GROUND-PENETRATING RADAR IN MARS ANALOG TERRAINS: TESTING THE STRATA INSTRUMENT. K.K. Williams1, J.A. Grant1, and A.E. Schutz2, 1Center for Earth and Planetary Studies, MRC 315, National Air and Space Museum, Washington, DC 20013-7012, williamsk@nasm.si.edu, 2Geophysical Survey Systems, Inc., 13 Klein Drive, North Salem, NH, 03073.

Introduction: Ground-penetrating radar (GPR) has been recognized as a time-saving tool for non-invasive exploration of subsurface structures and radar properties [1]. Whereas GPR has been employed for a variety of geological, archaeological, and engineering problems on Earth, its potential usefulness onboard future Mars rovers has also been discussed [2-7]. In support of development of the Strata GPR instrument for Mars rovers [8], prototype and commercial antennas were used to collect data in several Mars analog environments. Field testing was conducted in volcanic, cratered, and fluvially modified environments in northern Arizona (Fig. 1a) [9], ice-rich and ice-poor locations in the Canadian arctic (Fig. 1b) [10], and a paleo glacio-deltaic environment in southern Maine. Data collected at these locations demonstrate the ability of the Strata prototype to reproduce accurately the results of commercial antennas, which can reveal subsurface stratigraphy to depths of 10s of meters, depending on the substrate.

Instrumentation: Field data were collected with commercially available Geophysical Survey Systems, Inc. (GSSI) radar controllers and antennas. Antennas used in various parts of this study operated at peak frequencies of 200, 400, 500, 900, and 1500 MHz. Strata prototypes, also designed and built by GSSI, are low-mass, low-power, low-volume simple, loaded dipole antennas that operated at 600 and 400 MHz. An early, unshielded version was used at the Arizona sites and a mature, low-profile antenna was tested in the extreme environment of the Canadian arctic and was used to collect 3-D data over a deltaic deposit in Maine. As a complement to GPR data, seismic profiles were collected at several sites in Arizona and resistivity data were collected in the arctic.

Field Operations: This study complements others that employed GPR in Mars analog terrains in Egypt and other arid areas [4, 7, 11]. Those studies showed the ability of GPR to constrain local geologic setting and history in extremely arid areas, and this work reports on data collected in moderately arid, frozen, and moist environments. At each location, data were collected along traverses at several different frequencies using commercial antennas. Data were also collected with the prototype Strata instrument in different configurations, depending on the location. At the Arizona locations, an early prototype was suspended 20-25 cm above the ground. A more mature prototype was used at the arctic and Maine sites where data were collected with the antenna at ground level and elevated 50 cm above the surface. In addition, data were collected with the prototype 1 m above the ground at some locations in the arctic. Data collection with the prototype antenna above the ground was meant to mimic a likely configuration of a Mars rover-mounted GPR where the antenna would be mounted to the rover underside to minimize risk to rover operations. At the Maine site, a data grid was collected to demonstrate the ability to assemble GPR data profiles into a 3-dimensional representation of dipping layers in the subsurface.

Results: As expected, the performance of the commercial and prototype instruments depended on subsurface properties, but penetration in excess of 5-10 meters was achieved at most locations. A summary of results from different locations follows.

Northern Arizona. Testing of the Strata instrument took place at iron-rich volcanic, cratered, and fluvially modified sites including Sunset Crater, Meteor Crater, and the 2002 FIDO test site near Cameron. The greatest penetration among these sites in Arizona was at Sunset Crater where up to 5 meters of loose cinders overlaid basalt flows. GPR data collected with the Strata and commercial antennas reveal details of
layering within the cinders while revealing interface between cinders and basalt flow (Fig. 2). Interesting stratigraphic relationships were also revealed at Meteor Crater, though signals penetrated less deeply because of the higher dielectric properties. Data showed continued dipping of the southern ejecta blanket beneath an alluvium cover, which had a relatively high permittivity of 5. This interface could be followed to a depth of almost 3 meters, and has been confirmed by excavation [12]. At the FIDO site, GPR data confirmed the stripped nature of the surface and absence of a buried channel.

**Canadian arctic:** Fieldwork took place in the Mackenzie Delta, Northwest Territories in March 2004 when air temperatures dipped to ~40 and the ground had been constantly frozen for more than 5 months. Coordinated data collection with GPR and resistivity provided complementary datasets where locations of buried ice bodies detected in resistivity data could be compared to radar properties revealed in GPR data. Analysis of the two geophysical datasets shows that GPR signals are affected by material property differences between frozen ground and massive ice (Fig. 3). GPR profiles were also effective at detecting the base of the active layer (region that undergoes thaw in the summer) even though it was completely frozen when data were collected. Results from permafrost are especially relevant to Mars studies in light of the detection of near surface ground ice at moderate latitudes on Mars [13, 14].

**Deltaic deposit.** Southern Maine contains many areas where dipping, layered strata were deposited in deltas during the Pleistocene [15]. A 400 MHz GSSI antenna and the Strata prototype were used to collect data in parallel profiles that could be assembled into a 3-D data cube to add a new dimension to visualization of the subsurface (Fig. 4). The dipping foreset deposits are easily resolved, and horizontal slices through the data cubes show the strike of the dipping layers.

**Summary:** During development of the Strata GPR for Mars rovers [8], data were collected in a variety of Mars analog settings and effectively constrain subsurface layers even when the Strata antenna was mounted 50 cm or 1 m above the surface. The ability to reveal subsurface structure and properties remotely without drilling or excavating has proven invaluable on some applications on Earth and would add a new dimension to rover-based investigations on Mars or other solid bodies in the solar system.

**References:**