. 51-53 wt% SiO_2 have low MgO contents (4-7 wt%) and moderately low Ni (30-100 ppm) and Cr (50-180 ppm) contents suggesting that they are not primary liquids from a simple four-phase peridotite. When back-correcting the sample data to an inferred primary magma with ca. 8 wt% MgO, initial εNdi values of ca. -2 and 87Sr/86Sr ratios of ca. 0.704 are obtained. These values differ from the lithospheric mantle beneath the Damara orogen which has εNd: +1 and 87Sr/86Sr: 0.7035 as obtained on rift-related syenites elsewhere in the orogen.

The most plausible interpretation is that the distinct quartz diorite suites were derived from partial melting of mafic lower crust of various ages. δ18O values > 8‰ in the quartz diorites support their derivation from pre-existing crustal material. When back-corrected to a hypothetical primary magma with 8 wt% MgO, most suites have δ18O values greater than 7‰ which is higher than typical mantle values. Only the Goas-Okongava samples have back-corrected values of ca. 5‰ which are similar to upper mantle values. The inferred mafic lower crust must have been underplated during numerous stages of amalgamation of the African lower crust during the Proterozoic. Provided no fractionation of Sm/Nd during intra-crustal melting depleted mantle Nd model ages of the quartz diorites with the least or even no evidence for AFC processes are $\sim$ 1.2 Ga which gives a minimum estimate of the age of underplating.