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Graphite Precipitation from Reduced Methane in Subduction Zone

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Determining the behavior and mobility of carbon phases in subduction zone fluids remains an active and challenging research frontier, which holds significance for understanding the deep carbon cycle. This study presents evidence of abundant of CH_4-rich fluid inclusions and two types of graphite from ultrahigh-pressure (UHP) eclogites in the Western Tianshan, China. Through petrological analysis and three-dimensional (3D) Raman modeling, we quantify the compositions of reducing aqueous fluids in deep subduction zone, and identify evidence suggesting that fluid-derived graphite precipitates from the reduced CH_4-bearing fluids. Furthermore, the Deep Earth Water (DEW) model demonstrates that fluid-derived graphite can indeed precipitate through the reaction of $CO_2 + CH_4 = 2C + 2H_2O$. The fluids released by subducted slabs are initially reduced, but continuously evolve to become oxidized during decompression and exhumation. A portion of the reduced carbon in the fluids is fixed through the precipitation of fluid- derived graphite, rather than being entirely released into the mantle wedge. This finding contributes to a better understanding of Earth's internal processes.