Formation of abiotic hydrocarbon from reduction of carbonate in subduction zones Renbiao Tao[a], Lifei Zhang[a], Meng Tian[a], Jianjiang Zhu[a], Xi Liu[a], Yingwei Fei[a,b]

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Abstract:

Subduction is a key process for linking the carbon cycle between the Earth's surface and its interior. Knowing the carbonation and decarbonation processes in the subduction zone is essential for understanding the global deep carbon cycle. In particular, the potential role of hydrocarbon fluids in subduction zones is not well understood and has long been debated. Here we report graphite and light hydrocarbon-bearing inclusions in the carbonated eclogite from the Southwest (S.W.) Tianshan subduction zone, which are estimated to have originated at a depth of at least 80 kilometers. The formation of graphite and light hydrocarbon is likely resulted from the reduction of carbonate under low oxygen fugacity (~ FMQ – 2.5 log units). To better understand the origin of light hydrocarbons, we also investigated the reaction between iron-bearing carbonate and water under conditions relevant to subduction zone environments using large-volume high-pressure apparatus. Our high-pressure experiments provide additional constraints on the formation of abiotic hydrocarbons and graphite/diamond from carbonate-water reduction. In the experimental products, the speciation and concentration of the light hydrocarbons including methane (CH_4), ethane (C_2H_6), and propane (C_3H_8) were unambiguously determined using gas chromatograph techniques. The formation of these hydrocarbons is accompanied by the formation of graphite and oxidized iron in the form of magnetite (Fe_3O_4). We observed the identical mineral assemblage (iron-bearing dolomite, magnetite, and graphite) associated with the formation of the hydrocarbons in both natural carbonated eclogite and the experimental run products, pointing toward the same formation mechanism. The reduction of the

carbonates under low oxygen fugacity is, thus, an important mechanism in forming abiotic hydrocarbons and graphite/diamond in the subduction zone settings.