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SOIL MICROBIAL ECOLOGY OF WHEELER VALLEY, ANTARCTICA

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During Antarctic austral summer 1967–1968, soil ecological and microbiological investigations were undertaken in the dry valleys of southern Victoria Land. These studies were a continuation of 1966–1967 investigations, some of which were made in cooperation with Prof. Robert E. Benoit, Virginia Polytechnic Institute (2, 3).[2] The objectives are to determine the relationships of soil, microclimate, and habitat with the numbers, distribution, kinds and activities of microorganisms in the Antarctic cold deserts. These objectives are subordinate to the main objective, which is to obtain information on the ecology of cold polar, temperate and hot desert areas before detecting possible life in extraterrestrial environments, such as Mars (7, 9, 20). Although the Antarctic dry valleys are not "Martian," they approach some expected conditions in terms of low magnetic field, comparatively high UV irradiation, desiccating winds and low humidities, similar temperature conditions (−50° C to +20° C vs ~ −70° C to +20° C for Mars), diurnal freeze-thaw cycles, permafrost and moisture-holding salts, and surface or subsurface microbial life as the only possible life forms. Salty, deliquescent surface soils or subsurface permafrost, especially in the vicinity of glacial melt in Antarctic dry valleys, may provide analagous environments approaching those on Mars.

The dry valleys were found to show a gradient in environmental factors and the resultant density and variety of organisms (14). Following the recording of observations and measurements for a week or more at sites in McKelvey, Victoria and Taylor Valleys during austral summers 1966–1967 and 1967–1968, a subsequent study was made at Wheeler Valley (fig. 1), because it possessed a more favorable environment for life than the other dry valleys. Results of a more favorable environment were indicated by the visible presence of soil algal mats and crusts (2),[3] such as are observed in temperate desert soils. A campsite was subsequently established in the southwest end of the Valley, fig. 2, south of Lake Hall.[4]

Observations in Wheeler Valley

Wheeler Valley is located at 77°12′ S and 162°42′ E. It contains an area of ~5 km², with elevations of ~1600 m. in the southwest, sloping to ~1000 m. in the northeast. It has an orientation of 45° E and 135° W with a steep drop at right angles to Miller Glacier, opposite Killer Ridge. Four remnants of a cirque glacier are evident in the SW of the valley, with drainage patterns and solifluction lobes sloping toward Lake Hall, a shallow lake directly connected to a glacial remnant with a northeastern exposure. Surrounding the valley, except at its face, are mountains of ~1800 m. in elevation, which interrupt the low angle of incident solar radiation and provide the valley with diurnal fluctuations of visible light, heat, and relative humidity, even during mid-summer.

It is evident from observations of marginal lake freezing and thawing, as well as measurements of temperature, relative humidity, evapo-

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[2] Hall, C. L. 1968 "Isolation of psychrophilic halophiles from the Antarctic polar desert." M.S. thesis, unpublished. Virginia Polytechnic Institute, Blacksburg. 55 pp.

[3] R. E. Benoit. Unpublished data.

[4] Unofficial name.

