**PROBING THE MARTIAN SUBSURFACE WITH SYNTHETIC APERTURE RADAR.**
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**Introduction:** Many regions of the martian surface are covered by fine-grained materials emplaced by volcanic, fluvial, or aeolian processes. These mantling deposits likely hide ancient channel systems (particularly at smaller scale lengths) and volcanic, impact, glacial, or shoreline features. Synthetic aperture radar (SAR) offers the capability to probe meters below the surface, with imaging resolution in the 10's of m range, to reveal the buried terrain and enhance our understanding of Mars geologic and climate history. This presentation focuses on the practical applications of a Mars orbital SAR, methods for polarimetric and interferometric radar studies, and examples of such techniques for Mars-analog sites on the Moon and Earth.

**Modeling of SAR Applications:** The major science goals of a Mars-orbital SAR include:

(1) Detecting buried geologic features (i.e., penetrating the mantling material and receiving reflections from a subsurface interface).

(2) Constraining the relative proportion of surface and subsurface components in the radar return (i.e., verifying that the features are, in fact, beneath the surface).

(3) Estimating the thickness of the mantling materials as a guide to their volume and likely emplacement mechanism.

We have carried out a study of the utility of radar backscatter measurements, at a range of wavelengths and polarizations, to satisfy these requirements [1]. Our results show that a radar wavelength in the L- to P-band range (~30 cm) offers the best potential for deep penetration and a relatively strong scattered echo from rough buried terrain.

We also found that the HH/VV ratio provides sufficient information to estimate the fraction of surface and subsurface returns for typical incidence angles of ~40°. Multi-wavelength observations cannot provide a strong constraint on the depth of a mantling layer, due to the large uncertainty in the loss tangent of martian near-surface materials. A more robust thickness estimate may come from the "volume decorrelation" properties of interferometric radar echoes, but the required phase measurement accuracy is challenging.

**Terrestrial Radar Studies:** Validation of our conclusions from theoretical modeling is an important element of planning for the Mars-orbital radar. To this end, we are using data from the NASA/JPL AIRSAR system (6-, 24-, and 68-cm wavelengths, fully polarimetric) in a variety of Mars-analog settings. These studies are supported by 400-MHz ground-penetrating radar surveys to identify subsurface scattering horizons. Areas of interest include ash deposits in Hawaii, cinder layers in Arizona, sand-covered bedrock in Egypt, and near-surface structural and hydrologic features in Death Valley, CA.

**Lunar Radar Studies:** We are also using new 70-cm wavelength radar data for the Moon to test models for radar scattering in a dry regolith with highly variable scattering and loss properties. These new data have a spatial resolution of ~450 m, and are collected in both senses of circular polarization (Fig. 1). The radar maps are compared with Clementine multispectral data to study subsurface penetration and the effects of mineralogy on the regolith loss tangent.

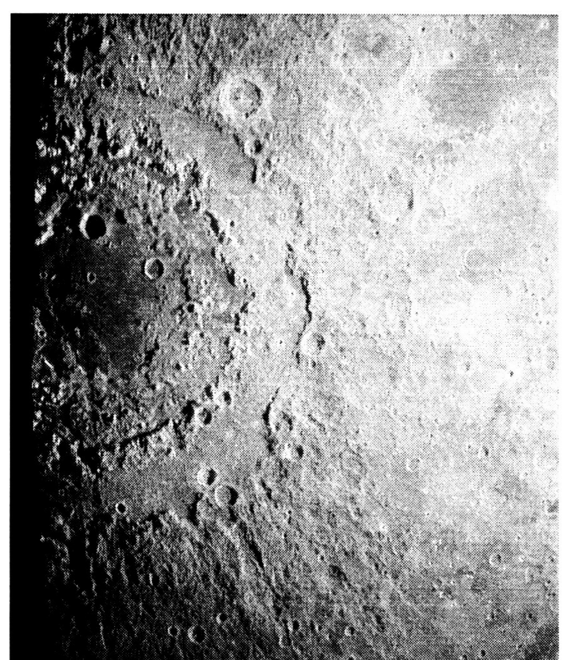

**Figure 1.** 70-cm radar image of Orientale Basin on the west limb of the Moon.

Work to date reveals significant new detail in the distribution of ancient lunar mare basalts that were buried by highlands material excavated in giant basin-forming impacts. We have also found that large impact craters are surrounded by extensive haloes of low 70-cm radar return, indicating a rock-poor ejecta layer [2]. Differences in polarization properties permit the tracing of Orientale-derived impact-melt materials across the permanently shadowed south polar region [3]. These results all have implications for probing of near-surface materials on Mars.

**References:** [1] Campbell, B.A., T. Maxwell, and A. Freeman, Mars orbital SAR: Obtaining geologic information from radar polarimetry, *J. Geophys. Res.*, *109, doi:10.1029/2004JE002264*, 2004. [2] Ghent, R.R., D.W. Leverington, B.A. Campbell, B.R. Hawke, and D.B. Campbell, Earth-based observations of radar-dark crater haloes on the Moon: Implications for regolith properties, *submitted to J. Geophys. Res.*, 2004. [3] Campbell, B.A., and D.B. Campbell, Surface properties in the south polar region of the Moon from 70-cm radar polarimetry, *submitted to Icarus*, 2004.