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The fate of subducted carbon and hydrogen from high-pressure melting in the Fe-C-H system

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The carbon(C) and hydrogen(H) cycles in deep Earth have attracted significant attention because C and H are essential elements for life on our habitable planet. Slab subduction is accompanied by the replenishment of mantle reservoirs with volatile elements such as C and H. Native iron (Fe) was proposed to exist in the deep mantle beneath 250 km depth, due to the disproportionation of Fe^{2+} in mantle silicates [1]. The occurrences and cycling of slab-originated C and H are thought to be controlled by their redox reactions with metallic iron in the increasingly reduced mantle to form Fe alloys containing carbon and/or hydrogen and their melting behaviors at depth. However, research on the melting behavior of Fe-C-H ternary system is rare. Here we show experimental results on the melting of the Fe-C-H system using both multi-anvil press combined with scanning electron microscope and laser-heated diamond anvil cell combined with synchrotron-based X-ray diffraction. We show experimentally the eutectic melting curves of the Fe-C-H metal phase are below the mantle geotherm, leading to the high mobility of subducted carbon and hydrogen, and the accumulation of metallic liquids in the deep mantle. The incorporation of hydrogen facilitates the formation of diamond in Fe-C-H liquids and the hydrogen-carbon enriched metallic liquids provide the necessary fluid environment for superdeep diamond growth.

[1] Frost, D. J., Liebske, C., Langenhorst, F., McCammon, C. A., Trønnes, R. G., & Rubie, D. C. (2004). *Nature*, 428(6981), 409-412.