ECHO SOURCE DISCRIMINATION IN AIRBORNE RADAR SOUNDING DATA FOR MARS ANALOG STUDIES, DRY VALLEYS, ANTARCTICA. J. W. Holt[1], D. D. Blankenship[1], M. E. Peters[1], S. D. Kempf[1], D. L. Morse and B. J. Williams[1], [1]University of Texas Institute for Geophysics, The John A. and Katherine G. Jackson School of Geosciences, University of Texas, 4412 Spicewood Springs Rd., Bldg. 600, Austin, TX 78759, jack@ig.utexas.edu

Introduction: The recent identification of features on Mars exhibiting morphologies consistent with ice/rock mixtures, near-surface ice bodies and near-surface liquid water [1,2], and the importance of such features to the search for water on Mars, highlights the need for appropriate terrestrial analogs in order to prepare for upcoming radar missions targeting these and other water-related features. Climatic, hydrological, and geological conditions in the McMurdo Dry Valleys of Antarctica are analogous in many ways to those on Mars, and a number of ice-related features in the Dry Valleys may have direct morphologic and compositional counterparts on Mars.

We have collected roughly 1,000 line-km of airborne radar data over permafrost, subsurface ice bodies, rock/ice glaciers, ice-covered saline lakes, and glacial deposits in Taylor and Beacon Valleys. These data are being analyzed in order to develop general radar propagation models of features with direct relevance to Mars.

A crucial first step in the data analysis process is the discrimination of echo sources in the radar data. The goal is to identify all returns from the surface of surrounding topography in order to positively identify subsurface echoes. This process will also be critical for radar data that will be collected in areas of Mars exhibiting significant topography, so that subsurface echoes are identified unambiguously.

Data Acquisition Methods: Using a Twin Otter airborne platform, data were collected in three separate flights during the austral summers of 1999-2000 and 2001-2002 using multiple systems, including a chirped 52.5 – 67.5 MHz coherent radar operating at 750 W and 8 kW peak power (with multiple receivers) and 1 - 2 microsecond pulse width, and a 60 MHz pulsed, incoherent radar operating at 8 kW peak power with 60 ns and 250 ns pulse width. The chirped, coherent data are suitable for the implementation of advanced pulse compression algorithms and SAR focusing.

A laser altimeter (fixed relative to the aircraft frame) was also used during both seasons. Post-processing of the positioning data yields accuracies of ~ 0.10 m for samples at ~ 15 m intervals. Precise positioning was accomplished through the use of two carrier-phase GPS receivers on the aircraft and two at McMurdo Station.

Surface and shallow subsurface properties are being supplied by glacial geomorphologists conducting ground-based studies in Taylor and Beacon Valleys.

Data Acquisition Targets: Flight paths for the Dry Valleys flights in late 2001 are shown in Figure 1. Flights in early 2000 achieved approximately the same coverage, excluding Beacon Valley (due to weather). Flight elevation was nominally 500 m above the surface. Radar and laser altimetry data were collected over the following targets relevant to Mars:

Taylor Glacier: The entire length of Taylor Glacier was surveyed. These profiles extend from Taylor Dome on the polar plateau to the terminus in Taylor Valley

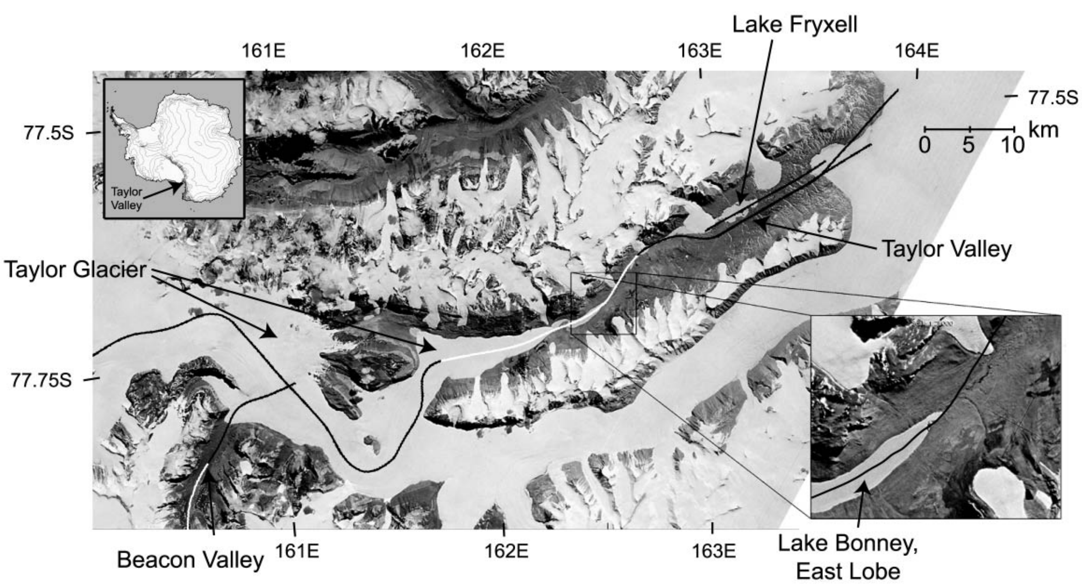

Figure 1. Optical satellite photo of Taylor Valley (center) and Beacon Valley (lower left) within the McMurdo Dry Valleys of Antarctica. UTIG airborne radar profiles (from 2001) are indicated by the solid

black and white alternating lines.
where it is characterized by a high-angle, ice-cored thrust moraine [3]; this profile also includes a lobe that penetrates Beacon Valley. Possible subsurface reflectors in the preliminary data near the terminus appear to be a root of the ice-cored thrust moraine.