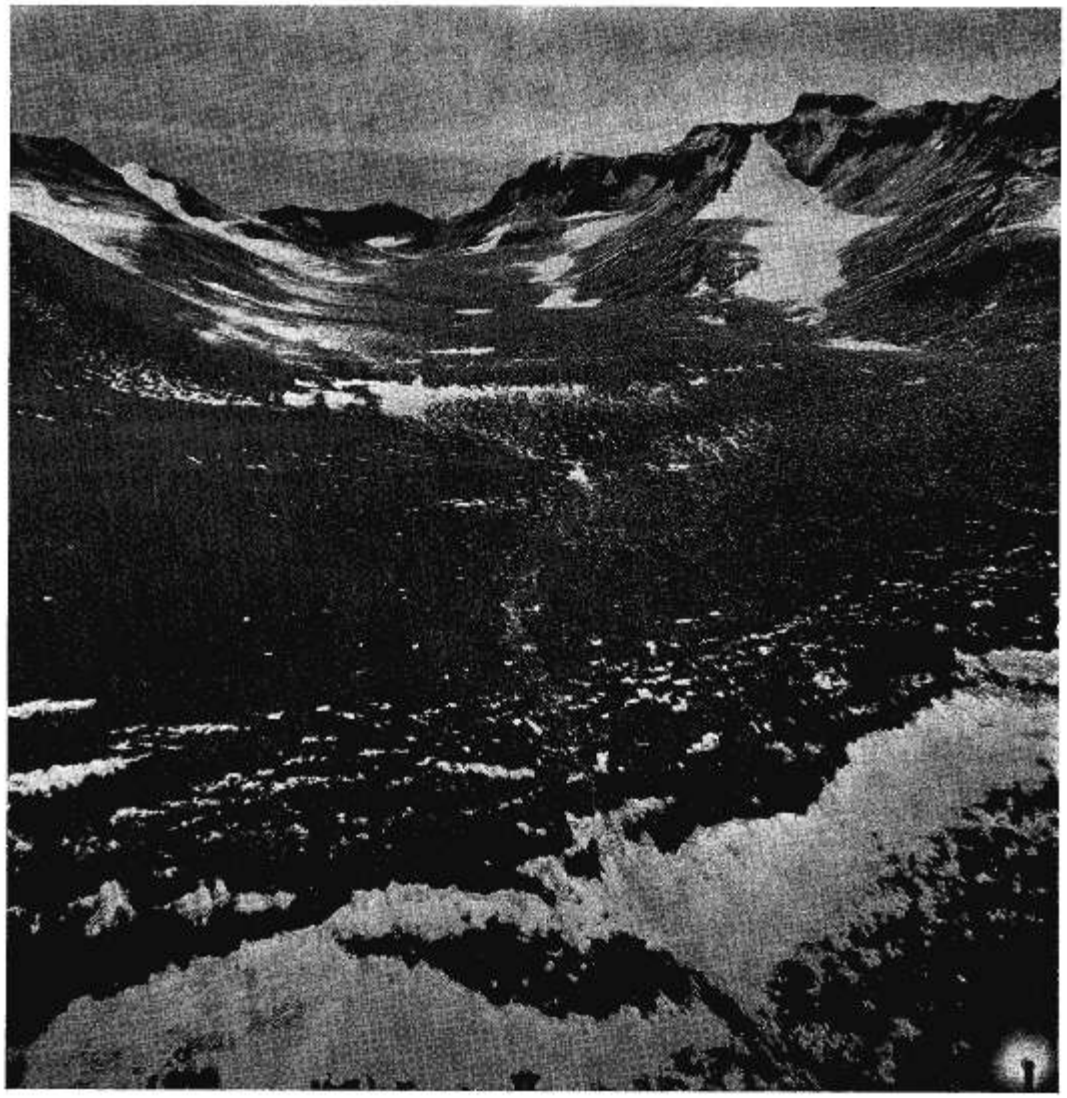

FIG. 1. Southwestern view of entire length of Wheeler Valley, Southern Victoria Land, Antarctica. (U. S. Navy Photo.)

ration rate, and solar radiation flux, that Wheeler Valley, in common with nearly all the other dry valleys, is subject to diurnal-freeze thaw cycles, with temperatures below freezing during the late afternoon through early morning. For the period of recorded measurements, December 27, 1967 to January 4, 1968, maximum temperatures were as follows: air 1 m. = +1° C, soil surface, = +15° C; soil 5 cm. = +7° C; soil 15 cm. = +1.5° C. Minimum temperatures were air 1 m. = −12° C, soil surface, = −5.8° C; soil 5 cm. = −0.3° C; soil 15 cm. = −0.4° C. The icy-hard permafrost layer (frozen ground table) was at ~15 cm. Soil and air relative humidity measurements for this valley, as well as for three other dry valley sites, have been given previously (11). Wheeler Valley generally had a higher relative humidity of both soil and air than McKelvey, Victoria, Taylor, and King-David Valleys.[4]

In Wheeler Valley, as in McKelvey Valley, most of the boulders, except at the mouth of the

