SOILS AND WEATHERING PROCESSES IN THE DRY VALLEYS OF ANTARCTICA: ANALOGS OF THE MARTIAN REGOLITH. E.K. Gibson, Jr., Geochemistry Branch, NASA Johnson Space Center, Houston, TX, and Barbara Ransom, Lunar and Planetary Institute, Houston, TX (now at Geology Dept., Louisiana State University)

The Dry Valleys of Antarctica are considered by many workers (1,2) to be the best terrestrial analog of the surfacce of Mars. The weathering processes operating in the Dry Valleys are related to the Martian surface in the following manner: low temperatures (mean temperature of -17°C in Wright Valley), low absolute humidities, diurnal freeze-thaw cycles (even during daylight hours), low annual precipitations, desiccating winds, low magnetic fields, and oxidizing environment. In the Dry Valleys physical or mechanical weathering predominates over chemical weathering processes (3). Even though chemical alteration is a secondary weathering process in the Dry Valleys, it is still present and plays an important role in regolith processes. In order to better understand the formation and modification processes operating on the Martian surface, a suite of systematically sampled soils, rocks, and cores from the valleys and brine ponds of Taylor and Wright Dry Valleys in Antarctica were collected during the 1979-80 austral summer. The samples have been stored at temperatures below -10°C since their time of collection. This report will discuss the abundances of the carbon, sulfur, and water, along with water soluble cations and anions (e.g., \( \text{Ca}^{2+}, \text{Na}^+, \text{K}^+, \text{NO}_3^-, \text{SO}_4^{2-}, \text{and Cl}^- \)) and their relationships to the regolith processes of soils obtained from the Prospect Mesa Formation in Wright Valley.

Soils of the Prospect Mesa Formation are one of the oldest, if not the oldest, soils present in Antarctica (4). Soil samples were collected from a one-meter deep soil pit (Fig. 1) and these soils sampled the aeolian zone, salt formation zone, active zone, seasonally frozen zone, and permanently frozen zones. Soils were chemically analyzed and the results are data presented in Figures 2 and 3. The aeolian zone (top 2 cm) represents an area of deflation and showed slight depletions in total water, sulfur, chloride, sodium, potassium, and sulfate concentrations as compared to the salt layer immediately below this surface. Concentrations of sodium, chloride, nitrate, sulfate, potassium, and total sulfur were the highest in the salt or evaporite-rich zone. Sulfur concentrations as high as 2.21% were found. Concentrations of water soluble ions (\( \text{K}^+, \text{Ca}^{2+}, \text{SO}_4^{2-}, \text{NO}_3^-, \text{Na}^+, \text{and Cl}^- \)) systematically decreased (Fig. 3) in the zones above the permanently frozen ground (depth of 35 to 40 cm) and remained essentially constant below the permanently frozen ground (Fig. 3). This suggests that essentially no exchange or transport of these cations or anions is occurring and the major geochemical changes are occurring above the permafrost level. It is
interesting to note that the molar concentration ratio of Na\(^+\) to Cl\(^-\) was almost identical. The presence of halite is suggested by these results. Secondary minerals previously identified in the Dry Valley soils include the following: halite, mirabilite, bloedite, gypsum, calcite, aragonite, monohydro-calcite, soda niter, therardite, antarcticite, bishovite, sylvite, trona, and limonite (5,6). The sulfur enrichments in water soluble cations and anions near the surface represent addition of these components from lateral transport and not from upward movement through the soils.

Figure 2. Total carbon, sulfur, and water (-40° to 110°C fraction) of soils from soil pit shown in Figure 1. Sulfur and chlorine abundances for Mars from Clark (7).

A comparison of the total sulfur and water soluble chloride concentrations present in the Dry Valley soils with those measured at the Viking 1 and 2 sites on Mars is given in Figures 2 and 3. The S and Cl data are from Clark (7). The chloride concentrations (Fig. 3) in the Dry Valley soils from below the permafrost level are almost identical to the 15 soils analyzed on Mars. The sulfur concentrations (Fig. 2) from the salt-rich regions are similar to those reported for the Martian regolith. From the normal weathering processes operating in the cold environment of Antarctica on the source rocks (Beacon sandstone and Ferrar dolerite), the enriched sulfur and chlorine concentrations are similar to the soils analyzed on Mars. Thus, such enrichments can be produced by normal weathering processes, and no "exotic" sulfur- or chloride-rich source rocks are necessary.

An idealized soils profile for the regolith present in the Dry Valleys of Antarctica is given in Figure 4. This profile may be similar to the soil profile expected for the Martian regolith. The major difference between the situation in the Dry Valleys and Mars would be the depth of the permafrost layer. For the soil pit studied, the upper 40 cm (soil above the permafrost zone) may represent an expanded version of the Martian regolith where the permafrost layer is expected to be closer to the surface. From the initial studies of the Dry Valley soils, it is obvious that the detailed study of these samples will provide critical information to the understanding of processes operating within the Martian regolith.
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References:

Idealized Soil Profile for Dry Valleys, Antarctica

![Idealized Soil Profile](image)

Figure 4. Idealized soil profile from the Dry Valleys of Antarctica which is applicable to the Martian regolith. Most of the chemical alterations and secondary mineral formation occur within or above the active zone. The vertical scale or depth may vary depending upon the local environment. In the Dry Valleys of Antarctica most of the addition of cations and anions to the soils results from lateral transport processes and very little from the permafrost zone.