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# Genesis and Metamorphic Evolution of Marbles in the Cycladic Metamorphic Complex, Western Anatolia, Türkiye: Insights from stable isotope geochemical approaches

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This study investigates the geological and metamorphic relationships between the Menderes Massif in western Anatolia and the Eocene high-pressure Cycladic Metamorphic Complex, focusing on marbles within the thrust sheet of the western Aydın Mountains. The Cycladic unit, which structurally overlies the Menderes Massif, consists of schists, marbles, amphibolitized eclogites, serpentinites, and metabasites, exhibiting intense post-metamorphic shearing that produces a mélange-like fabric. Field mapping and petrographic analyses reveal a polyphase metamorphic history, including an initial high-pressure (eclogite–blueschist facies) event overprinted by greenschist-facies retrogression. The schist–serpentinite–metabasite assemblage is interpreted as an olistostrome deposited on a Mesozoic carbonate platform, later subducted and metamorphosed during the Eocene.

Geochemical analyses of 12 marble samples reveal a wide MgO compositional range (0.66%–18.43%), distinguishing calcitic from dolomitic varieties. Stable isotope data show $\delta^{13}C$ values of 1.25‰–2.45‰ (VPDB) and $\delta^{18}O$ values of 24.10‰–25.40‰ (SMOW), with associated $\delta^{13}C$ of $CO_2$ ranging from 4.0‰ to 5.2‰ (VPDB). These elevated $\delta^{13}C$ values, relative to typical marine dissolved inorganic carbon (DIC), suggest contributions from metamorphic $CO_2$ derived from carbonate breakdown or organic matter oxidation. The $\delta^{18}O$ of water (23.3‰–24.5‰ VSMOW) is anomalously high compared to seawater, indicating interaction with metamorphic fluids at elevated temperatures. While the marbles retain primary marine carbonate signatures, isotopic and geochemical evidence points to significant fluid-rock interactions during metamorphism.

The tectonic evolution of this unit reflects Eocene subduction and exhumation processes in the Aegean region, where marine sediments and carbonates were subjected to high pressures and temperatures, facilitating isotopic exchange with metamorphic fluids. The preservation of marine carbonate isotopic signatures, coupled with variations in CaO–MgO contents, underscores the significance of these marbles for reconstructing the region's metamorphic and tectonic history. This study highlights the interplay of subduction, metamorphism, and fluid–rock interaction in shaping the geological record of the Aegean domain.