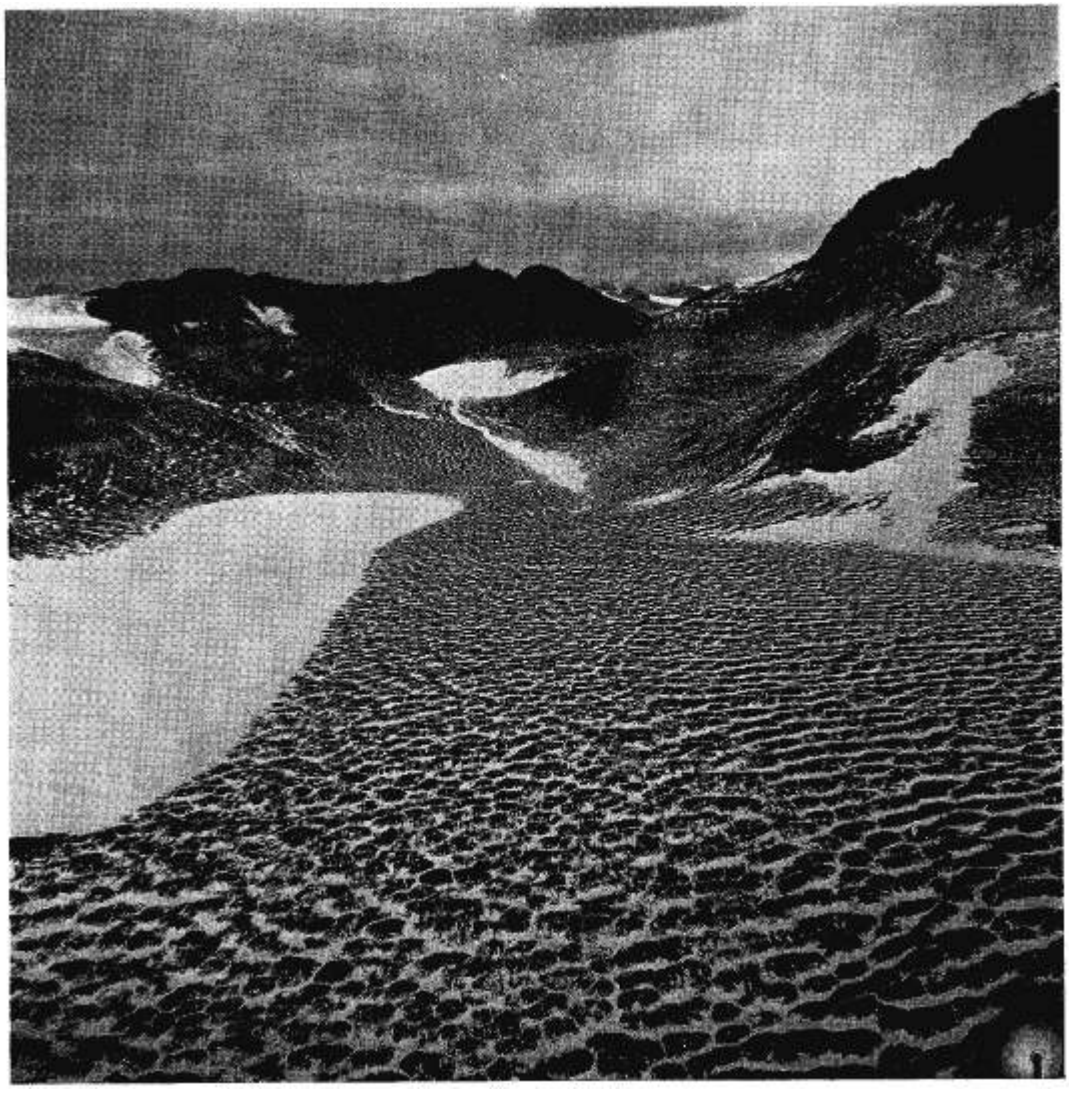

FIG. 2. Southwestern enclosed end of Wheeler Valley, showing patterned ground, Lake Hall, and mountains with glacial remnants. Environmental measurements were taken at temporary camp location near tip of lake. (U. S. Navy Photo.)

valley, have been reduced to ground level. Most of them are of the more resistant rock types, including ~80 per cent medium or fine-grained dolerite, with remaining fractions composed of sandstone, granite gneiss, silicious siltstones, schists and quartzites. These occur as a desert or lag pavement of pebble and gravel-sized fragments in a rolling terrain of swales and depressions intersected by conspicuous frost-crack polygons, figs. 1, 2. Desert varnish was not as evident as in drier McKelvey Valley, which has very few polygons in the valley proper. Surficial salt deposits are generally inconspicuous in Wheeler Valley, but secondary salts are sometimes present on the underside of cobbles. Jackhammer excavation showed a soil with very weak profile development and no evidence of compound structure, (fig. 3).

Field and laboratory methods

Soil samples were collected from six sites made during a traverse of the valley. Samples were

