# Genesis of Vein Stockwork and Sedimentary Magnesite and Hydromagnesite Deposits in the Ultramafic Terranes of Southwestern Turkey: A Stable Isotope Study

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## Abstract

Vein stockworks and lacustrine developments of cryptocrystalline magnesium carbonates of Neogene and Quaternary age occur within the partially serpentinized, discontinuous ultramafic belts of southwestern Turkey. They are comparable to the Neogene cryptocrystalline magnesite bodies elsewhere in the Alpine orogen to the northwest and southeast. Our previous work (Fallick et al., 1991) suggested that cool (•100°C) modified meteoric water was the mineralizer, that ultramafic rock was the source of the magnesium, but that there were three separate sources of the (bi)carbonate. These sources were distinguishable by their stable isotope composition as follows: (1) low-temperature carbonate with $\delta^{18}O_{(SMOW)}$ values of ~36 per mil and $\delta^{13}C_{(PDB)}$ values of ~4 per mil, derived from atmospheric $CO_2$; (2) moderate-temperature carbonate with $\delta^{18}O_{(SMOW)}$ values of +28 per mil and $\delta^{13}C_{(PDB)}$ values of -15 per mil, derived by decarboxylation of organic-rich sediments; and (3) higher temperature carbonate with $\delta^{18}O_{(SMOW)}$ values of ~19 per mil and $\delta^{13}C_{(PDB)}$ values of ~3 per mil, assumed to have been generated by thermal contact metamorphism of Paleozoic marine limestone at depth. In general these magnesite deposits were found to fall into two groups, comprising carbonate generated on two mixing lines. The first group spanned the putative mixing line from the ''atmospheric'' source (1) to ''organically derived'' source of $CO_2$ (2). The second group extended between atmospheric source (1) and the ''thermal'' source (3), although there were concentrations either around the atmospheric end, or precisely at the contact metamorphic end of the line.

In the present study we found that large stockwork deposits at Helvac•baba and Koyakc• Tepe have $\delta^{13}C_{(PDB)}$ and $\delta^{18}O_{(SMOW)}$ values averaging ~-12 and ~+27 per mil, respectively, indicating a derivation mainly by oxidation of organic-rich metasediments perhaps underthrust at depth (end-member 2), with some involvement of atmospheric carbon dioxide as bicarbonate in the circulating, hot, and modified meteoric water (end-member 1). Calcite veinlets in a meta-argillite of the Cambro-Ordovician Seydisehir Formation, most likely to have been underthrust beneath the stockworks, yielded $\delta^{13}C_{(PDB)}$ values of -20 per mil, consistent with, though not proving, oxidized organic carbon being one of the sources of carbonate. The $\delta^{18}O_{(SMOW)}$ values of these same veinlet carbonates are also rather low (22‰), indicating precipitation from heated ground water, though their age is unknown.

The major stratiform magnesite deposit at Hirsizdere in the center of the Menderes graben has $\delta^{13}C_{(PDB)}$ and $\delta^{18}O_{(SMOW)}$ values averaging ~3 and ~25 per mil, respectively, and thus appears to be an example of the hydrothermal-sedimentary (i.e., exhalative) type (Ilich, 1968). In contrast, the hydromagnesite stromatolites presently growing in Salda Gölü (Lake Salda) are apparently developing at cool ground-water seepages. The gross morphology of the Salda Gölü stromatolites and the hydromagnesite sediments derived therefrom is reminiscent of that revealed in the Bela Stena magnesite pit in Serbia. These lacustrine deposits have mean $\delta^{13}C_{(PDB)}$ values of ~4 and ~2 per mil and mean $\delta^{18}O_{(SMOW)}$ values of ~36 and ~33 per mil, respectively, i.e., they both plot broadly over the atmospheric $CO_2$-meteoric water field (end-member 1), consistent with microbially mediated precipitation at cool ground-water seepages in enclosed evaporating lakes.