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Petrogenesis of syn-orogenic basement-derived granites (Central Damara Orogen, Namibia): insights from Nd, Sr and Pb isotopes

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The Pan-African Damara orogen (Namibia) represents a well-exposed and deeply eroded orogenic mobile belt consisting of the north-south extending Kaoko belt and the northeast-southwest trending intracontinental Damara belt. The latter has been subdivided into a Northern, a Central and a Southern Zone based on stratigraphy, metamorphic grade, structure and geochronology. In the central part Proterozoic basement gneisses are overlain by Neoproterozoic to Paleozoic metasedimentary sequences. The Kubas pluton in the Central Zone (ca. 25 km south of Usakos) consists of two different, non-genetic granite types, the grey Kubas granite and the red Kubas leucogranite. The weakly deformed grey Kubas granite consists of quartz, plagioclase, microcline/orthoclase and biotite. Major and trace element variations show weak negative correlations of TiO_2, MgO, CaO, Na_2O, Sr and Ba vs. SiO_2 and weak positive correlations of K_2O vs. SiO_2. Rubidium, Sr and Ba covariations demonstrate that fractional crystallisation processes of mainly plagioclase and K-feldspar occurred ($< 10\%$ fractional crystallisation). This observation is supported by moderate negative Eu anomalies. The grey granites are isotopically evolved (initial $\sum_{Nd}$: $\sim$ -16; initial $^{87}Sr/^{86}Sr > 0.719$; calculated for an assumed age of 500 Ma) and were likely derived from sources with early Proterozoic crustal residence ages, as shown by depleted mantle Nd model ages between 2.1 and 2.6 Ga. Pb isotope data, obtained on acid leached feldspar, show significant variation of $^{207}Pb/^{204}Pb$ relative to $^{206}Pb/^{204}Pb$ and plot above the Stacey and Kramers reference curve. In $^{208}Pb/^{204}Pb$ vs. $^{206}Pb/^{204}Pb$ the samples also plot above the Pb reference curve with minor variations in $^{208}Pb/^{204}Pb$. These features suggest that the source of the granites had a high U/Pb and Th/U ratio. These isotope characteristics support a model of an ancient source for the granite. Major element features (Na_2O: 3.0-3.5 wt.%, K_2O: 4.2-5.1 wt.%) and trace element characteristics (Rb: 230-280 ppm; Sr: 110-140 ppm; Ba: 520-630 ppm) of the granites are between those assumed to be characteristic for metasedimentary or meta-igneous sources. Since Proterozoic metasedimentary rocks are not known from the basement-dominated part of the Damara orogen, the likely source for the grey Kubas granites is meta-igneous pre-Damara basement located in the lower crust. The heating events that promoted melting of fertile deep crustal rocks might have been caused by the inferred high heat productivity of heat-producing radioactive elements (Th, U, K) together with crustal thickening during the main periods of the Damara orogeny. This view is supported by moderate high Th/U ratios of the granites (4-6) and moderate high heat production values of ca. 3-4 $\mu W/m^3$. In addition, delamination of mantle lithosphere during the final extensional stages of the Pan-African orogeny is a possibility.