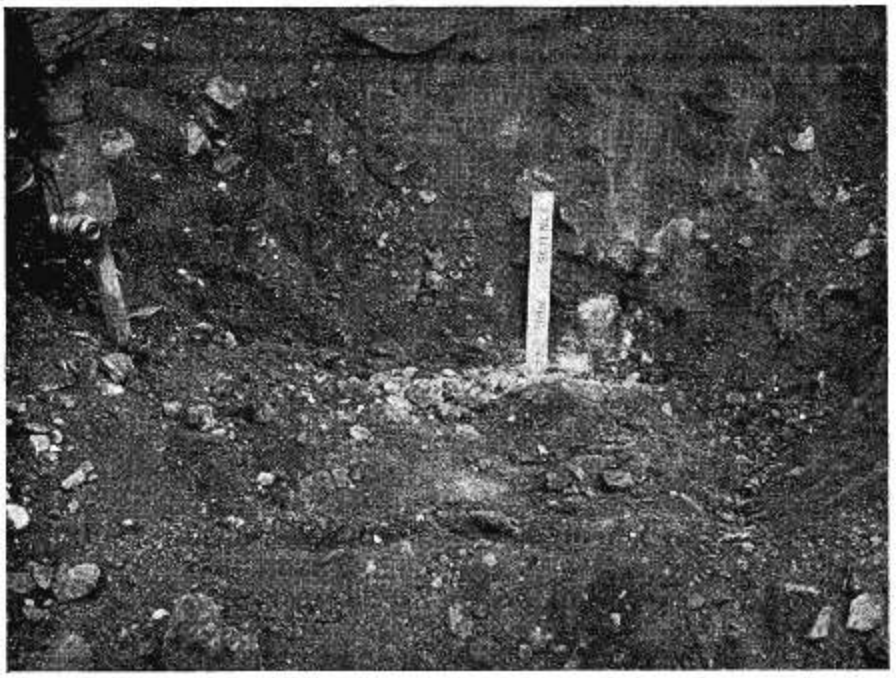

FIG. 3. Soil sample site 609–612, showing Jack-hammer excavation of exposed soil profile and frozen ground table.

collected by aseptic techniques previously developed for desert soils (10). Standard methods recommended for arid soils were used for the determination of soil texture, pH, and electrical conductivity (23). Using micro techniques, organic and inorganic carbon were analyzed by wet combustion and gravimetric determination of absorbed CO_2, and nitrogen was determined by the Kjeldahl method (21). All cations and anions were determined by colorimetry, flame photometry, or atomic absorption spectrometry following 1:5 soil water extraction (15, 21). The modified barium-chloride triethanolamine procedure was used to determine cation exchange capacity (15).

Soil microbiological properties were analyzed by inoculation and incubation into commercially available media (BBL or Difco). The following special media were also used: simulated Taylor valley salts with added organics (13), Burk's agar (1), Van Delden's agar (1), Thornton's standard salt medium (1), and yeast agar (18). Incubations were from 15 days to 3 months, usually at 20° C but 2°, 25°, 37°, and 55° C were employed in some cases. Anaerobic incubations were carried out under CO_2.

Results and discussion

Soil physical and chemical properties are given in table 1 for the 15 samples collected from six sites. The soils are mostly coarse-textured, brownish or yellowish sands, although there is some increase in fines and lighter colored materials with proximity to icy-hard permafrost or frozen ground table. As has been noted for other dry valleys investigated (2, 11), there is also a noticeable increase in moisture content and relative humidity with depth of soil to the frozen ground table. In this respect, Wheeler, King-David, and eastern Balham Valleys were the wettest valleys, and they also have somewhat similar orientations.

The pH values, electrical conductivities, and predominance and proportions of ions on the exchange complex are indicative of weakly saline, normal or calcareous cold desert soils (24–26).[5] Only three of the 15 samples contained almost

[5] Some of the soil analyses were performed by G. Conrey, H. P. Conrow, E. S. Babcock & Sons, Riverside, Calif., and Elek Microanalytical Labs., Torrance, Calif. Some of the microbiological analyses were performed by D. R. Gensel.

TABLE 1

Wheeler Valley, Antarctica. Soil physical and chemical properties.

SOIL No.	DEPTH cm	SOIL TEXTURE	COLOR AND MUNSELL NOTATION, AIR DRY	IN SITU MOISTURE WT %	pH SATURATED PASTE	ELECTRICAL CONDUCTIVITY EC x 10^6 mhos/ cm^2 AT 25°C 1:5 EXTRACT	IONS ppm IN 1:5, SOIL: H_2O EXTRACT									ORGANIC C WT %	ORGANIC N WT %	CARBONATE C WT %	CATION EXCHANGE CAPACITY meq/100 gm
							Na^+	K^+	Ca^{++}	Mg^{++}	Cl^-	$SO_4^=$	HCO_3^-	NO_3^-	$PO_4^{\equiv}$				
609	SURFACE 2	SAND	10 YR 5/3 BROWN	0.75	8.3	792	37	3.	1	1	16	24	37	4	0.4	0.05	0.007	0.04	6
610	2 → 15	SAND	2.5Y GREYISH BROWN	1.66	8.6	73	6	2	0.1	0.4	2	0	15	1	0.3	0.01	0.003	0.02	5
611	30*	LOAMY SAND	2.5Y 7/6 YELLOW	9.5	8.0	688	20	4	3	3	23	6	40	5	0.3	0.01	0.003	0.02	6
612	60*	LOAMY SAND	2.5Y 7/6 YELLOW	144.*	7.9	780	27	3	20	6	39	62	24	11	0.2	0.02	0.004	0.01	6
613	SURFACE 2	SAND	2.5Y 5/2 GREYISH BROWN	0.68	8.4	198	14	4	2	1	11	6	30	2	0.2	0.04	0.007	0.04	5
614	2 → 10	SAND	2.5Y 6/2 LT GREYISH BROWN	2.12	8.6	109	6	4	0.5	1	7	0	18	0	0.4	0.03	0.005	0.02	6
615	SURFACE 2	SAND	2.5Y 5/2 GREYISH BROWN	4.3	8.1	1278	21	8	20	5	41	15	61	7	0.2	0.17	0.024	0.06	2.5
616	2 → 10	SANDY LOAM	2.5Y 6/2 LT GREYISH BROWN	7.3	8.6	135	5	5	0.5	1	4	0	15	0	0.2	0.03	0.004	0.03	3.5
617	SURFACE 2	SAND	10 YR 5/3 BROWN	1.35	7.2	416	18	2	4	1	2	21	37	0	0.3	0.04	0.007	0.03	3.5
618	2 → 10	SAND	10 YR 6/3 PALE BROWN	2.82	8.1	146	6	2	0.6	0.5	2	0	18	2	0.2	0.04	0.005	0.02	3.5
619	SURFACE 2	SAND	10 YR 5/3 BROWN	1.32	7.8	951	39	4	18	3	13	76	61	0	0.2	0.06	0.010	0.03	3
620	2 → 10	SAND	10 YR 6/3 PALE BROWN	2.27	8.2	120	4	3	0.2	0.3	2	0	15	0	0.3	0.02	0.002	0.02	3
621	SURFACE	SAND	2.5Y 5/2 GREYISH BROWN	5.1	8.8	215	14	3	0.6	1	2	0	43	0	0.4	0.03	0.004	0.02	3
622	2 → 15	SAND	2.5Y 6/2 LT BROWNISH GREY	7.3	8.4	81	3	3	0.3	1	4	0	12	0	0.02	0.03	0.005	0.02	3
623	18 → 33*	SANDY LOAM	10 YR 6/3 PALE BROWN	41.5	8.0	261	9	4	12	2	7	4	55	2	0.3	0.03	0.007	0.03	9

