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SERPENTINIZATION OF OCEANIC CRUST AND FISCHER-TROPSCH TYPE SYNTHESIS OF ORGANIC COMPOUNDS

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Serpentinization of peridote in oceanic crust is probably the most likely geochemical process that would result in Fischer-Tropsch type (FTT) synthesis of organic compounds. Oxidation of Fe(II) of the olivine $(Mg,Fe)_2SiO_4$ in peridotite to magnetite would lead to the reduction of water and the formation of H_2. The reaction may be registered by the pH increase due to the occurrence of free OH^-. The FTT synthesis is likely to be most significant in fractured rock where degassing of CO_2 from the mantle occurs and percolation of water leading to serpentinization of olivine is efficient. This is also the type of environment where fresh surfaces of potential minerals catalysts are abundant. Such minerals would, for instance, be the magnetite that is formed during serpentinization and different metal sulfides like chalcopyrite, pyrite, pyrrhotite and sphalerite. An interesting piece of information is the article by Sakai and coworkers (1990) on the hydrothermal fields of the Okinawa backarc spreading center. They observed the release of bubbles of liquid CO_2 from the sea floor of active hydrothermal sites. The approximate composition of the bubbles was 86% CO_2, 3% H_2S and 11% residual gas, mostly CH_4 and H_2. The isotopic ratios of C and S, as well as He indicated that the CO_2-rich fluid had a magmatic origin. Charlou and coworkers (1991) reported intense degassing of CH_4 associated with H_2 and CO_2 at 15°05'N on the Mid-Atlantic Ridge that was related to an axial mount consisting of serpentinized peridotites. In addition, Bougalt and coworkers (1993) described the association of CH_4 outputs with exposures of serpentinized ultramafic rocks at several sites of the axial region of the Mid-Atlantic Ridge. However, the most apparent potential evidence for FTT synthesis in oceanic crust has been provided by Mottl (1992) from holes drilled by ODP (the Ocean Drilling Program) Leg 125 at Conical Seamount in the Mariana forearc. He reported the occurrence of methane concentrations up to 37 mmol/kg in serpentine-associated sediment pore fluids along with ethane and propane and a pH of 12.6. Haggerty and Fisher (1992) reported the occurrence of carboxylic acids in the same serpentine-associated pore fluids sampled during ODP Leg 125. The maximum measured concentration of formate was 2.3 mmol/kg, whereas acetate amounted to about 210 μmol/kg. Propionate and malonate were also detected. Geological evidence indicates that Conical Seamount is an active mud volcano, with a central conduit of low-density serpentine that rises buoyantly through the crust and produces periodic cold serpentine mud and debris flows (Mottl, 1992). The high pH indicates that serpentization was going on when the fluids were sampled. Methane was also found in fluid inclusions of cold seep carbonate chimneys at the summit of Conical Seamount along with aromatic compounds (benzene, toluene and xylene), long-chain paraffins, naphtenes and acetate ions (Haggerty, 1989, 1991). Mottl (1992) suggested that the presence of of acetate limits the temperature range in the source region of the organics to 150°C or less, i.e. the source region would maintain a temperature where the activities of metastable organic phases like the organic acids are close to their theoretical maximum values (Shock, 1990, 1992). Mottl (1992) hypothesized that the organic compounds of the pore fluids were thermogenic, although the organic carbon content of the serpentine sediments were only 0.1 to 0.3%. In addition, very little organic compound was present in the pore fluids when peridotite was absent. Unfortunately he did not provide stable isotope data that would shed light on the origin of the organic compounds. Mottl also discussed whether or not the low salinity values of Conical Seamount pore fluids depends on melting of gas hydrates that could be present at depth of the drilled hole. Such gas hydrates might continuosly melt, supplying freshwater and hydrocarbon gases that may upwell to the summit. No evidence of hydrocarbon gas hydrates were, however, found in any of the drilled cores of Conical Seamount, nor was there any seismic evidence of a bottom-simulating reflector that might indicate the presence of such gas hydrates (Mottl, 1992).

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