

Origin of ^{13}C -depleted kerogen in ca. 3.5 Ga hydrothermal silica dikes from Western Australia

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Abundant organic matter (kerogen) was identified in ~3.5 Ga hydrothermal silica dikes from the North Pole area, Pilbara craton, Western Australia. The silica dikes developed up to the uppermost 1000 m of the ancient oceanic crust. Thus, they would have deposited in the 3.5 Ga sub-seafloor hydrothermal system. Understanding the origin of the kerogen may provide important implications for the origin of life and its earliest evolution, because the organic matter must have been produced either by biological carbon fixation or by pre-biotic organic synthesis. Petrography of the silica dikes together with carbon isotopic analyses of the kerogen were performed. The silica dikes consist mainly of fine-grained silica with minor pyrites and sphalerites. These mineral assemblages indicate that the silica dike was deposited from relatively low temperature (probably less than 150°C) reducing hydrothermal fluid. Thus, anaerobic, thermophilic/hyperthermophilic organisms could have survived in the hydrothermal fluid, which formed the silica dikes. The highly ^{13}C -depleted isotopic compositions of the kerogens ($\delta^{13}\text{C} = -38$ to -33%) are consistent with their biological origin, especially chemoautotrophic organisms such as methanogen. Although the abiological origin can not be eliminated, pyrite-dominated mineral assemblages indicate that the effective catalysts of FTT reaction (e.g., Fe-Ni alloy, magnetite, and hematite) would not have been present in the hydrothermal system.

Biogeochemical stability of iron phosphate minerals for attenuation of acid mine wastes

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Introduction

The precipitation and dissolution processes governing the stability of iron phosphate minerals are particularly important in aquatic and terrestrial environments because the availability of phosphate is largely controlled by iron. Moreover, microorganisms could play a more important role in the stability of such minerals because phosphate is an essential nutrient. In mining environments, the formation of Fe-PO₄ minerals on sulfide-rich rock surfaces is seen as a mean to attenuate acid-generation during and after treatment of the waste rocks with phosphate-rich residues or solutions (Evangelou, 2001; Elsetinow, 2001). However, little is known about the long-term stability of these iron-phosphate minerals in the presence of bacteria living in mining environments. We report here the stability of iron-phosphate bearing biofilms and precipitated iron phosphates under acidic and neutral conditions and in the presence of bacteria.

Discussion of results

Pyritic mine waste rocks previously treated with phosphate residues developed biofilms which contained Fe-phosphate minerals (Kalin et al., 1994). The same dehydrated biofilms were revived by immersing them in culture media under acidic (pH 2 and 4) and neutral (pH 7) conditions for a period of 89 days. ESEM observations first showed the rapid formation of thick biofilms, whereas SEM/EDS analyses indicated the presence of P, S and Fe in the biofilms under acidic conditions and the presence of S, K and Fe under neutral conditions. During the same period of time, PO₄ concentrations in the liquid media declined overtime for the systems adjusted to pH 2 and 4, whereas they increased in the system at pH 7. These observations are in agreement with MINEQL+ calculations which indicated that ferric phosphate minerals were stable under acidic conditions whereas calcium phosphate and ferric hydroxide minerals were stable under neutral conditions.

Conclusions

Iron phosphate biofilms appear to be stable under acidic conditions (pH 2-4), but unstable near neutral pH conditions.

References

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