TERRESTRIAL ANALOG STUDIES OF EARLY MARTIAN ENVIRONMENTS: CHEMICAL ANALYSIS OF SEDIMENTS FROM LAKE HOARE, ANTARCTICA. Janice Bishop, Department of Chemistry, Brown University; Robert A. Wharton,Jr., Desert Research Institute, Biological Science Center, University of Nevada System; Christian Koeberl, Institute for Geochemistry, University of Vienna; Christopher P. McKay, Space Science Division, NASA Ames Research Center; Loren A. Foster and Peter A.J. Englert, Department of Chemistry, San Jose State University.

Intense investigation of Mars is one of the cornerstones of scientific exploration missions of many nations. One of the major goals is to explore and map the present mineralogical and chemical composition, to return samples and to obtain other significant information for manned missions to this planet.

One important aspect of geochemical mapping and rover/sample return is the question of finding evidence for the conditions that prevailed on Mars during its formative period [1]. The search for hydrogen/water below the surface of this planet is indeed very exciting.

A variety of scientific sources suggest that Mars had abundant water, warm temperatures, and a biologically favorable atmosphere [2-7]. If indeed life may have evolved on early Mars, it was associated with liquid water. Terrestrial analogues have been studied extensively [e.g. 8] as an important step in identifying the sites and evidence for past life on Mars. We report on a study of sedimentation at the perennially ice-covered Lake Hoare, Antarctica, through elemental analysis of a benthic core, obtained during the 1986/87 season. In addition, rock and soil samples from the lake environment were analyzed. Sediment formation at Lake Hoare affects, as well as is influenced by, biological activity under the ice. Ancient sediments that were formed similar to those of Lake Hoare may preserve evidence for biological activity on Mars. It is therefore important to understand the sediment formation process in the Lake Hoare environment.

The benthic core from Lake Hoare had a length of only 12.6 cm. Six layers of sedimentation could be distinguished. At the water/sediment interface was a silty material, followed by three layers of sand that could be differentiated by their color. The fourth layer was a mixture of sand and a little silt material, separated by a very thin layer of organic material in the middle. At the bottom of the tube was another layer of silt. Two soil samples were taken from the top of the ice cover and from the lake shore. Four typical rock samples from the area completed the set. The samples were dried at low temperatures, crushed, and homogenized. Up to 30 minor and trace elements were determined by instrumental neutron activation analysis and an additional three minor elements were determined by Direct Current Plasma spectroscopy in each of the samples. Additional analyses are in progress to obtain the complete composition. Selected results are presented in Figures 1 an 2.

Figure 1 shows the variation in Fe content and Figure 2 the differences in Zr and Rb concentrations for all samples (11-beach soil, 10-soil on ice, 1-top silt, 2-sand 1, 3-sand 2, 4-sand 3, 5-sand 4 top, 5a-sand 4 bottom, 6-bottom silt, 7-8-9-12-local rocks). Considering all elemental abundance data available the sediment formation processes at Lake Hoare seems to be complex. Major, minor and trace element patterns of each of the sediment layers differed significantly in some cases. This is obvious for the top and bottom silt layers of the investigated core. The top silt layer is enriched in almost all element abundances measured including the Rare Earth Elements, Uranium and Thorium by a factor of two over the bottom layer. The four sand layers show some variation in the iron concentration, but more significant variations in, e.g., Sr and Zr. REE patterns are almost identical for all sediments. The overall conclusion from these observations is that each of the two silts and four sands analyzed must have had a unique combination of source materials.

The assumed mechanism of sand accumulation in the sediments includes as a major source windblown debris that penetrates the ice surface [8]. For this study we had only one sample of soil recovered from the lake ice. The trace element contents of this material are significantly lower than that of both the silts and the sands in the sediment. This may, however, provide a hint on the variability of the source materials: the composition of windblown debris can be a function of many parameters, including wind direction and strength, so that a highly variable sediment source is suggested by our analyses.

The major source for the silt layers in the sediments of Lake Hoare should be water of the nearby Canada glacier, water from one Canada Glacier meltstream, and overflow from Lake Chad [9]. With only two silt layers analyzed, the observed chemical differences neither completely support nor reject the assumptions made about the sources.

