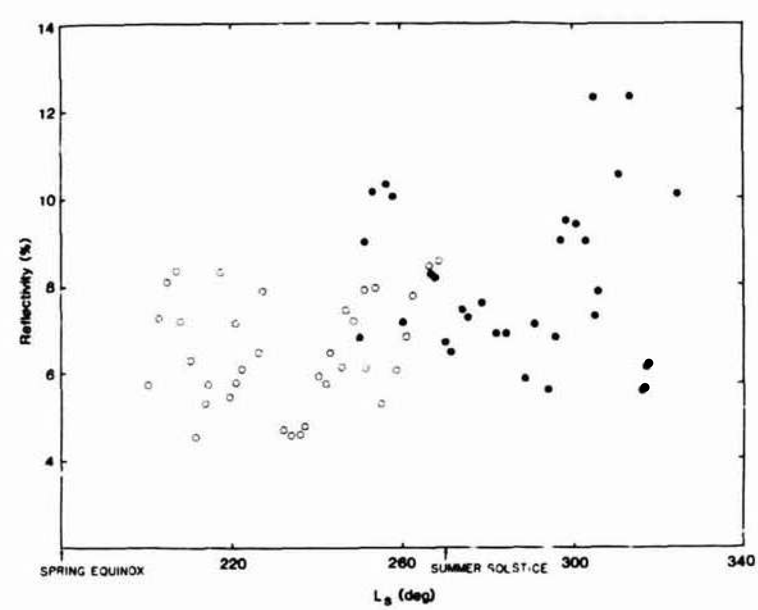
MARS: SEASONALLY VARIABLE RADAR REFLECTIVITY; L. E. Roth, G. S. Downs, and R. S. Saunders, Jet Propulsion Laboratory, California Institute of Technology, Pasadena, California 91109; G. Schubert, Department of Earth and Space Sciences, University of California, Los Angeles, California 90024.

Reconnaissance by radar from Earth is one way of exploring our closest planetary neighbors, Mercury, Venus, and Mars. Radar exploration of Mars, begun in mid-sixties (1,2) produced a wealth of information on the topography, roughness, and reflectivity of the planet. In dealing with the radar reflectivity, the work discussed here indirectly addresses the question of liquid water on Mars, a subject tainted by the memory of the extravagant claims of Percival Lowell made at the turn of the century (3). We have analyzed the 1971/1973 Mars data set acquired by the Goldstone Solar System Radar (4,5) and established that the seasonal variations in radar reflectivity thought to occur in only one locality on the planet (the 'Solis Lacus radar anomaly' (6)) occur, in fact, over the entire subequatorial belt observed by the Goldstone radar. Since liquid water appears to be the most likely cause of the reflectivity excursions, a permanent, year-round presence of subsurface water (frozen or thawed) in the Martian 'tropics' can be inferred.

This conclusion is based on the following ideas: The ability of materials or objects to reflect electromagnetic waves is expressed through a quantity called reflectivity. The magnitude of reflectivity ranges from 0.0 for ideal absorbers to 1.0 for ideal reflectors. Both the common rocks and the water ice are poor reflectors (reflectivity ~0.1). Liquid water, on the other hand, is a good reflector (reflectivity ~0.8). Presence of liquid water in geologic targets increases their reflectivity. A target containing mixture of rocks, soil, and liquid water would be more reflective than the same mixture, but with solid ice instead of liquid water. Since the reflectivity is a quantity characateristic of a given target, the same target examined by radar at two different occasions should have the same reflectivity. If the reflectivity varies from one experiment to the next, the target must have undergone a change during the intervening period. This change could either be internal, involving the composition/phase of the target itself, or external, involving the geometry/texture of its surface.

During the 1971/1973 oppositions, the Goldstone radar scanned the Southern Martian latitudes on almost 70 occasions. The observations extended from the early Martian spring to the Martian mid-summer. Applying the notions of our terrestrial calendar to Mars, the observations would have started on 10 (Martian) April and terminated on 15 (Martian) August. Many areas were scanned more than once. Intervals between some observations corresponded to up a few (Martian) months. (The analogy with the terrestrial calendar is helpful; it should not be taken literally, however. A year on Mars is almost twice as long as a year on Earth; a (Martian) month, in the context of our analogy, is almost twice as a long as a month on Earth, a (Martian) week almost twice as long as a week on Earth.) In view of what we said before, the reflectivity of an inactive, unchanging target should always be the same, regardless of how often or at what time intervals the target is scanned by radar. Analysis of the Goldstone data shows, however, that the Mars reflectivities do not conform to the expected, steady pattern. Instead, starting from the lower values in the Martian spring, they tend toward higher values in the Martian summer (Fig. 1). This overall trend can be observed

FIGURE 1



over the entire planet. For instance, in Solis Lacus/Sinai Planum (6) (Fig. 2) an avearge reflectivity of 0.08 was measured on 6 (Martian) June; an average reflectivity of 0.11 was recorded five (Martian) weeks later, on 10 (Martian) July. As still another example, consider the cratered highlands in Margaritifer Sinus (Fig. 3) and Aeolis (Fig. 4). Those radar scans that followed each other by less than about one (Martian) week (ΔL_s < 10 deg) show no change in reflectivity (i.e., the ratio of respective reflectivities equals unity). An increase in the interval of separation from about one (Martian) week to two-to-three (Martian) months is usually accompanied by a corresponding increase in the average reflectivity (the ratios of respective reflectivities are larger than unity).

