Extraterrestrial Soil Science

*by James T. Conway**

A desert laboratory? Who would want such a thing? Isn't a desert just a barren wasteland where very little grows and few animals call home? Many might believe this. However, to Roy Cameron and others like him in the Jet Propulsion Laboratory (JPL), a desert is a storehouse of information. It's a proving ground for new ideas and equipment.

Since 1961 the JPL in conjunction with the National Aeronautics and Space Administration (NASA) has been collecting samples from arid and semi-arid regions. At present there are approximately 200 samples from 100 sites that comprise the Desert Soil Collection. Most of the samples came from areas of Mexico, Argentina, Chile, Baja California, Egypt and California. The purpose of collecting these soils is to furnish samples for various studies on soil-microorganism interrelationships in JPL's Desert Microflora Program.

Why all the interest in deserts? Surely a sand dune would hold little economic value for anyone but a desert rat. Perhaps the ideas behind all these studies are not entirely understood at first. However, the answer lies in man's eternal dream to travel to other planets. More specifically the answer is in this quotation by Cameron who states that "Given the same soil forming factors, the same kind of soil will be formed, whether it occurs on this planet or in some extraterrestrial environment."

Knowing that very harsh conditions exist on other planets of our solar system, scientists believe that some earth deserts closely resemble these conditions. Through the use of the Desert Soil Collection, a comparison of the unknown with the known soils and soil-like materials can be made. When the idea of the Voyager landing on Mars becomes a reality, NASA will be prepared for its interpretation of the findings.

Eventually man will be able to more closely study the conditions of other planets. At that time, the background work of the Desert Soil Collection will become more valuable. It is this collection that will be the first step in extraterrestrial soil science and astropedology.

As mentioned before, science believes that some earth deserts resemble conditions on the planet Mars. However, there is one desert that comes the closest to being like those found on Mars. This is the Atacama desert located in northern Chile just south of the Peruvian Andes. NASA has become extremely interested in this desert. They hope to test some of the ideas and equipment that they plan to use for the Voyager landing in the Atacama desert first.

So far, of all the deserts tested, Atacama offers the greatest challenge. It is often thought of as a desert's desert. Although Roy Cameron has been to almost every well known and seemingly harsh desert, he was totally unprepared for Atacama. Never did he expect such a barren salt desert (Figure 1).

In Atacama, the annual humidity index is quite low. The normal leaching rainfall is zero because the humid season is non-existent. In 1964, precipitation at the University of Antofagasta was recorded as 1 mm. In 1962, it rained 12 times for a total of 5 mm. There are some sections of the desert that have never recorded any rain, and for this reason it is sometimes termed as an "absolute" desert.

The desert covers 140,000 sq. mi. at an elevation from less than 1000 to more than 20,000 feet. As a result of its aridness, the desert is a vast collection of Borax and "dry" lakes. Until 1928, almost 100% of this region's economy came from its extensive nitrate deposits. The mining of these deposits furnished the world with its primary source of nitrogen fertilizers. With the advent of synthetic fertilizers this industry became defunct. Since that time, the diggings have been reanalyzed and great quantities of copper rich ore have been discovered. This discovery has placed Chile as the number one exporter of copper in the world.

Geologically the desert is extremely old. However, because of the lack of weathering factors, the soils themselves are termed as very young. One of the most distinctive peculiarities of the desert is its passiveness. It initiates no change, but once it is altered, that change is eternally recorded on the deserts face. Long abandoned trails remain as they were a half a century ago when commerce among the small merchants in Peru, Bolivia, and Chile flourished in this northern region.

Microbial decomposition on the desert is virtually non-existent. The trails are scattered with unfortunate pack animals who became lost and wandered into the desert to die. Their carcasses have exhibited very little change, except for some drying from the wind and sun. Even in the Inca burial grounds at Indio Muerto, the skin of the deceased can still be found, after more than 500 years.

In comparing the microbial activity of Atacama with other soils, the observer is often shocked. Where a typical

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1. Typical scene from the barren portions of Atacama Desert in northern Chile, South of the Peruvian Andes. Most soil samples came from areas of Mexico including Baja California, Argentina, Chile, Egypt and California.

2. At another location in the Atacama Desert these plant species presenting another contrast to the barren area in Figure 1. Areas as these were studied because scientists expect to find such conditions on Mars.

garden would contain four million aerobes (organisms require oxygen) per gram of soil in the first inch of soil, and a caliche desert soil (Figure 2) would contain only 135 per gram, there are only 23 aerobes per gram in the Atacama desert. A quick glance at table 1 shows that a comparison of anaerobes (those organisms not requiring oxygen), fungi, and algae is even more appalling.

Perhaps some of the low numbers are due to poor techniques in detection. Many of the organisms encountered in Atacama, although somewhat similar to known microbial species, have not been pin pointed in their classification. Because of this difference in physiology from the better known microbes, the growing media used in detection is not as satisfactory as it should be. Thus there is some doubt as to the actual numbers of organisms in the soil.

Table 1—Number of organisms/g of soil in the surface inch of selected soils.

	Aerobes (Bact. & Actino)	Anaerobes	Fungi	Algae
Typical Garden Soils	9.8×10^6	1.9×10^6	1.2×10^5	2.5×10^4
Typical Caliche Desert	135	10^6	30	100
Atacama	11.5	.5	1.7	0

Sampling is also a problem. When it is done by hand, there would be little doubt as to its precision. However, when a machine, thousands of miles away from its controls is doing the sampling, problems immediately arise. The answer was thought to have been found in the Gulliver (Figure 3). It worked on the principle of dragging a sticky string across the surface and then analyzing the soil that had adhered to the string. Then it met Atacama, and there was a sudden realization that the possibility of dragging several strings across one area and never encountering any microbial life was not too remote.

With a great need for a perfected sampler, is there any wonder that such an avid interest should be directed to this "absolute" desert as a proving ground for new equipment.

Is there life on Mars? Perhaps the Voyager will answer that . . . and Atacama will lead the way.

3. This illustrates the use of Gulliver. It projects a sticky string onto the desert. As it is reeled in it collects samples of the soil. The sticky string can be seen starting in lower left hand corner.