*ICY-HARD PERMAFROST

*GREATER % ICE THAN SOIL

as much Ca^{++} as Na^{+}. The principle anions were Cl^{-} and HCO_3^{-}, but some samples contained significant concentrations of $SO_4^{=}$. The variable distribution of small concentrations of gypsum would indicate that local factors, rather than the overall aridity of the valley, contributed to the upward movement of salts. The relationship between aridity, movement of salts and leaching of Antarctic soils has been indicated by Claridge (16), Claridge and Campbell (17), and McCraw (22). Both NO_3^{-} and $PO_4^{\equiv}$ are present in low concentration, or are undetectable and comparable to values for other arid regions. Organic C and N, except for one soil, No. 615, which contained discernible organic matter, are quite low. The organic C corresponds to the lowest values obtained for typical desert soils of temperate regions, e.g., western U. S., the Sahara, Negev, Patagonian, and Atacama Deserts (9). Cation exchange capacities compare favorably with low values obtained for western U. S. desert areas, but are generally higher than those obtained for the salty Chilean Atacama Desert (7, 9).

Soil microbiological properties are given in tables 2 and 3 for bacteria, fungi, algae and protozoa. The "standard" determinations which were used for the cultural detection and enumeration of microorganisms are presented in table 2; "supplementary" tests which were performed to confirm or obtain further information on physiological groups of microorganisms are shown in table 3. As indicated in these tables, the total abundances of microorganisms cultured at 20° C or room temperature were between 10^3–10^6/g of soil. One soil, No. 615, contained $\sim 10^7$ microorganisms/g. of soil. This sample was from a site that contained both lichens and mosses in addition to algal crusts. The abundance of aerobic bacteria is comparable to that found in typical temperate or hot desert soils (9), but higher than for drier sites in McKelvey, Taylor, Victoria, or Wright Valleys and the Asgard Range (2, 3, 6, 14, 20).

In general, similar abundances of bacteria were obtained, frequently within one log unit, whether the culture medium was trypticase soy agar (TSA), simulated Taylor Valley salts-organic agar (STV), trypticase soy broth (TSB), or fluid thioglycollate. Nitrate reduction broth and actinomycete isolation agar were also good media, but results were more variable with lactose broth, Burk's agar and Van Delden's agar. Bacterial abundances obtained with Burk's agar do not necessarily indicate strict nitrogen-fixers, even though ion agar and deionized-redistilled water were used. For some samples, there is obviously a carry-over of NO_3^{-} or organic N in the soil dilutions, table 1. For the three permafrost samples, fewer bacteria were isolated at 2° C than at 20° C with TSA. Lengthening the incubation period beyond five to six weeks may show further growth of colonies (3, 12).[3]

In addition to the bacteria found in all samples, the algae were also present at all sites, both in surface and subsurface samples. In soil No. 615 they were as abundant as the bacteria. Streptomycetes were detected in five of the six sites, but not at all depths. Fungi (molds and/or yeasts) and protozoa were present in four of the six sites, but were considerably less abundant than the bacteria and less abundant than the algae. Some of the fungi grew at 20° C as well as 2° C; yeasts were isolated only at 2° C, indicating their psychrophilic nature. Despite the high soil pH values, table 1, the yeasts were cultured at pH 4.5, and some bacteria, streptomycetes, and fungi grew on sulfate reduction agar at pH 5.8.