As biological activity is normally associated with the silt layers, mineral formation through bacterial activity may also have enriched some elements.

Biological reduction of sulfate present can lead to precipitation of iron and other sulfide mineral forming elements from the water column [9,10]. The enrichment of all elements in the top silt layer compared to the deeper ones does not support such a process for the sediments analyzed.

The Na/K weight ratios in the sediments range from 0.64 and 1.01 for the top and bottom silt layer, respectively, to 1.19 for the third sand layer. The ratios throughout are lower than those of the surrounding rocks (>1.52), much lower than those for dissolved ions in the feeder streams (>3), and significantly lower than the Na/K ratio in the lake water column (>10). Our analysis provides evidence for the postulated selective potassium uptake by the sediments [9]. The mechanisms suggested are mineral reconstitution or reverse weathering.

One of the many important questions still to be resolved is the influence of biological activity on the chemical composition of the sediments formed. Further investigations of the presently studied sediment core and additional analyses of further cores are necessary to substantiate the preliminary results presented.

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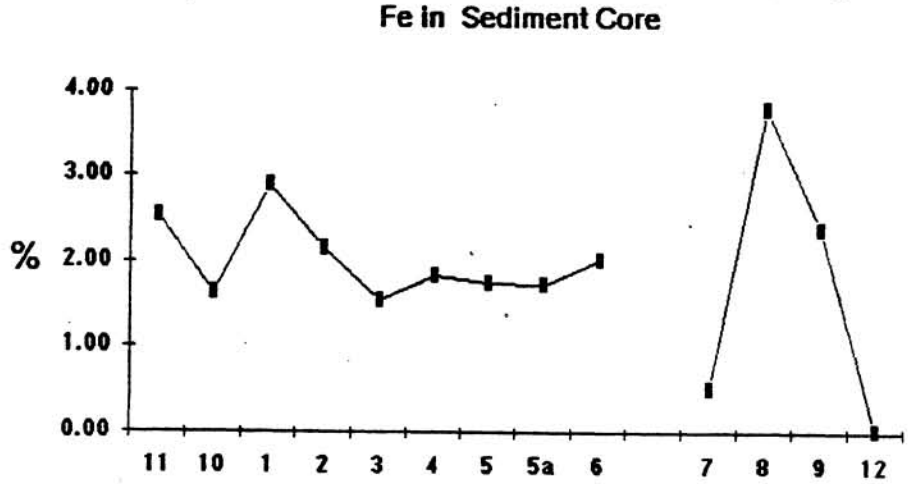

FIGURE 1

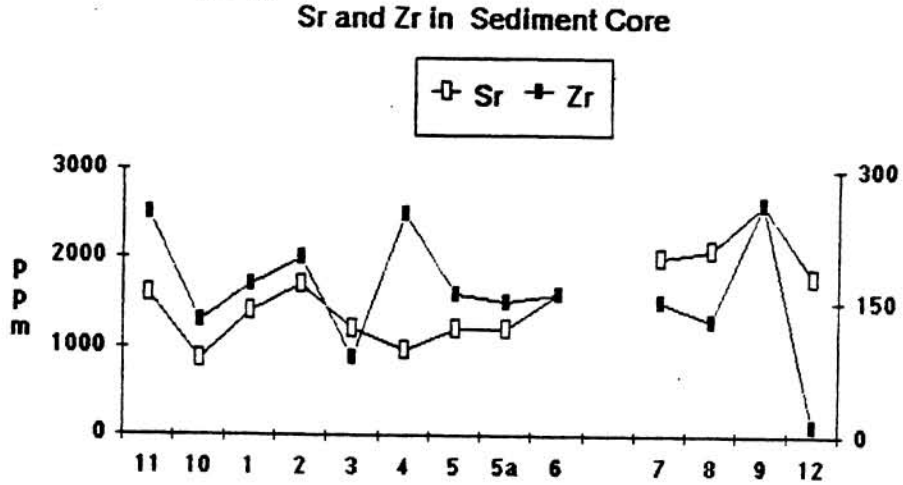

FIGURE 2