WHERE DO WE LOOK FOR LIFE IN THE POLAR REGIONS OF MARS? A.T.Wilson Dept. of Geosciences, University of Arizona, Tucson, Az, 85721, USA (atwilson@U.arizona.edu).

Introduction and Analysis of the Problem: The problem is initially to decide where, in the polar regions of Mars, "ecological niches" might exist in which life forms may currently be present. To find "carbon-based" life (similar to our own) in other parts of the Solar System, one must find places where liquid water in some form might exist. To locate currently living carbon-based life forms, the liquid water must have existed continuously on a geological (as opposed to a biological) time scale. The energy source for these organisms would, in the absence of photosynthesis, have to be chemical. For example, one such energy source is the reaction of atmospheric oxygen with ferrous iron to produce ferric iron. The ferric iron would interact with rock minerals and be converted back to ferrous iron. This is the case with iron bacteria on the Earth today. The life forms would take part in the weathering of the rock and derive their energy from it.

The Approach Suggested: As will be discussed below, we favor looking for current life forms on Mars in very saline water. This is because such a system has a very low freezing point, and under cold conditions, can be in dynamic equilibrium with very low partial pressures of water vapor. Both these conditions are likely to exist or have existed on a planet such as Mars. In practice, this would mean a very concentrated magnesium/calcium chloride solution produced by the weathering of rock. Such solutions can exist in a liquid state down to below -30 degrees centigrade at as low as 0.1 torr water vapor pressure.

Such a system has the advantage of being a "steady state" system, able to exist for times which are long on a geological time scale. The problem for life forms in an intermittent non-steady-state system is how to survive the quiescent periods (with no energy source).

Terrestrial Model for Such a System: This proposal suggests that the geochemical system found in the cold rainless deserts of the Antarctic might be studied as models for similar, but probably more extreme, systems that probably exist on Mars currently or have existed at times in the past.

The Dry Ice-Free Areas of the High Latitude Southern Hemisphere: Although much of the Antarctic continent is covered with ice and snow, some areas are ice-free. These so-called "dry areas" are extreme deserts, characterized by extreme cold and aridity. They are also unique among terrestrial deserts in being completely rainless. All precipitation falls as snow, which is lost by sublimation. If one digs into the loose "soil" of a dry area in this cold and arid region, one passes through loose dry debris and can suddenly strike a very hard and impenetrable layer, which on examination proves to be debris as above but cemented with ice crystals. Sometimes in late summer, saline water can be detected moving downslope along the surface of what Wilson [1] called the "frozen water table."

In the lowest points of dry enclosed drainage basins, one can sometimes sink into a subsurface shallow pond of very saline water. One of these, in the south fork of the Wright Valley, had a composition of 60,000 ppm chloride, 18,000 ppm calcium, 7,000 ppm magnesium and 9,900 ppm sodium.

In an even more arid situation such as the surface of Mars, one would predict that the concentration of chloride would be higher, as would the magnesium, followed by the calcium, and the sodium would be lower.

It is clear that in a cold rainless desert different phenomena exist which can produce subsurface shallow ponds of very saline water. On Earth we only just reach the beginning of this rainless desert ecosystem, but as Wilson [1] suggested two decades ago, Mars is also a rainless desert, and is probably even more arid. It would be a natural progression from the Antarctic systems, and may have similar subsurface pools of even more saline brine. It is suggested that these pools might be a place to look for "extra-terrestrial" life.

The aim of the earlier work [1] was to understand the geochemistry of the Antarctic rainless deserts. How the salts were separated, why some remained in the "soil" and others moved down-slope, were areas of study.

Work To Be Undertaken As a Result of the Above Discussion: *Long Term.* The above discussion suggests that we should put an infra-red sensing satellite in polar orbit around Mars and look for halos of water vapor in topological depressions, particularly those in the front of glaciers. The very existence of bare ice suggests that the ice must be losing water by sublimation. If a steady state situation is assumed, then there must be some form of snowfall which represents an infall of salts to the drainage basin. These, over time, must end up as a sub-surface saline pond in depressions in front of the ice sheets. This might ultimately be a prime area to look for life on Mars.

Short Term. We should do research on Earth to answer the following questions: (1) Can we locate subsurface pools of saline brine in the Antarctic "Dry Valleys" using infra-red sensing from an orbiting satellite? (2) Is the summer-time water vapor higher over subsurface brine pools than their surroundings? Is it high enough to detect with infra-red sensing from an orbiting satellite? The relative humidity over the brine is a constant under equilibrium conditions. It is a function of its concentration (strictly the fugacity of the water in the brine). It changes only slightly with temperature. The relative humidity of a sample of air of fixed water vapor pressure changes rapidly as the air warms. (Relative humidity is defined as the partial pressure of water vapor in the air, divided by the partial pressure of water vapor in the air if it were in equilibrium with pure liquid water at that temperature - expressed as a per cent.) For this reason, one would expect water to be given up by the brine under warm conditions and to be adsorbed under cold conditions. Thus in "summer" under calm conditions, one might expect our brine pools to have a halo of water vapor above them.

The geomorphology on Mars is very similar to that in the older parts of the Antarctic dry areas. The weathering that creates these landforms on Mars is caused by the repeated recrystallization of salts made possible by the cycling of the relative humidity (see Wellman and Wilson [2], Cotton and Wilson [3] [4]). This lends strong support to the possibility that salts have been absorbing water from the atmosphere and going into solution. If this is occuring now, then it is possible that microorganisms may still be living in subsurface liquid brine ponds on Mars. If this happened in the past, then these subsurface ponds will have frozen or dried up. On a planet without life, the bodies/spores of these organisms would have a good chance of surviving millions of years in frozen brine or locked in salt crystals. It would be a relatively simple matter to recover fossil microorganisms or spores from samples of frozen brine or salt crystals. There would be fewer problems with other objects that may look like microorganisms, since the matrix would be expected to be water soluble.

References: [1] Wilson A.T. (1979) Nature, 280, 205-208. [2] Wellman H.W. and Wilson A.T.(1965) Nature, 205,1097. [3] Cotton A. and Wilson A.T. (1971) Earth Science Journal, 5, 1-15. [4] Cotton A. and Wilson A.T. (1971) Z. Geomorph. 15, 199-211.