Soil Toxicity in Antarctic Dry Valleys[1]

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Soils collected in various dry valleys (Fig. 1) of southern Victoria Land during the antarctic summer of 1967-1968 have been examined at the Jet Propulsion Laboratory to determine their toxicity.

During a traverse made with Prof. Robert E. Benoit of the Virginia Polytechnic Institute, 18 soil samples were collected at depths up to four inches near the head of the Matterhorn Glacier in the Asgard Range (Fig. 2), on a ridge east of Rhone Glacier at 1,867 m, and in an intersecting east-west valley that extends from the Matterhorn to Lake Bonney in Taylor Valley at an elevation of 107 m. Two additional samples, nos. 632 and 639, were obtained on the northern side of the Asgard Range, above Wright Valley.

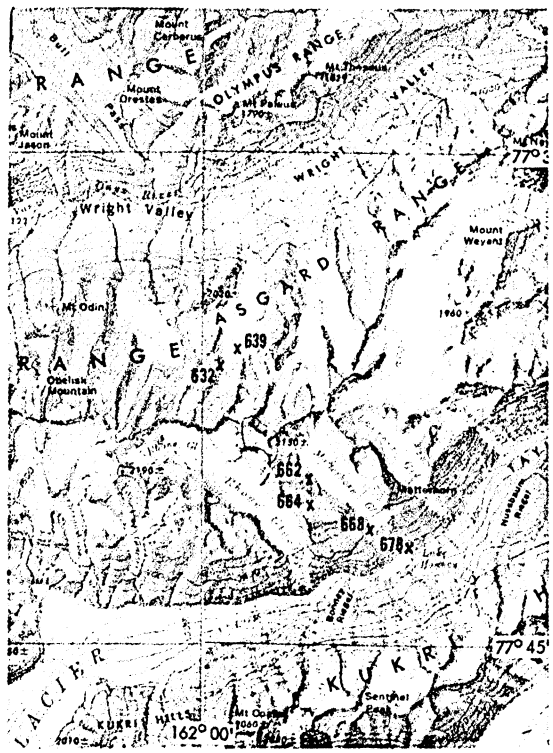

Figure 1. Location of antarctic soil-sample sites.

The soils were collected aseptically by techniques developed for sampling and handling desert soils (Cameron *et al.*, 1966). Microbiological analyses were performed by methods previously reported for samples from this region (Boyd *et al.*, 1966; Cameron, 1967).

Soil Toxicity Test

All samples were kept frozen until analyzed. Microbiological analyses were performed on the 18 samples while they contained the *in situ* moisture. All other analyses were performed on air-dried and sieved or powdered aliquots. The results of some of the an-

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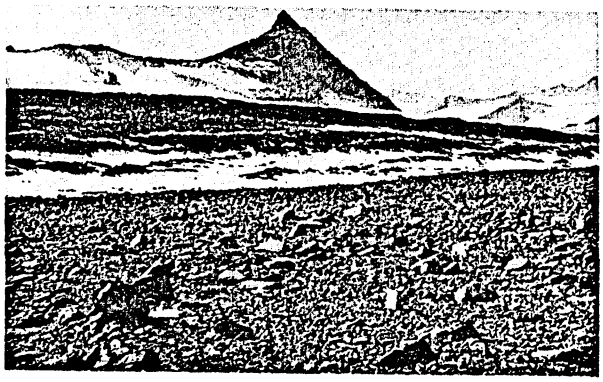

(*U.S. Navy Photo*)

Figure 2. Soil sample site 661-662, beside Matterhorn Glacier, Asgard Range.

alyses of cultures of various groups of microflora have been presented previously (Cameron *et al.*, 1968).

