EXPERIMENTAL MEASUREMENTS OF SURFACE AND VOLUME SCATTERING PROCESSES AT MICROWAVE WAVELENGTHS by Gary R. Olhoeft, B. Schaefer, and G. R. Johnson, U.S. Geological Survey, Box 25046 DFC, Denver, CO 80225

Surface and volume scattering processes are important factors in the interpretation of earth based and orbital microwave observations of lunar and planetary surfaces. Such scattering processes may dominate measurements intended to observe heat flow or other parameters, thus masking a more desirable quantity. To determine the importance of surface and volume scattering, a 1.22 meter diameter by 2.44 m long vacuum chamber was outfitted as a microwave anechoic chamber. A bed of quartz sand approximately 0.6 m wide by 1.4 m long by 0.2 m deep was placed in the chamber as the medium of study. Preliminary experiments were performed in air at frequencies of 27-36 GHz, but later experiments will be performed with basalt under vacuum at lower frequencies.

Initial characterization of the chamber measured a reduction in the chamber response by about -50 dB in air and more than -60 dB in vacuum relative to the chamber without absorptive foam. Experimental repeatability was ±2 dB or better (average ±0.8 dB) with residual chamber frequency response on the order of ±10 dB from the mean frequency response. In order to reduce the chamber effects further, all measurements of scattering properties were performed relative to a standard smooth sand surface.

Scattering measurements were performed in both forward and backscatter geometries with antennas arranged to measure either on nadir (antenna aimed normal to the sand surface) and off nadir or in two orientations relative to the antenna E-field. Measurements in air include scattering sand surfaces with various ripple textures, ball bearings as volume or surface scatterers, and combinations of surface ripples and buried ball bearings. Ripple texture included variations in ripple amplitude, ripple spacing, orientation, and other parameters. Measurements were also performed on sloping or tilted sand surfaces up to the angle of repose (29°).

The general conclusions drawn from these preliminary studies are:

1) Buried volume scatterers of a given size and shape are equal or greater in importance than equivilant surface scatterers.
2) Surface and volume scatterers interact to depths of about 10 wavelengths.
3) Spacing between surface scatterers is more important than amplitude.
4) Mean surface slope or tilt is more important than either surface or volume scatterers.
5) Surface and volume scatterers on slopes tend to reduce the effective angle of the slope as it effects scattering processes.
6) Nadir and off-nadir viewing of a surface have very different responses to scattering processes: a) the frequency dependence of scattering is more pronounced on nadir than off nadir, and b) volume and surface scattering effects appear to simply add on nadir but not off nadir.

Figure 1 illustrates the dependence of scatterer size relative to the wavelength of microwave energy being scattered for forward scatter through a grid of ball bearings as the bearing size changes on a constant grid spacing.

Figure 2 illustrates the on-nadir and 60° off-nadir scattering response of various surface ripple spacings versus frequency. Note that both the scattering and the frequency dependence increase with size of ripple spacing. The 1 cm ripple spacing is shorter than the microwave energy wavelength, the 3 cm is about equal, and the 10 cm is much longer.

Figures 3 and 4 illustrate combinations of surface and volume scatterers with sloping sand surfaces. Note that roughening of the sloped surface reduces the overall scattering.

EXPERIMENTAL SCATTERING

OLHOEFT, G.R. et al.

Figure 1:

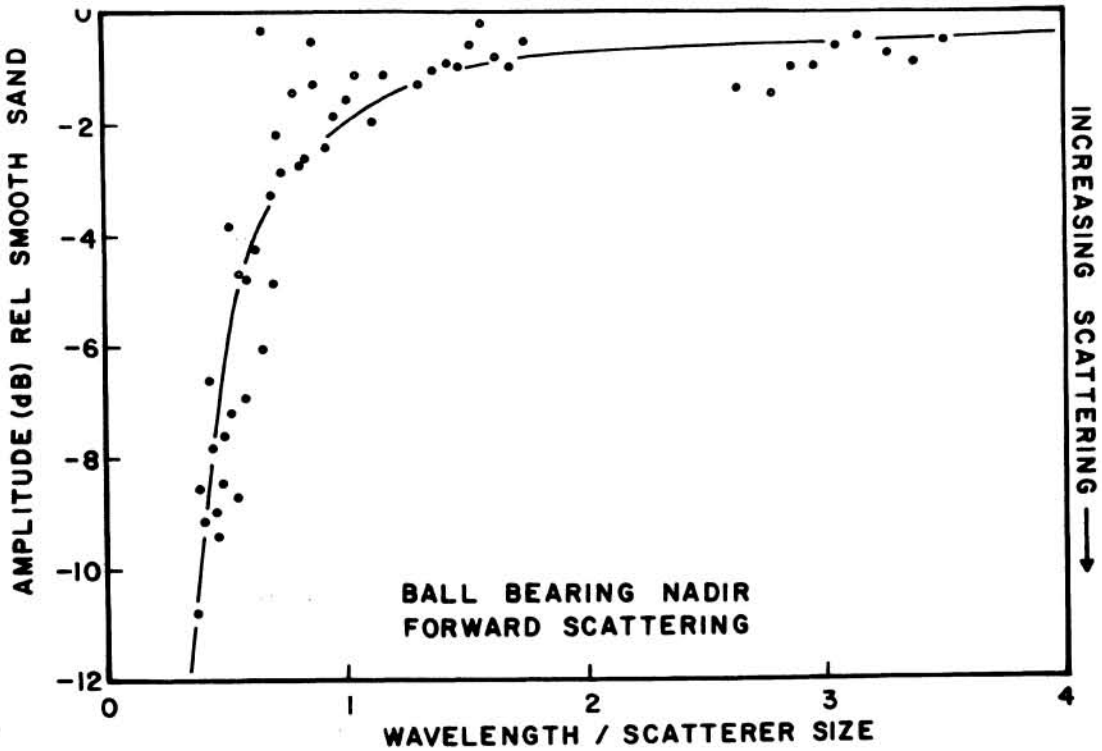

Figure 2:

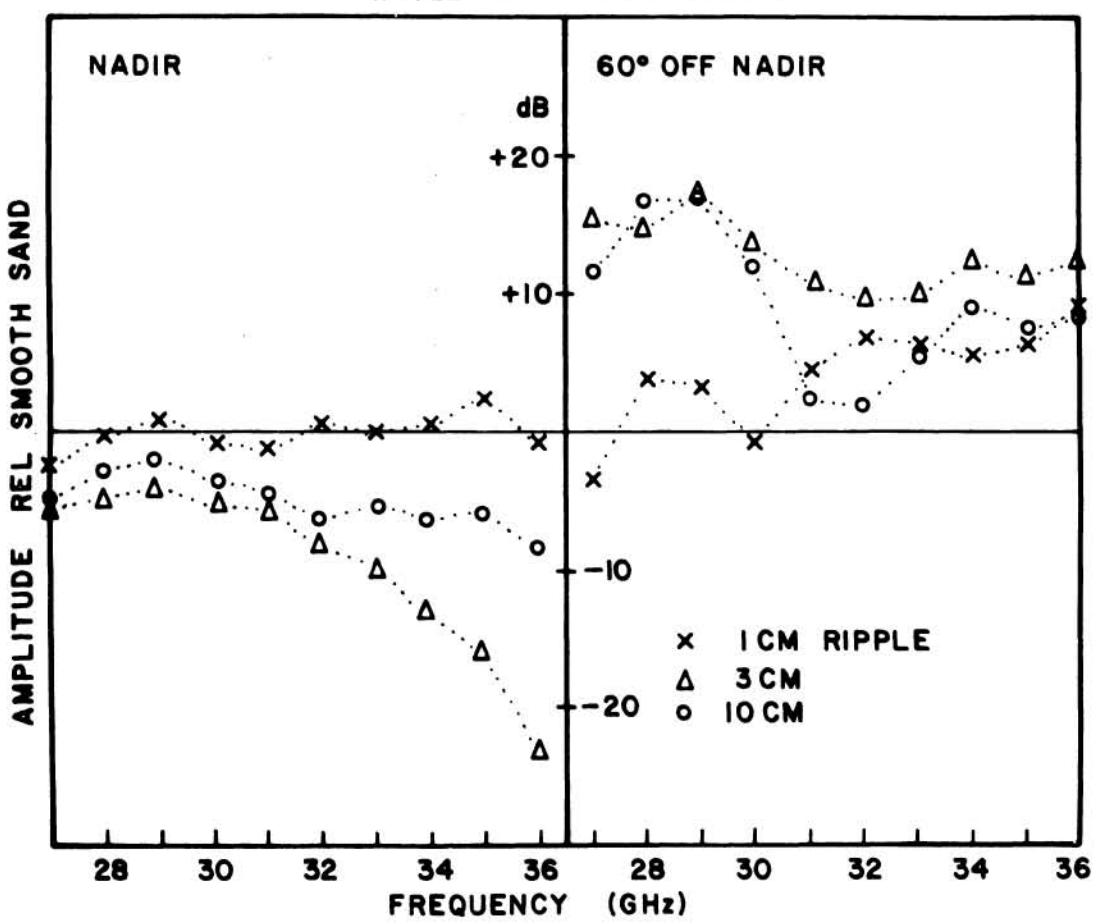

Figure 3:

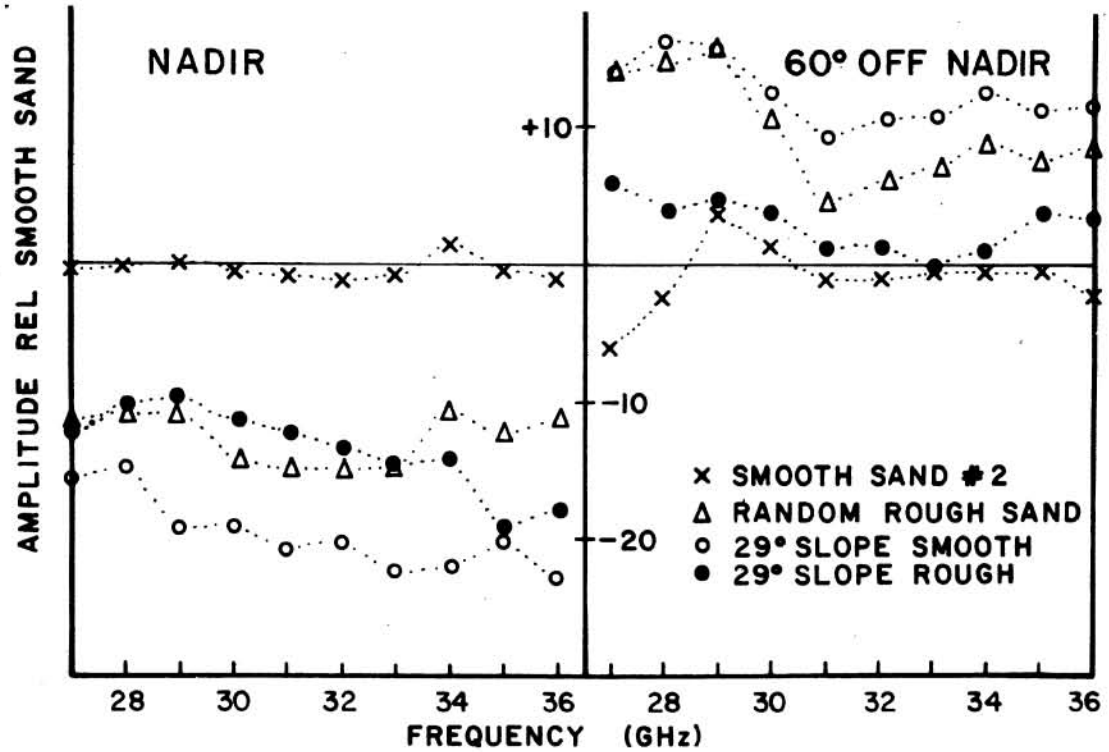

Figure 4: