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Genesis of Late Pan-African Dike Rocks from Northern Arabian-Nubian Shield

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The Arabian-Nubian Shield (ANS) and the Central Asian Orogenic Belt (CAOB) have much in common with regard to their crust evolution. ANS is a large Neoproterozoic accretionary orogen at the northern end of the East African Orogen. ANS underwent the main stage of crustal accretion in the period of ca.900 to 530 Ma (= Pan-African event), whereas CAOB took place later from ca.600 to 100 Ma. Both orogenic belts are composed of a variety of terranes, including continental-margin and intra-oceanic arcs, ophiolite complexes, granitic batholiths and some Precambrian continental fragments. However, the most renowned feature is the massive generation of juvenile crust in the respective periods of Neoproterozoic for ANS and Phanerozoic for CAOB. In southern Israel (northern part of ANS), late Pan-African dike swarm of basic to acid compositions were emplaced in several episodes from 600 to 530 Ma. Late Pan-African dike swarms are abundant throughout the Sinai Peninsula and the Eastern Desert of Egypt, and their geochemical characteristics are comparable with the dike rocks occurring in southern Israel. All these dike rocks were formed in post-orogenic and within-plate tectonic settings. They are enriched in alkalis, LILE and HFSE; and in some basalts, high TiO_2contents (4.5%) are observed. Sr-Nd-O isotope analyses on the dike rocks from southern Israel yielded a very intriguing result. Most rocks, regardless of their chemical compositions, have a small range of weakly positive εNd(560Ma) values of +3 to zero, suggesting a significant proportion of juvenile component in their petrogenesis. By contrast, a very wide range of radiogenic I(Sr) values of 0.704 to 0.760 is observed, with alkaline and ultra-K acid rocks in the high end. In the conventional εNd(T) vs I(Sr) plot, the present data points fall in the first quadrangle, a very rare situation for any terrestrial rocks. The Sm-Nd model ages (T_{DM}) are rather uniform about 1050 +/- 100 Ma, and the Rb-Sr model ages also fall in a small range of 900 to 1000 Ma (except basic rocks). Severe post-magmatic water-rock interaction is indicated by the oxygen isotopic analyses of constituent minerals, especially the elevated δ^{18}O for plagioclase (+10 to +14‰) and K-feldspar (+13 to +15‰), in comparison with quartz (+8.5 to +9.5‰). Clearly, the feldspars are out of isotope equilibrium with the quartz. A correlation between Δ^{18}O (Qtz-Fsp) and I(Sr) indicate that the variable and high ^{87}Sr/^{86}Sr ratios could have resulted from water-rock exchange of Sr and O isotopes at low temperatures ($\leq$ 100°C). The small range of Sm-Nd model ages (ca.1100 Ma) and positive εNd(560Ma) values imply that the protoliths are relatively "young". Severe water-rock interaction would not only modify Sr isotope compositions but also Rb/Sr

ratios, therefore, the surprisingly small range of Rb-Sr model ages is difficult to interpret. The water would have to be extremely radiogenic ($^{87}Sr/^{86}Sr \geq 0.760$) in order to be effective in the modification of Sr isotopes in the dike rocks. To explain the rather uniform εNd(T) values the water should have a very low Nd concentration, and this would be expected to occur in low-T and low-P condition. In conclusion, the petrogenesis of the late Pan-African dike rocks requires the involvement of late Proterozoic enriched lithospheric mantle, and probably some country gneisses. Strong water-rock interaction after the emplacement of the dike swarm has modified the Sr-O isotope signature, but the source of the highly radiogenic (Sr) water remains to be identified.