FIGURE 2

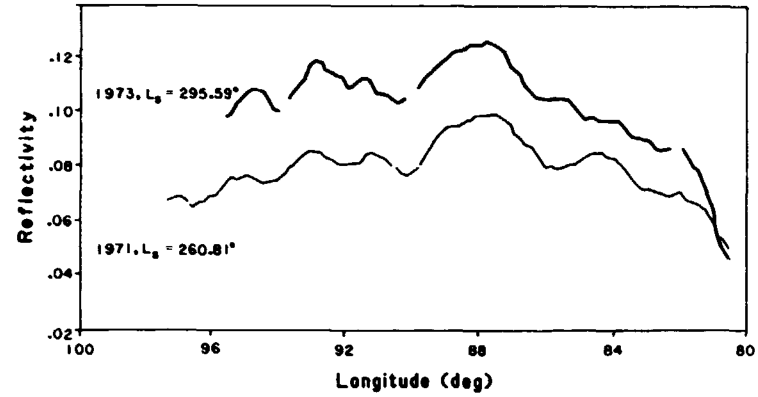


FIGURE 3

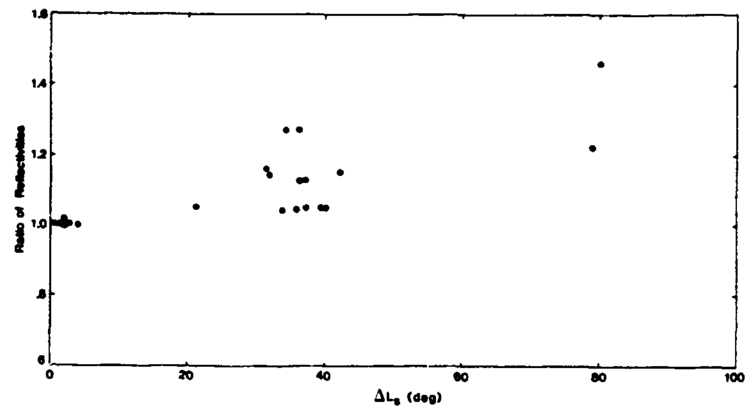
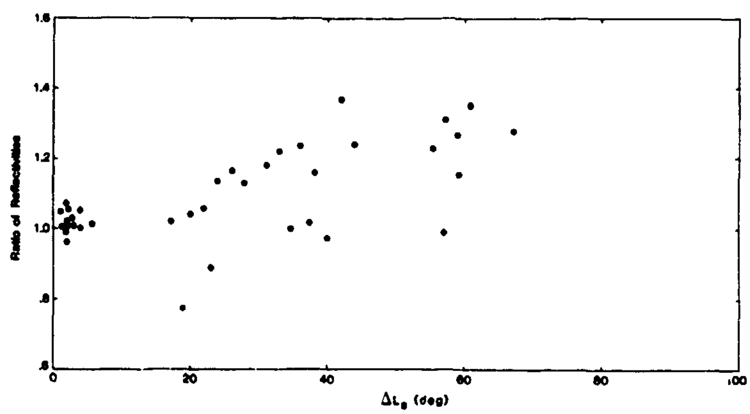


FIGURE 4



What should be the interpretation of this puzzling phenomenon? Discarding the unlikely case of a systematic increase in the instrumental bias/calibration error, we are left with two possibilities: (a) Seasonal variations in Mars reflectivities are due to changes taking place on the planet's surface. These changes could be related to the action of wind and associated with it redistribution of dust. Even though this mechanism cannot be ruled out entirely, a significant contribution does not seem to be supported by the photogeologic evidence. (b) Seasonal changes in Mars reflectivities are due to changes taking place below the planet's surface. What is the most probably subsurface change that could occur in parallel with the progress of the Martian seasons from the early spring to the mid-summer? It has to be the thawing of water ice and the emerging presence of the liquid water as a temporary constituent of the Martian soil. This brings us full circle to the beginning of our story: Since the liquid water is the most likely cause of the observed reflectivity excursions a permament, year-round presence of sub-surface water (frozen or thawed) in the Martian 'tropics' can be inferred.

The final judgement on this controversial issue should be suspended until more data are available and the reality of the effects observed in the 1971/1973 Goldstone data is confirmed. Until then, the possibility of the presence of liquid water in the Martian soil should be treated as a working hypothesis rather than an established fact. Mars is a difficult object to observe; geometric considerations make the subequatorial areas on Mars visible to radar from Earth only during 2-3 favorable oppositions out of the full cycle of 7-8 oppositions. The last pair of favorable oppositions took place in 1971/1973. The forthcoming apparitions, favorable ones in 1986/1988 and an intermediate one in 1990, should make it possible to enlarge the Mars radar data base and allow a new attempt at solving the variable-reflectivity riddle.

References:
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