Friedman Rock Glacier, upper Beacon Valley: This glacier is 1-2 km wide by 3-4 km long, is heavily debris-covered and is slow moving (max 40 mm/a) [4]. Preliminary data show possible basal reflectors below the glacier where we overflew it.

Debris flows, Taylor Valley: East of Lake Bonney (Fig. 1), a debris flow emanating from the northern wall of Taylor Valley is hypothesized to have occurred in a subaqueous environment [3]. This flow is fairly well defined in the preliminary data (Fig. 2) .

Ancient subsurface ice body, central Beacon Valley: This body is covered by < 1m of glacial drift and hypothesized to be ~ 8 Ma [5].

Permafrost and active layers: In lower Taylor Valley, the Bonney drift includes reworked lake deposits and hummocks thought to be dessicated thrust moraines [3]. Polygonal terrain that we overflew in Beacon Valley is underlain by ice bodies and ice-cemented soil [6].

Lakes Fryxell and Bonney, Taylor Valley: We collected data over both of these ice-covered saline lakes. Permafrost underlies Lake Fryxell [7] and probably Lake Bonney, so we expect a shallow perched water table near the lakes. The reflector underlying the debris flow adjacent to Lake Bonney appears to merge with the lake (Fig. 2).

Data Analysis: The first stage of analysis is the discrimination of subsurface echoes from surface echoes due to surrounding topography. Two techniques are being used in parallel for echo discrimination. Surface returns are being simulated using aircraft position data, the modeled radar antenna pattern, and surface topography from a digital elevation model (DEM) recently acquired by the USGS and NASA in the Dry Valleys with 2-meter postings. These will be compared with the actual data to reveal side echoes.

The second method identifies all echoes in the radar data and maps them into possible correlative surface features to the sides of the aircraft through range estimation. This uses the measured time delay of the echo and known surface topography. We map the echoes onto the DEM (and optical imagery) at the appropriate range in order to identify candidate surface return sources. The two methods should identify all echoes that are not from the subsurface. The comparison of different radar configurations and parallel tracks where they are available will also be utilized to identify the source of any ambiguous echoes.

Once this stage is completed, forward models of the radar properties of these targets will be developed. These can then be applied in a general sense to similar features on Mars, in the context of future radar missions.

Conclusions: Preliminary results of airborne radar sounding in the Dry Valleys of Antarctica indicate penetration of a debris flow, a rock glacier, and massive subsurface ice bodies. Two methods of echo discrimination are being developed in order to confirm apparent subsurface reflectors: (1) forward modeling of echoes using known properties of the radar, antenna pattern and topography, and (2) mapping of radar echoes to the sides of the aircraft to identify features in the topography that could be echo sources.

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References: [1] Malin M. C. and Edgett K. S. (2000) *Science, 288,* 2330–2335. [2] Baker V.R. (2001) *Nature, 412,* 228-236. [3] Higgins S. M., Denton G. H., and Hendy, C. H. (2000) *Geogr. Ann., 82A,* 365-389. [4] Rignot E. J., Hallet B. and Fountain A. (2002) *JGR,* submitted. [5] Sugden D. E., Marchant D. R., Potter N., Jr., Souchez R. A., Denton G. H., Swisher C. C., and Tison J.-L., (1995) *Nature, 376,* 412-414. [6] Sletten R. (2002), *pers. comm..* [7] Harris H. J. H. and Cartwright K. (1981), *Antarctic Res. Ser., 33,* 193-214.

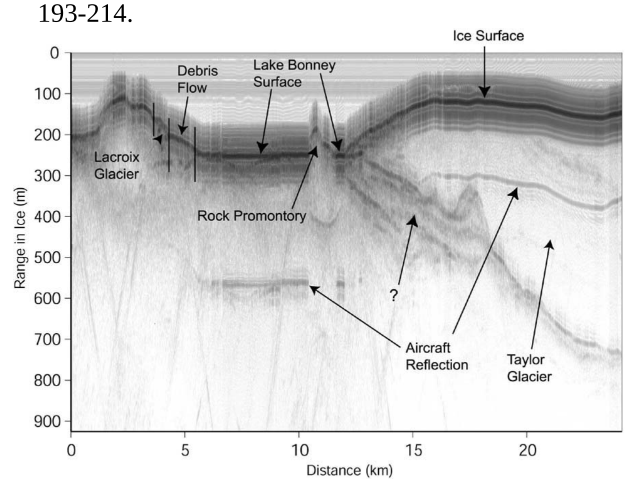

Figure 2. A portion of the radar sounding profile of Taylor Valley (white segment of flight path in center of Figure 1). Up-valley is to the right in this figure. The (?) points to a possible debris-rich layer at the base of Taylor Glacier that may be the source of ice-cored thrust moraines that outcrop at the terminus.