

SHARAD Penetrates Only the Youngest Geological Units on Mars

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The SHAlow RADar (SHARAD) instrument on the Mars Reconnaissance Orbiter was intended to receive echoes from up to 1 km deep in the rocky martian subsurface. Such deep penetration only occurs in the icy polar caps and in certain ice-rich units. In fact, over the majority of the rocky units of Mars, only surface echoes are detected. Therefore, rocky units are more attenuating than expected. To gain insight into the cause of this attenuation, we correlated SHARAD subsurface reflectors with a geologic map of the northern plains of Mars [Tanaka et al., 2005]. Our survey was restricted to this area due to general smoother topography and hence less potential influence of surface scattering (clutter). All released SHARAD data (approximately 1,500 radargrams) overlying the geologic map were individually interpreted. Geologic units were categorized by their map description into ice-rich, pristine volcanic, and water-altered units. The last category comprises units interpreted to be fluvial, lacustrine, or periglacial in origin, as well as volcanic and other units that were subsequently altered by water or ice. Radar reflections in each unit were further categorized as abundant, occasional, or none. We found that abundant reflections are only detected in geologic units that are Amazonian in age, and ice-rich or pristine volcanic. No reflections are seen in water altered units. Occasional reflections are detected in Hesperian-aged pristine volcanic units. We propose two endmember hypotheses for this attenuation behavior, scattering and absorption, but they could act jointly. The young pristine volcanic units that SHARAD penetrates consist of thick (about 50 m) flood basalts or tuff. These units are expected to have cooling joints in them, but little if any other heterogeneity; therefore their scattering loss should be small. With increasing age and thermoelastic stress due to global cooling and contraction, these previously homogeneous volcanics could become increasingly fractured, thus more efficient at scattering. Under this hypothesis, all of the water-altered units have significant subwavelength heterogeneity due to their primary mode of origin or secondary alteration. Alternatively, absorption due to the dielectric relaxation of adsorbed water could influence the attenuation. Alteration minerals such as phyllosilicates and palagonite drastically increase the surface area and can hold up to three monolayers of adsorbed water at martian temperatures. Our lab measurements indicate that about 6% phyllosilicates or 15% palagonite by volume can completely attenuate the reflected signal of an interface at a depth of 30 m; which is the shallowest depth SHARAD can detect due to sidelobe effects. These minerals would not be confined to Noachian units as currently suggested by orbital spectroscopy. A smaller proportion of hydrated minerals could be accommodated if the shallow geotherm is steep, or if alteration minerals are below the detection threshold due to their degree of hydration or grain size. In either case, subsurface radar attenuation on Mars is less than that of the Earth, but more than that of the Moon. Tanaka, K.L., J.A. Skinner, and T.M. Hare (2005) Geologic map of the northern plains of Mars, USGS Sci. Invest. Map, 2888.

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