Some groups of microorganisms were not present in our samples as determined by culture methods. These included coliforms and thermophiles, although they have been previously reported for Antarctic soils, where it was indicated that they were in areas of known human and animal contamination (4, 5). Coliforms apparently survive for only a short time in Antarctic soils (4), and also in other desert soils unless the contamination is recent, heavy, or continual, and kept moist (9). Thermophiles may survive for longer time periods (5). In our first analyses of Antarctic soils samples, we obtained one bacillus that grew at +55° C (8) and several have been subsequently isolated that will grow at +45° C. This is probably indicative of contamination during sampling procedures, or possibly from previous investigators, transitory animal invaders, or droppings from skuas flying through the valleys.

One or two possible anaerobes per gram of soil were found in two subsurface samples at one site near the center of the valley. These microorganisms were cultured from the permafrost samples procured by jack-hammer dislodgment,

TABLE 2

Wheeler Valley, Antarctica. Microbial abundance, "Standard Determinations." Microorganisms/g of soil.

SOIL No.	SAMPLE DEPTH cm	AEROBIC BACTERIA AND STREPTOMYCETES				MICROAEROPHILES POSITIVES AT HIGHEST DILUTION*	ANAEROBES	FUNGI			ALGAE POSITIVES AT HIGHEST DILUTION	PROTOZOA POSITIVES AT HIGHEST DILUTION
								MOLDS	YEASTS			
		+2°C	+20°C	+2°C	+20°C	+20°C	ROOM TEMP	+20°C	+2°C	+20°C	ROOM TEMP	ROOM TEMP
609	SURFACE 2	1.8×10^4	2×10^4	2×10^4	3.2×10^4	6.4×10^4 (1)*	0	20	0	0	2×10^3	200
610	2 —→15	4.4×10^4	4.8×10^4	6.4×10^4	1.2×10^5	3.2×10^4 (1)*	0	0	0	0	2×10^3	0
611	30	4.8×10^3	7.8×10^3	6.2×10^3	5.8×10^3	6.4×10^4	2	0	0	0	20	0
612	60	100	1.3×10^3	200	2.2×10^3	3.2×10^3 (1)*	0.5	0	0	0	200	0
613	SURFACE 2	4×10^4	2×10^4	1×10^4	3×10^3	6.4×10^4 (1)*	0	0	0	0	800	40
614	2 —→10	1×10^3	1×10^4	3×10^3	2×10^4	1.3×10^6 (12)*	0	0	0	0	800	0
615	SURFACE 2	1.2×10^5	1.2×10^5	9.6×10^4	1.5×10^5	1.3×10^6 (3)*	0	200	2	0	6.4×10^6	40
616	2 —→10	1×10^5	2×10^5	2×10^5	2×10^5	1.3×10^6 (18)*	0	25	12	0	800	2
617	SURFACE 2	200	3×10^3	2×10^3	2×10^3	1.3×10^6	0	35	0	0	2	0
618	2 —→10	6×10^3	1×10^4	1×10^4	2×10^4	1.3×10^6	0	15	0	0	40	0
619	SURFACE 2	1×10^3	8×10^3	8×10^3	1×10^4	3.2×10^3	0	50	0	0	40	0
620	2 —→10	2×10^3	2×10^4	2×10^4	1×10^5	1.3×10^6	0	200	0	0	1.6×10^3	0
621	SURFACE 2	1×10^3	3×10^3	4×10^3	2×10^4	6.4×10^4 (4)*	0	0	4	0	1.6×10^3	2
622	2 —→15	1×10^4	2×10^4	4×10^4	6×10^4	1.3×10^6	0	0	0	0	800	0
623	18 —→33	500	1×10^3	1×10^3	3×10^3	3.2×10^3 (2)*	0	0	0	0	40	0
MEDIA		TRYPTICASE SOY AGAR		SALTS (SIMULATED TAYLOR VALLEY) + YEAST EXTRACT + NEOPEPTONE (STV AGAR)		FLUID THIOGLYCOLLATE MEDIUM *COLONY COUNT, WHERE DISCERNIBLE. ALL COLONIES SUB-SURFACE AT HIGHEST DILUTIONS	AVERAGE RESULTS OF TSA IN CO_2, ANAEROBIC AGAR + DEXTROSE IN CO_2, STV IN CO_2	ROSE BENGAL AGAR APPROX SAME RESULTS WITH TSA AT 2°C AND 20°C	DIMENNA'S DEXTROSE-NEOPEPTONE AGAR, pH 4.5		THORNTON'S SALT MEDIUM (WITHOUT ORGANICS) SYLVANIA GRO-LUX FLUORESCENT LIGHTS, ~250 ft.cd. INTENSITY	

TABLE 3

Wheeler Valley, Antarctica. Microbial abundance, "Supplementary Determinations." Microorganisms/g of soil.

