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Reduced Phosphorus and the Origin of Life

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Abstract

Phosphorus is an important element for the origin of life. Phosphorus is an integral part of genetic material, molecular energy carriers, and phospholipids [9]. Under present conditions, phosphorus exists predominately in its most oxidized form in orthophosphate minerals. Studies on prebiotic phosphorus sources have focused on reduced forms of phosphorus for example the meteoric mineral schreibersite, $(Fe,Ni)_3P$ [8]. This project focuses on identifying a feasible terrestrial reduced phosphorus source.

1. Introduction

Origin of life studies have focused on phosphide as the main source of phosphorus for prebiotic chemistry because reduced forms of phosphorus are more soluble and reactive than the oxidized phosphorus forms. Previous work has identified schreibersite, a meteoric iron-nickel phosphide, as an important prebiotic source [3, 5]. This iron-nickel alloy has extraterrestrial origins; however, the chemistry is similar to josephinite, an iron nickel alloy produced during serpentinization of ophiolites.

1.1 Phosphides

Localized phosphides have been identified in fulgurites from lightning, pyrometamorphic rocks in Levant, microbial activity under anaerobic conditions, geothermal fluids, and volcanic processes; however, most phosphides are meteoric in origin [1, 3, 7, 9]. Since the phosphorylation of biomolecules is inhibited by surface geochemistry, extraterrestrial material may have provided the initial source of phosphorus in a reactive and soluble form [3]. The extraterrestrial origin gained further support from the identification of phosphonic acid in the Murchison carbonaceous chondrite. Inorganic orthophosphates were also present in the meteorite [2].

2. Josephinite

Josephinite is an iron-nickel alloy found as placer deposits along the rivers flowing off the Josephine Ophiolite. Initial microprobe data has identified phosphorus up to 15 weight % in samples. The iron nickel ratio in josephinite is similar to the 1:2 ratio found in schreibersite.

2.1 Josephine Ophiolite

The Josephine Ophiolite (age ~150 Ma) was emplaced during the Nevadan orogeny and represents one of the most complete sections of ophiolite – oceanic crust left on top of continental crust. Located in the Klamath mountains on the border of California and Oregon, the ocean rocks have been serpentinized through hydrothermal activity [4].

2.2 Field and analytical methods

Josephinite samples are collected from Josephine Creek and surrounding area in the Klamath mountains. Phosphorus contents are measured using microprobe. Speciation data is obtained using P NMR.

3. Corrosion Experiments

Corrosion studies with deionized water, simulated sea water, and sulfidic ocean were completed with josephinite and synthetic schreibersite. A multi-valent solution of phosphorus compounds is found during corrosion.

4. Summary and Conclusions

Josephinite, an iron-nickel alloy, has phosphorus within the mineral structure. Further studies are needed to quantify the oxidation state and distribution study

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