Natural Carbon Sequestration in the Oman Mountains by Carbonated Ultramafic Rocks (listwaenite and Fanjaite)

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Abstract

Orange-brown listwaenite (fully carbonated/silicified ultramafic rock) forms naturally when carbon-rich fluids react with ultramafic rocks. Olivine and pyroxene transform to carbonate and quartz, which makes this rock resistance to erosion and a carbon-free rock becomes a carbonate, permanently reducing the carbon content of the atmosphere. We structurally mapped the Fanja area (Eastern Oman Mountains) at the scale of 1:10,000, covering an area of ~15 km x ~25 km, to decipher the relationship between listwaenite, faults and regional tectonics. There are two listwaenite generations. The older set (list1) dips shallowly, while the younger set (list2) dips steeply to sub-vertically. Locally, list2 cuts list1. List1 is exclusively positioned at the base of the Semail Ophiolite. List1 is either in contact with the underlying metamorphic sole, which formed by heating of the obducted hot ophiolite, or fully within the mantle rocks of the ophiolite, but a few meters away from the metamorphic sole. List1 is associated with extensional structures/faults. List2 is always in contact with peridotite, but may be also in contact with rocks of the postobductional latest Cretaceous clastic Al-Khod Formation, gabbro, metamorphic sole and deep marine Tethyan Hawasina rocks. List 2 is mostly associated with NW-striking sinistral transtensional faults. We suggest that List1 formed during postobductional extension during the latest Cretaceous to earliest Eocene (~70-57 Ma) as confirmed by U-Pb dating of listwaenite carbonate. List2 probably formed during the Oligocene to early Miocene Arabia-India shortening, forming a NW-striking wrench-fault assemblage and/or during NE-directed extension that caused surface uplift of major domes during the late Eocene to Miocene.

Furthermore, the prone to erosion and overall dark-green peridotite of the Fanja area consists of NW-striking units with 10s to 100s-of-meters in thickness. These units are near the listwaenite and have the same morphology and appearance (i.e., prone to erosion) in the field as the peridotite but the same orange-brown color as the nearby listwaenite. Thin sections reveal that the orange-brown zones consist of mostly dolomite and quartz with varying concentrations of olivine, orthopyroxene, serpentine and chlorite. Thus, we interpret these orange-brown zones within the peridotite to be partially carbonated/silicified ultramafic rocks. We term these rocks “fanjaite”. Fanjaite significantly contributes to carbon sequestration, similar to listwaenite. We suggest that fanjaite forms similar to list2, the difference being that either not enough carbon-rich fluids were present to fully transform olivine and pyroxene to carbonate/quartz and/or the composition of the fluids differed from those forming listwaenite.