NEW RESULTS FROM THE MAGELLAN BISTATIC RADAR EXPERIMENT. ***M. A. Kreslavsky***[1,2], ***P. G. Ford***[3], ***G. H. Pettengill***[3] and ***J. W. Head***[1], [1]Dept. Geol. Sci., Brown University, Providence RI 02912-1846, USA misha@mare.geo.brown.edu [2]Kharkov Astronomical Institute, 35 Sumska, Kharkov, 61022, Ukraine, [3]Center for Space Research, Massachusets Institute of Technology 37-571, Cambridge, MA 02139-4307, USA.

Introduction: Bistatic radar is a powerful tool for studying planetary surfaces. In this technique, the incident signal from a spacecraft-borne transmitter is directed to the specular point on a planet, and the signal scattered by the surface is received on the Earth. At microwave frequencies typical planetary surfaces scatter electromagnetic waves quasi-specularly, which means that the mirror-like reflection component dominates the scattered signal. In this case, the polarization state of the received echo depends only on the electromagnetic properties (dielectric permittivity and magnetic permeability) of the surface material (according to Fresnel's equations), thus providing unambiguous constraints on these parameters.

Several bistatic radar observations of the Venus surface were carried out by the Magellan spacecraft. During bistatic radar observations on June 5, 1994, the specular reflection point crossed Maxwell Montes [1]. The polarization signature of the reflected signal indicated that the peculiar radar-bright material at high elevation in Maxwell Montes has a moderately high electric conductivity [1].

Similar bistatic observations were performed on November 9, 1993 during three consecutive Magellan orbits. On that date, the specular reflection point moved through Aino Planitia, the western (topographically lower) part of Ovda Regio, Tellus Tessera, Audra Planitia and Snegurochka Planitia. Although these passes did not cross any area of anomalous scattering properties, they passed through a great variety of terrain types and geological units. Incidence angles varied in a narrow range from 78° to 81°, which is particularly favorable for interpreting the results since echo polarization at these angles is very sensitive to the electromagnetic properties of the surface. Here we present a progress report on our analysis of these data.

Observations and data processing: Continuous-wave bistatic radar probing was carried our with the Magellan S-band telemetry transmitter at 13.05 cm wavelength (2.298 GHz frequency). The probing signal was linearly polarized at 45° to the scattering plane. The scattered signal was received with a pair of right- and left-circularly polarized coherent DSN receivers (L and R channels) and digitally sampled at 50 kHz. 256-sample segments were Fourier transformed to obtain Doppler spectra with a spectral resolution of 195 Hz. The spectral intensities in L and R (left and right circular polarization) channels and L-R correlations were calculated over groups of 100 consecutive segments (0.512 s intervals). The surface echo is clearly visible in the power spectra as a 1.5 kHz-wide peak above the thermal background.

The time-varying background intensity in each channel was derived from those spectral components lying outside the central Doppler peak and subtracted to derive the surface echo, integrated over its Doppler width. A correction for the difference in sensitivity between L and R channels was made. This correction was derived from observations of the direct signal from the spacecraft through a sidelobe of the spacecraft antenna. There are indications of a slow drift of this correction during the observations; we are working on using the data to derive the time-varying correction.

The corrected L- and R- echo intensities and complex L-R correlations were median filtered in a running window in order to reduce noise. After that, the complete set of four Stokes parameters describing the polarization state of the echo was calculated from the intensities and their correlations. Circular, linear, and total polarization degrees and linear polarization angle were then were calculated from the Stokes parameters.

Preliminary results: Partial results are presented in Figs. 1-3. These show surface tracks of the specular reflection point. (The actual tracks are closer to each other than shown in the figures.)

Fig. 1 shows the *total echo intensity* superposed on a map of decameter-scale roughness derived from Magellan radar altimeter data [2]. Violet color denotes zero intensity. The correlation between orbits is seen to be very good. There is generally an anticorrelation between roughness and echo intensity; very rough tesserae give almost no measurable echo; the strongest echoes come from very smooth areas; many local roughness contrasts coincide with changes in echo intensity. Quantitatively, however, the correlation between roughness and echo intensity is not very high. This implies that the bistatic echo intensity is not sensitive to the same roughness scale as that of the slope derived from the radar altimeter data. The bistatic echo intensity, however, can be systematically in error due to a cross-track deflection of the footprint center from the specular reflection point.

There is no correlation between roughness or echo intensity and the Doppler width of the echo, because, in these observations, the Doppler width is controlled by the footprint size rather than by surface roughness.

The total *polarization degree* of the echo is very close to unity for all terrains, except the roughest tesserae, where we do not detect any pronounced echo. This independently confirms that the scattering is quasi-specular and we can expect that echo polarization is well described by the Fresnel equations. There is no correlation between roughness or echo intensity and the total echo polarization degree. The echo is mostly linearly polarized.

The color-coded *linear polarization angle* superposed on a Magellan SAR mosaic is shown in **Fig. 2** for the same region as in Fig. 1. There are systematic differences between the adjacent passes and systematic trends along the passes. These are only partly explained by the small differences in the incidence angle. We are currently working on ways of removing these spurious effects. Despite them, the along-track variations of the polarization angle correlate very well between adjacent passes (although this correlation is not readily apparent in Fig. 2), suggesting that these variations reflect true variations of surface dielectric permittivity. For example, the surface material in the ridge belt shown by the arrow in Fig. 2 has a lower dielectric permittivity than the surrounding plains.

The degree of *circular polarization* is small and displays a spurious trend apparently caused by a drift of the sensitivities in the R and L channels. No pronounced correlation between adjacent passes is observed. There is only one well-expressed deflection of the circular polarization degree from the trend line. It is shown in red in **Fig. 3**, where the color-coded circular polarization degree is superposed on a SAR mosaic. Unfortunately, only one orbit passed over this region, and we cannot confirm that this is a real phenomenon. The observed increase of 15% in circular polarization degree would imply extreme electromagnetic losses in the surface material. This possibly anomalous area contains a wide variety of geomorphic features, but it is geologically unique due to the presence of vast dune fields resolved in SAR images [3].

Future work: Further analysis is in progress. We are working to remove the slow drifts in cross-calibration of the R and L channels. This will improve the absolute accuracy of the derived Stokes parameters, and we will be able to estimate the dielectric permittivity along the tracks. A comparison with reflectivity derived from the Magellan radar altimeter data can be used to identify layers of surficial deposits, and a comparison with emissivity from Magellan radiometric measurements can be used to look for magnetic materials on the surface [4].

References: [1] Pettengill, G. H. et al. (1996) *Science 272*, 1628-1631. [2] Ford, P. G. and Pettengill, G. H. (1992) *JGR 97*, 13103-13114. [3] Greeley, R. et al. (1992) *JGR 97*, 13115 – 13139. [4] Starukhina, L. V. & Kreslavsky, M. A. (2004) *LPS XXXV*, #1956.