For this study, five grams of three soils believed to be toxic (nos. 664, 668, and 678) were mixed with five grams of viable sample no. 662 in 40 cm^3 of distilled water. Aliquots of appropriate serial dilutions were then pipetted onto the surface of Petri dishes containing either trypticase soy agar or simulated Taylor Valley soil extract enrichment agar to give final dilutions of 1:10, 1:50, and 1:500. Spread plates were then prepared in triplicate and the organisms incubated at 20° C. for three weeks, following which the plates were examined with an illuminated Quebec counter. Ten grams of each soil was cultured separately for comparison.

The numbers of bacteria found on the agar plates upon conclusion of the test are given in the table. Values for the mixed samples were adjusted to 10 g of soil. As indicated in the table, the mixing of viable sample no. 662 with each of the three soils believed to be toxic resulted in significant reductions in the expected count of the viable sample (about 30–70 percent on trypticase soy agar and about 80–90 percent on the simulated Taylor Valley soil extract enrichment agar).

Chemical analyses of the four soils showed that nos. 664, 668, and 678 contained higher concentrations of water-soluble cations and anions than no. 662. In order of abundance, these ions included chloride, sulfate, sodium, calcium, magnesium, potassium, and nitrate. The microelement boron was present at levels of 7–16 ppm, which could definitely present a toxicity problem (Stout *and* Johnson, 1957). Of nearly all the soils tested chemically, no. 664 had the least favorable chemical properties, although in terms of physical properties (*i.e.*, texture, moisture, and porosity) it was one of the most favorable collected in the antarctic dry valleys.

Unfavorable Environments

A fourth soil, no. 632 (Fig. 1), collected in King Valley* in the Asgard Range, was also tested for soil toxicity because it yielded no microorganisms by culture techniques. This soil was combined with viable sample no. 639, collected below the junction of King and David Valleys*. It was not toxic, since the bacteria count per gram of soil was essentially the same for no. 639 as for nos. 639 + 632. This test indicates that in some cases factors other than chemistry are important in limiting the numbers of microorganisms in these soils. Unfavorable environmental factors include primarily poor exposure and slope, low level and duration of solar-radiation influx, desiccating winds, and very low moisture supply. Favorable and unfavorable ecological factors in antarctic dry valleys have been discussed previously (Cameron *et al.*, 1968).

This study suggests that toxicity is responsible for the absence or near absence of microorganisms in three antarctic soil samples. Unfavorable environments have also been shown to be responsible for the absence of microorganisms even when the soils had favorable physical and chemical properties. Both edaphic and environmental (microclimatic and topographic) factors must be considered in attempts to explain the presence or absence of life in antarctic soils. For the purposes of detecting life on Mars and

* Unofficial names.

Abundance of bacteria in Asgard Range soils

Soil no.	Colony count (per gram of soil)			
	Trypticase soy agar		Simulated Taylor Valley soil extract enrichment agar [1]	
	Actual	Expected	Actual	Expected
662	52,500		85,000	
664	0		0	
668	15		10	
678	5		20	
639	72,500		74,000	
632	0		0	
Test Soils:				
662+664	18,500 [2]	52,500	7,800 [2]	85,000
662+668	35,000 [2]	52,500	16,500 [2]	85,000
662+678	17,000 [2]	52,500	15,100 [2]	85,000
639+632	77,000 [2]	72,500	68,000 [2]	74,000

[1] An analysis was made of Taylor Valley soil extract prepared by Prof. Robert E. Benoit. On the basis of this analysis, and the Taylor Valley soil extract enrichment used successfully by Prof. Benoit, the following medium was prepared:

$CaSO_4$	0.2 g	Neopeptone	5 g
K_2HPO_4	0.1 g	Yeast extract	1 g
NaCl	0.03 g	Agar	15 g
$NaNO_3$	0.03 g	Dist. H_2O	1 l
$MgCl_2$	0.03 g		

[2] Compensated to approximate original 10-g sample; i.e., results are based on 5-g sample x 2 for viable test soil.

avoiding contamination of the planet's surface by terrestial microorganisms, similar soil and environmental factors should be considered.

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