Deep weathering and mineralization in the Sirius Group: A Martian analogue in the Dry Valleys, Antarctica

W. W. DICKINSON[1]

[1] Antarctic Research Centre, Victoria University Wellington, PO Box 600, Wellington, New Zealand
Warren.Dickinson@VUW.AC.NZ

A large body of evidence suggests Antarctica has been a frozen continent for approximately 15 million years, and water has not flowed at high elevations (<1000 m) in the Dry Valleys for at least this long. The Sirius Group is a suite of consolidated glacial sediments pre-served in isolated outcrops at high elevations along the Transantarctic Mountains. Sandy facies of the Sirius Group at Table Mt may provide the best analogue on Earth for Martian sediments. On the surface the sand is weakly cemented with zeolite, but at depths generally below 50 cm it is ice cemented. Thin sections along with samples of ice from pores and fractures were taken from cores to depths of 9.5 m and analysed for stable isotopes and major ions.

The chemistry of this permafrost is extremely complex. Stable isotope values plot distinctly below the meteoric water line and become lighter with depth below the surface. Deuterium excess ranges from –75 $^{o}/oo$ at the surface to near 0 $^{o}/oo$ at depths of 3 – 4 m suggesting intense evaporation at the top of the ice cemented horizon. Cations and anions show no trends with depth, but the ice appears to be dominated by either sulphate or nitrate and chloride. Concentrations vary from nil to about 2000 ppm in chloride, and ionic ratios vary between ice samples taken only millimetres apart.

To explain these data, a conceptual model suggests that brine films from salts on the surface feed the under-lying ice cemented sediment. Major supporting evidence for brine-film recharge is the presence of dissolved feldspar grains and diagenetic chabazite and calcite cement, which are pervasive in the sediments from the surface to a depth of at least 9.5 m. The composition of fluids needed to dissolve and precipitate these minerals is not consistent with waters derived from glacial environ-ments, because chabazite and other zeolites are only known to form in alkaline Ca- and Na-rich brines. The transport of solutes along thin films is demonstrated by the dissolution and precipitation of minerals in an environment that has been frozen for the most part of 15 m.y. In the absence of flowing water, these processes allow large volumes of both water and salt to accumulate over long periods of time in the Antarctic permafrost.