New Very-High-Resolution Lunar Radar Measurements at 3.0 cm Wavelength: Initial Maps of the Hadley/Apollo 15 Area. S. H. Zisk, MIT Haystack Observatory, Westford, MA 01886; P.J.Mouginis-Mark, Planetary Geosciences, HIG, Univ., Honolulu, Hawaii 96822; G.H.Pettengill, Center Space Research, MIT, Cambridge, MA 02139, T.W. Thompson, Jet Propulsion Lab., Pasadena, CA 91109.

Beginning in June 1986, and at irregular intervals thereafter, we have had several opportunities to use the Haystack radar system in a new experimental configuration to obtain radar images of the lunar surface at a much higher resolution than has been possible in the past. We report on the first maps produced from these observations.

I. EXPERIMENT: The first good-quality data were obtained in early November 1986, and consisted of a total of about 1.5 hours of observing time on an area centered on the Apollo 15 landing site (26°N, 158°W). Circular polarization was transmitted, and both senses of polarization of the echo were received. Fig. 1 shows part of a map of the "polarized" echo (the sense expected from a specular reflector) and the "depolarized" echo (the opposite sense) for exactly the same area (pixel-by-pixel). These images are in the form of raw radar maps. They are presented in the range-doppler coordinates of the observations, i.e. the data have not yet been transformed into a standard cartographic projection. Fig. 2 is a Transverse Mercator sketch map of the same region outlining the area covered by the radar maps.

The vertical (range) resolution on the radar maps is approximately 75 m (0.5 microseconds of delay). At the selenographic latitude of the Apollo 15 site, this is equal to about 150 m resolution on the lunar surface. The vertical size of the image is 512 pixels, or about 75 km on the surface, and is directed approximately 30 deg. east of north. The horizontal (doppler) resolution was set during the data processing to be approximately equal to the range resolution. Each figure shows about 500 pixels out of the center of the 4096- pixel final image. The actual doppler resolution is 0.006 Hz, which equalled about 95 m on the lunar surface at the time of the observations.

II. RESULTS: A comparison of the polarized and depolarized maps shown in Fig. 1 indicates a "ghost" image (presumably due to instrumental characteristics) in the depolarized map whose origin has not yet been traced. Otherwise, the maps appear to be good radar data, albeit with some speckle because the displayed image was produced using only one look. A number of surface features can be identified. Fig. 2 is a sketch map, on the same range-doppler projection as Fig. 1, and indicates the locations of Mount Hadley, Hadley Rille, Hadley Crater, Hadley Delta, and an unnamed peak just east of Mt. Hadley. Fig. 3 is a transverse Mercator map (LTO map series) showing the same area without cartographic distortion.

Note that many of the Earth-facing slopes seen in Fig.1 show a strong radar enhancement in both polarized and depolarized maps. While the polarized image is expected to show this quasi-specular effect, the depolarized map is not. In addition, several of the mountains including Hadley appear to have their entire profiles radar-bright, rather than only their earth-facing surfaces. Neither data-compression nor specularity are convincing explanations of this phenomenon. It is also apparent that the depolarized map shows several areas of enhanced echo strength, for example on the away-facing slope of Mt. Hadley. These are presumably regions of enhanced roughness as are evident in earlier, lower-resolution maps. It is hoped that closer examination will show if this roughness can be correlated with small-diameter craters, or more regionally-extensive surface characteristics. The distorted appearance of Mt. Hadley, caused by the strong "layover" (parallax) effect of topography at this angle of incidence, is similar to that observed in imaging radar views of the Earth (such as the data obtained from the Seasat SAR). The summit of Mt. Hadley, which is 4 km higher than its base, is apparently displaced toward the lower edge of the map (i.e. closer ranges) by (4 x tan(inc.angle)), or about 7 km.

