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Generation of felsic crustal melts – partial melting of metapelites

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Most leucogranites are peraluminous and are considered to be melts of pre-existing continental crust. The classical model involves orogenic melting triggered by fluxing of fluids derived from dehydration of metasedimentary rocks during 'hot-over-cold' thrusting of crustal slices. Other leucogranites possibly form by extensive fractional crystallization from intermediate parent magmas with some contribution from upper mantle melts. The intra-continental Damara Orogen (Namibia) consists of mostly granitic rocks, with minor tonalite/diorite and basement outcrops. Many of the syn-orogenic granites are of leucocratic character and are little fractionated. New geochronological data from leucogranites at Okombahe suggests that emplacement took place during the main peak of metamorphism (∼510 Ma). The leucogranites have unradiogenic initial εNd values (-4.4 to -6.2) and variable initial $^{87}Sr/^{86}Sr$ ratios (0.707-0.712), precluding involvement of a significant mantle component. Trace element ratios (Rb/Sr >2.4, Sr/Ba <0.26 and Rb/Ba >0.4) suggest a metapelitic source. Rb/Sr ratios >2 and Sr/Ba <0.4 suggest biotite-dehydration melting as the main process. Lead isotope data from the granites obtained on acid leached feldspar separates ($^{206}Pb/^{204}Pb$: 18.51-18.60; $^{207}Pb/^{204}Pb$: 15.63-15.67) are broadly similar to ratios obtained on metasediments ($^{206}Pb/^{204}Pb$: 18.32-18.69; $^{207}Pb/^{204}Pb$: 15.62-15.67) and metasedimentary xenoliths ($^{206}Pb/^{204}Pb$: 18.31-18.53; $^{207}Pb/^{204}Pb$: 15.62-15.68) from nearby S-type granites. The granites are emplaced into crd-sil-Kfs-bearing metapelites that record Na-in-cordierite temperatures in excess of 725°C at ca. 4-5 kbar. Zircon saturation temperatures obtained on the granites record temperatures of 800-840°C and, assuming an average geothermal gradient of 30°C/km, indicating pressures of 6-7 kbar for the generation of the leucogranites. The absence of a mantle component during melt generation indicates that advective heat input is negligible. Owing to their intrusion close to peak regional metamorphism, decompression melting is also unlikely as the lower crust underwent maximum thickening and hence compression at that time. As an alternative, we propose that crustal thickening moved metapelitic sources to lower crustal levels and induced biotite dehydration melting under granulite facies conditions. Although the granites are little fractionated their high temperatures -as recorded by high zircon saturation temperatures- facilitated rise into shallower crustal levels.