GPR surveys of Sand Dunes in Antarctica as Analogs for Dunes on Mars

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The cold, dry, windy conditions on Mars have created a variety of sand dunes especially in the areas surrounding the polar ice caps. Antarctica is the coldest, driest, and windiest continent on Earth. As a consequence, the areas on Antarctica that are free of ice and snow are analogous to the surface conditions on Mars. In this paper we report the results of a ground penetrating radar (GPR) survey of sand dunes in Antarctica. In Victoria Valley, one of the McMurdo dry valleys of Antarctica, there are areas of sand dunes that include reversing, transverse - barchanoid dunes, and slipfaceless 'whaleback' dunes (Fig. 1). We have used ground penetrating radar (GPR) systems with central frequencies between 100 and 900 MHz to image the sedimentary structures within the dunes.

The results of the GPR surveys are exceptionally good with good depths of penetration and very high resolution. The lack of attenuation is attributed to a lack of liquid water within the frozen dunes. Successive layers within the dunes imaged by the radar provide a record of sand accumulation on the dune surface and record the development of the dunes.

Interpretation of the GPR profiles indicate that the reversing dunes of the Packard dune field show net migration towards the west in response to easterly winds blowing along the Lower Victoria Valley in the summer. There is evidence for wind reversal with strata dipping towards the east at the crest of the dune (Fig. 2). These eastward dipping strata are interpreted as the deposits of katabatic winds that descend from the Antarctica Plateau which are stronger and more frequent during the winter months. The seasonal reversing winds reprofile the producing low-angle bounding surfaces that are imaged by all the GPR antennae. However, the higher frequency antennae (especially the 450 MHz) successfully image strata between the bounding surfaces. In addition, we have also identified frequency dependent anomalies from layers of snow and ice within the dunes. Discontinuous snow layers that appear to produce parabolic reflections on GPR profiles collected with lower frequency antennas have less obvious effects on the profiles collected with the high frequency antennas, although they may produce some multiples. Because the multiples are parallel to the snow layers and strata within the dune they could easily be mistaken for reflections from primary sedimentary strata.

The Victoria Valley dunes show evidence of topographic control on dune orientation and wind direction. The results of this study illustrate the potential for GPR surveys on future missions to Mars.

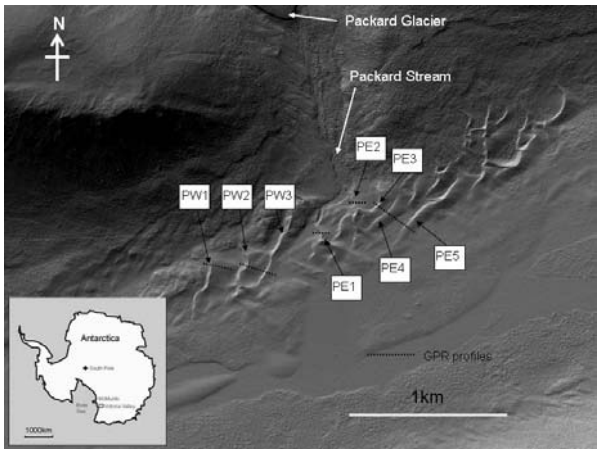

Figure 1. Locality map and Lidar image of sand dunes in the Victoria Valley, Antarctica

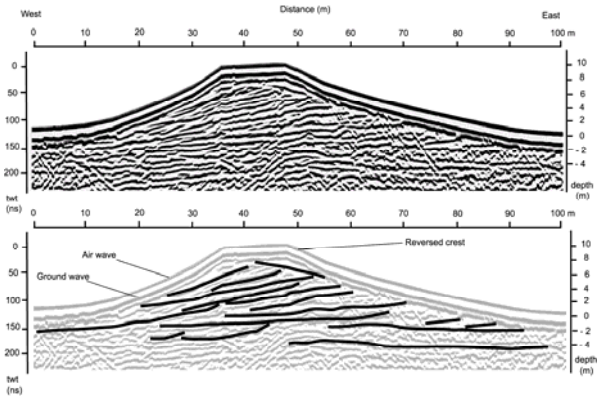

Figure 2. GPR profile PE1 (see location above) showing inclined reflections from bounding surfaces within a reversing dune. Data collected using Pulse EKKO 100 with 100 MHz antennas and 1000 volt transmitter.