As we gain experience with this radar system, even higher spatial resolutions may be possible. However, target selection will have to accompany specific scientfic goals, since the mapped area per observation is likely to decrease when the resolution is improved. With respect to the

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geological objectives of these studies, it is apparent that the higher spatial resolution of the radar system provides the capability to better test models of radar scattering for photogeologically defined surface units, such as volcanic flows, pyroclastic deposits and impact crater ejecta blankets. In addition, in instances such as the Apollo 15 site, it may also be possible to directly correlate the radar data with surface features (e.g., slopes, surface boulders) observed by the astronauts on the lunar surface.

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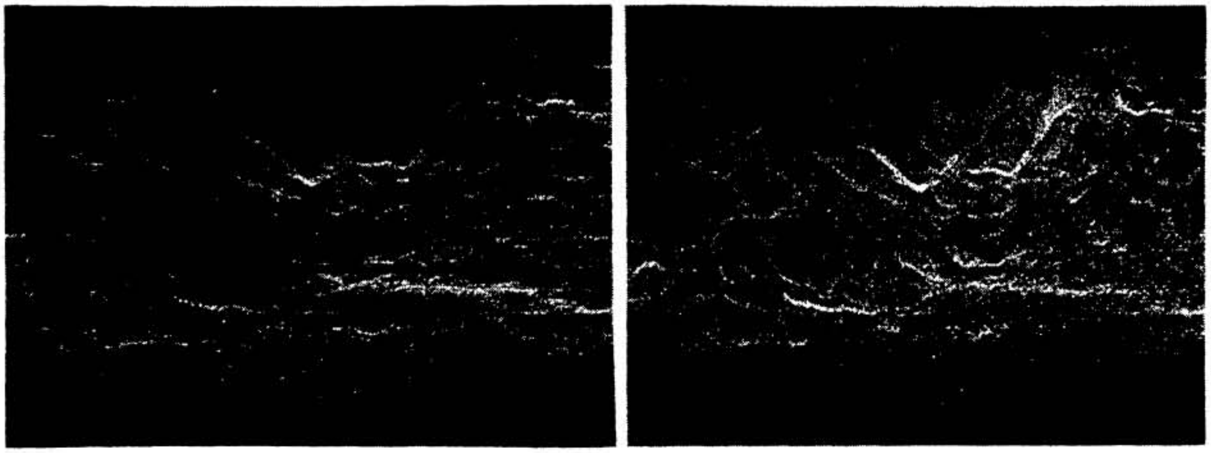

Fig. 1: Polarized (left) and depolarized (right) 3.0 cm radar images of the Apollo 15 site acquired November 6th 1986. Radar resolution is approximately 75 meters.

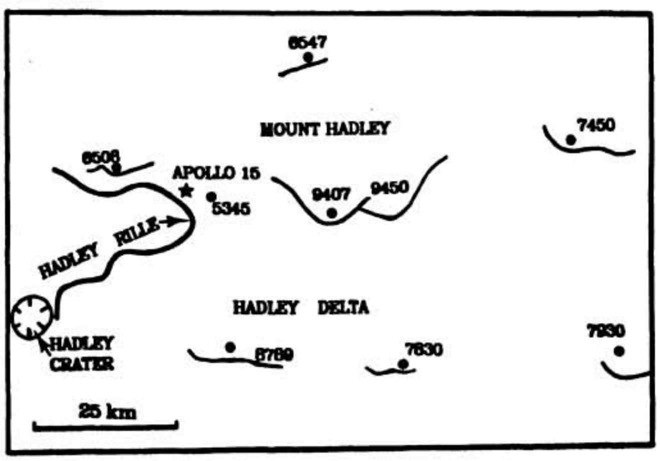

Fig.2 (Left): Sketch map of the same geographic area (at the same projection) as the radar data presented in Fig.1. The Apollo 15 landing site is located by "*". Point elevations on topographic highs are given in meters above the lunar datum. The lay-over positions of the higher peaks (bright linears in Fig.1) are also shown. **Fig.3 (Right):** Lambert conformal conic projection of the Hadley/Apollo 15 area. Due to radar lay-over of the mountain peaks, the borders of the radar scene are arcuate in outline.