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Regional carbonate alteration in the eastern desert of Egypt: Isotopic evidence for a mantle-derived fluid source

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The migration of carbonate-rich solutions was common during deformation and metamorphism of the Arabian-Nubian Shield (ANS), forming veins and dykes, and causing diffuse and pervasive carbonation of a wide range of basement rocks (1). Pervasive carbonate alteration focused along faults and shear zones is extremely abundant in ultramafic and mafic components of the ophiolitic sequences of the Central Eastern Desert (CED) of Egypt. Despite the abundance of this alteration, there have been few isotopic investigations into the source of fluids that caused the alteration. Isotopic investigations of intrusive carbonate dykes reveal a mixed mantle-sedimentary C source ($\delta^{13}C_{pdb}$ ranges -8 to +3.5) (1), but the genetic relationship between these and the pervasive carbonate alteration is unclear. We report isotopic (C, O, Sr) compositions of whole rocks and veins, and fluid inclusion compositions from veins in a sequence of carbonated mafic and ultramafic rocks surrounding the Meatiq core complex (MCC) in the CED of Egypt.

The MCC occurs within the Najd mega shear zone corridor and represents one of the structurally lowest units in the CED basement (2). It is exposed in a tectonic window through the Neoproterozoic cover nappes that comprise variably carbonatized/silicified ophiolitic sequences and metasedimentary and metavolcanic rocks. Carbonate alteration replaces silicates with dolomite, magnesite and ankerite with the ultramafic rocks becoming talc-carbonate rocks. Vein carbonate is dominantly dolomite and magnesite.

Carbon, O and Sr isotopic compositions of carbonated serpentinites and metavolcanics and of pure carbonate veins are used to constrain the origin of the fluid involved. The $\delta^{13}C_{pdb}$ and $\delta^{18}O_{SMOW}$ isotope compositions of pure vein carbonate range -6.8 to -8.1 and 6.4 to 10.5 respectively, whereas the age-corrected $^{87}Sr/^{86}Sr$ ratios range 0.7028 to 0.7034. The $\delta^{13}C_{pdb}$, $\delta^{18}O_{SMOW}$ and $^{87}Sr/^{86}Sr$ values in carbonated metavolcanics range -9.3 to -10.0, 9.4 to 11.1, and 0.7029 - 0.7031 respectively. The carbonated and weekly carbonated serpentinites have $\delta^{13}C$ values ranging -4.1 to -5.9, $\delta^{18}O$ compositions ranging 10.3 to 15.1, and $^{87}Sr/^{86}Sr$ ratios of 0.7039 to 0.7062. Some of the carbonated serpentinites have low Sr contents (0.2 to 0.5 ppm) whereas most samples contain between 6 and 2365 ppm. The isotopic composition of the altered rocks and veins are similar to those from intrusive carbonates in the CED (1). The pure carbonate veins have strong mantle signatures with little or no crustal Sr or surficial C and O. The carbonated serpentinites have Sr isotope ratios indicating mixing between a mantle and a more radiogenic Sr component with higher $\delta^{18}O$. The isotopic data suggests that large fluxes of mantle-derived CO_2-rich fluid through the CED basement rocks during the Neoproterozoic. Carbonate veins contain abundant carbonic ($CO_2 \pm CH_4 \pm N_2$) and aqueous-carbonic (H_2O-NaCl-$CO_2 \pm CH_4 \pm N_2$) fluid inclusions with low salinity (<5 wt.% NaCl eq.), similar to those reported from gold-rich vein deposits in the CED (3). It is possible that the auriferous veins were formed from the same mantle-derived fluids.

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