SOIL No.	SAMPLE DEPTH cm	AEROBIC BACTERIA AND STREPTOMYCETES POSITIVES AT HIGHEST DILUTION			LACTOSE FERMENTERS POSITIVES AT HIGHEST DILUTION	NITRATE REDUCERS POSITIVES AT HIGHEST DILUTION	NITROGEN FIXERS	SULFATE REDUCERS	COLIFORMS
		+20°C	+20°C	+55°C	+20°C	+20°C	+20°C	+20°C	+20°C, +37°C
609	SURFACE 2	6.3×10^6	$1.9 \times 10^{3*}$	0	3.2×10^3	3.2×10^3	< 10	900	0
610	2 → 15	6.4×10^4	$1.3 \times 10^{4*}$	0	3.2×10^3	3.2×10^3	9.6×10^3	8.8×10^3	0
611	30	6.4×10^4	$2.5 \times 10^{3*}$	0	3.2×10^3	6.3×10^6	320	550	0
612	60	3.2×10^3	$2.8 \times 10^{3*}$	0	3.2×10^3	3.2×10^3	250	250	0
613	SURFACE 2	6.4×10^4	8×10^4	0	160	3.2×10^3	3×10^3	5×10^5	0
614	2 → 10	6.4×10^4	1×10^5	0	160	3.2×10^3	8×10^4	2×10^5	0
615	SURFACE 2	1.3×10^6	$1 \times 10^{5*}$	0	6.4×10^4	1.3×10^6	7×10^4	2×10^5	0
616	2 → 10	1.3×10^6	$5 \times 10^{5*}$	0	6.4×10^4	6.4×10^6	4×10^5	6×10^5	0
617	SURFACE 2	3.2×10^3	$2 \times 10^{3*}$	0	160	3.2×10^3	2×10^3	800	0
618	2 → 10	6.4×10^4	8×10^3	0	3.2×10^3	6.4×10^4	8×10^3	4×10^3	0
619	SURFACE 2	6.4×10^4	$\sim 10^{4*}$	0	160	160	5×10^3	2×10^3	0
620	2 → 10	1.3×10^6	$> 10^{4*}$	0	160	6.4×10^4	6×10^3	3×10^3	0
621	SURFACE 2	3.2×10^3	$3 \times 10^{3*}$	0	160	3.2×10^3	1×10^3	200	0
622	2 → 15	6.4×10^4	$\sim 10^4$	0	6.4×10^4	6.4×10^4	$\sim 10^4$	$\sim 10^4$	0
623	18 → 33	6.4×10^4	3×10^3	0	3.2×10^4	6.4×10^4	600	800	0
MEDIA		TRYPTICASE SOY BROTH	ACTINOMYCETE ISOLATION AGAR *STREPTOMYCETES PRESENT	TRYPTICASE SOY AGAR	LACTOSE BROTH	NITRATE REDUCTION BROTH	BURK'S N-FREE "ION AGAR"	VAN DELDEN'S SULFATE REDUCTION "ION AGAR"	DESOXYCHOLATE AGAR

TABLE 4

Wheeler Valley, Antarctica. Relative abundance of bacterial colonies. (All cultures, 2°C and 20°C.)

SOIL No.	SOIL DEPTH cm	SMOOTH WHITE	PINPOINT	CRENATED GREY	OPALESCENT	YELLOW	ORANGE	RED	PINK	STREPTOMYCETES
609	SURFACE 2	++		+	++	++		+	++	+
610	2 —→15	++		+	++					+
611	30	+		+	++					+
612	60	+++			++		+	+		+
613	SURFACE 2	+	++	+	+++	++		++	++	
614	2 —→10	++	++	+	++	+			+	
615	SURFACE 2	++			++	+	+	+		+
616	2 —→10	++		+	++					+
617	SURFACE 2	+		++	+	+		+	+	++
618	2 —→10	+++	++	+	++		+			
619	SURFACE 2	+			++					+++
620	2 —→10	+			++					+++
621	SURFACE	++			++	++		++		+
622	2 —→15	+++		+	++	+	+	++	+	
623	18 —→33	+++	+		++	+				

\+ = <10% OF BACTERIAL POPULATIONS

++ = ~10 —→40% OF BACTERIAL POPULATIONS

+++ = >40% OF BACTERIAL POPULATIONS

fig. 3. They were cream-colored composed of bacilli that appeared on TSA in a CO_2 chamber after 30 days incubation. The cultures were nonviable following their return to JPL for further study. A previous report of anaerobes in Antarctic dry valley soils is not valid because of failure to obtain anaerobic conditions in a chamber containing pyrogallic acid and NaOH (8). Reculturing in CO_2 gave negative results.

