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Hydrocarbon micro-inclusions in olivine in high-P titanoclinohumite-bearing dunites: hydrocarbon activity in a subduction zone and Ti mobility

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Micro-inclusions of methane and propane were examined in olivine and titanoclinohumite in dunites from Fujiwara, Sanbagawa high-P metamorphic belt, Japan, in order to understand the behavior of hydrocarbons in the subduction zone and mantle wedge. In the Fujiwara dunite, olivines coexist with magnetite and exhibit a wide range of chemical compositions (Fo88-96 and 0.2-0.6 wt% NiO), possibly indicating a deserpentinization origin for the dunite (Ishibashi et al., 1978; Enami, 1980). The primary chromian spinel shows an intermediate Cr/(Cr + Al) atomic ratio, 0.5-0.6, and 1 to 3 wt% TiO_2, and are enclosed by its alteration phases (ferritechromite and magnetite) that contain less than 0.8 wt% TiO_2.

Hydrocarbons are usually associated with serpentine and brucite, with or without magnetite, in individual micro-inclusions, suggesting initial entrapment of hydrocarbon-rich aqueous fluids and subsequent reaction only between their water component and the wall olivine or titanoclinohumite. It is evident that they were not in-situ formed via reaction of olivine and trapped (H_2O + CO_2) (Miura et al., 2010). The primary rock for the Fujiwara dunite was originally formed as a cumulate from intra-plate magma (Arai et al., 2011), essentially composed of olivine of Fo85-86 and the Ti-rich chromian spinel. After uplift to the surface by some tectonism, it was serpentinized and brecciated to contain carbonaceous matter in the matrix part before incorporation in the subduction zone. The hydrocarbons possibly formed with maturation of the carbonaceous matter in the process of subduction (e.g., Itaya, 1981). The continuously formed hydrocarbons mobilized Ti released upon serpentinization from the primary chromian spinel to leave low-Ti ferritechromite and magnetite in the Fujiwara dunite. Ti was finally stabilized as titanoclinohumite and other Ti-rich minerals during deserpentinization in the Fujiwara dunite within the subduction zone.

Ti is possibly mobile within the mantle wedge through hydrocarbons (cf. Parnell, 2004) only if they are available from the slab. The mantle wedge is, however, hardly enriched with Ti, because most of hydrocarbons are possibly emanated at shallow depths from the slab. In addition the source of Ti is not easily available from the subducted sediments and their surroundings.