An attempt was made to determine proportions of morphologically different bacterial populations in the samples, table 4. All of the soils contained white or cream-colored, opalescent or translucent colonies, regardless of sample depth. In nearly all samples, these microorganisms were the most abundantly distributed. Pigmented colonies, except for orange ones, were most frequently isolated from the surface samples. Pale yellow colonies on STV were white on TSA and also isolated from some subsurface soils. Streptomycetes were found throughout the profile, either at the surface or below the surface. The diptheroids were usually white, grey, or cream-colored, and the *Mycococcus* spp. were opalescent, translucent, or sometimes pigmented. As indicated previously, the soil diphtheroids are composed of at least a half dozen related genera that have not been well-defined (9). Depending upon the culturing conditions and time of observation, they have been found to be primarily pleomorphic cocci-rods. These include species presently classified in such diverse groups as *Arthrobacter, Brevibacterium, Corynebacterium, Mycobacterium, Mycococcus, Nocardia,* and *Protoactinomyces.*[6] Pigmented colonies were usually *Micrococcoccus* spp., and had a greater tendency to develop pigment on STV agar. The streptomycetes were represented only by *Streptomyces longisporoflavus,* which occurred throughout the valley in both surface and subsurface samples.[6]

The algae were represented by xeric, mesophytic and mesothermic species which are mor-

[6] Bollen, W. B., Byers, K., and Nishikawa, S. 1965–1969 Desert soil microorganism study. Systematic key and description of isolants. Oregon State University, Corvallis, Oregon. Progress Reports, JPL Contract #950783.

phologically similar to those found in temperate or hot deserts (10). These were primarily nonsporeforming filamentous and coccoid blue-green algae, e.g., *Schizothrix calcicola, Microcoleus vaginatus,* and *Anacystis montana.* A coccoid green alga, resembling the form popularly known as *Trebouxia* sp., was observed in cultures of soil No. 615, which was collected in the vicinity of lichens and also developed an abundance of moss protenema. Protozoa observed in the algal cultures were amoeboid or flagellated forms, *Pelomyxa* spp. or *Cercomastix* spp. Fungi included *Penicillium* spp. or members of the *Moniliaceae,* which are among the most frequently observed molds in typical desert soils.[7] *Crypticoccus albidus* and *Pullularia pullulans* were two of the identifiable yeasts.[8]

The investigation of Wheeler Valley yielded further results in support of ecological factors that determine the distribution, diversity and abundance of populations in the dry valleys (14). Wheeler Valley, as a whole, has one of the most favorable environments for life in the dry valley systems. This can be observed or measured in terms of valley orientation, exposure, slope, drainage, solar radiation, temperature, relative humidity, microclimate, the length and duration of available water, wind pattern, and presence of non-salty soils with a relatively balanced ionic composition. The presence of glacial remnants facing a northern exposure is especially important for providing melt water for growth and activities of microorganisms, and they are largely responsible for the diversity and abundance of microorganisms in this valley.

Although only three permafrost samples were taken from two sites, it is quite probable that these samples contained indigenous populations. Microorganisms are not subject to desiccation in this habitat, and relatively high population levels can be maintained in the frozen state, as shown by long term incubation of subsurface samples (12). Their regeneration time is slower than for the surface microflora (21) which may indicate a past history of prolonged quiescence. A similar phenomenon in regard to regeneration time has been noted following culturing of 65 to 85 years old soil samples from the Hilgard museum, desert algal soil crusts which have been desiccated for some years, or algae which have been dried for many decades on herbarium sheets. The time required for microorganisms to show activity and growth is important not only in relation to their age and past history in a particular habitat, but also for designing experiments for extraterrestrial life detection, such as investigations of Martian permafrost.

[7] Staffeldt, E. E. 1966–1968 Desert soil microorganisms study. Identification of fungi and microorganisms colonizing organic matter in moist chambers. New Mexico State University, Las Cruces, New Mexico. Progress Reports, JPL Contract #951602.

[8] Dr. M. di Menna, Ruakura Agricultural Experiment Station, Hamilton, New Zealand, kindly gave of her time to study and identify the yeasts.

Summary

Investigations of Wheeler Valley have shown that it possesses microclimatic, geographic, and edaphic factors that promote the development and abundance of communities of microflora. This valley is not as arid as most of the other dry valleys of southern Victoria Land and the resultant microorganisms include pigmented and nonpigmented heterotrophic, aerobic and microaerobic bacteria, streptomycetes, yeasts, molds, algae, and protozoa. Algal crusts and mats, scattered lichens, and a few mosses are present where water is more available and other ecological factors are most favorable. Microorganisms are present in both surface and subsurface soils and predominantly include diverse species grouped together as soil diphtheriods. The investigation of Wheeler Valley has provided additional information for grading the Antarctic dry valleys along an ecological scale.

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