MARS AIRBORNE NEUTRON SPECTROMETRY, RELICT ICE AND RECENT CLIMATE CHANGE.

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Introduction: Gamma ray and neutron spectrometers in orbit around Mars have revolutionized our views of the present distribution of water ice and hydrogenous minerals [1,2]. In particular, hydrogen enhancements (expressed as water equivalent hydrogen, or WEH) at low- and mid-latitudes could potentially be related to comparatively recent climate change on Mars. The identification of glacial landforms, viscous flow features and dissected terrain above 40 latitude all point to near-surface water ice undergoing change [3,4,5,6,7]. But how much ice actually exists beneath these landforms, and how much has been lost to sublimation or melting?

Because of its orbital altitude, Mars Odyssey does not permit neutron-derived hydrogen abundances at better than a few hundred kilometers resolution. To address the question of the current state of near-surface ice, better spatial resolution is needed. To compare with the scales of ice-related features we observe today, a resolution of less than 1 km up to a few tens of kilometers is desired. Hydrogen variations can be observed on a rover down to a few tens of centimeters, but only over the area covered by the rover. How can we obtain better knowledge over regional scales, over hundreds of kilometers?

Aerial Neutron Sensing: A Mars aerial vehicle can cover regional scales from low altitudes, making it an ideal platform for neutron measurements. An epithermal neutron detector with sufficient collection area can provide the count rates and statistics to enable detection of hydrogen enhancements down to kilometer scales. Here we describe simulations of the operation of such an instrument for various scale sizes, abundances, and burial depths of water ice.

The simulations are run for two large epithermal neutron detectors, 20 cm active length by 3.8 cm diameter. These dimensions are similar to those of the Lunar Prospector epithermal neutron detectors. We also take the altitude of the airplane to be 1.5 km above ground level. At this altitude, the instrument would sense approximately 48 epithermal neutron counts per second over a 2-wt% water-equivalent hydrogen soil with Pathfinder composition.

Detection of 10 wt% WEH: Figure 1 shows a flight profile over several deposits with 10 wt% WEH. The deposits a, b, c, d, and e have sizes of 2, 5, 10, 2, and 20 km, respectively. The top panel of the figure shows the original raw count rate data in red (counts are accumulated every 1 second), the time-smoothed average of the raw count rate in green, and idealized count rate of an infinite signal-to-noise (SNR) instrument in black. The middle panel shows the SNR for the measurements, in terms of their difference from the expected 2 wt% epithermal count rate of the surrounding soil. The SNR is expressed in units of the standard deviation expected from counting statistics – 3-sigma is considered a certain detection. The lower panel shows the corresponding depth to pure ice (under a 2 wt% WEH Pathfinder soil) in gm/cm^3. The depth in cm can be obtained by dividing by the soil density. Note that both 2-km deposits are close to 3-σ detections, while the larger deposits greatly exceed 3-σ, which is shown by the red line. Thus, for such a depth to ice,

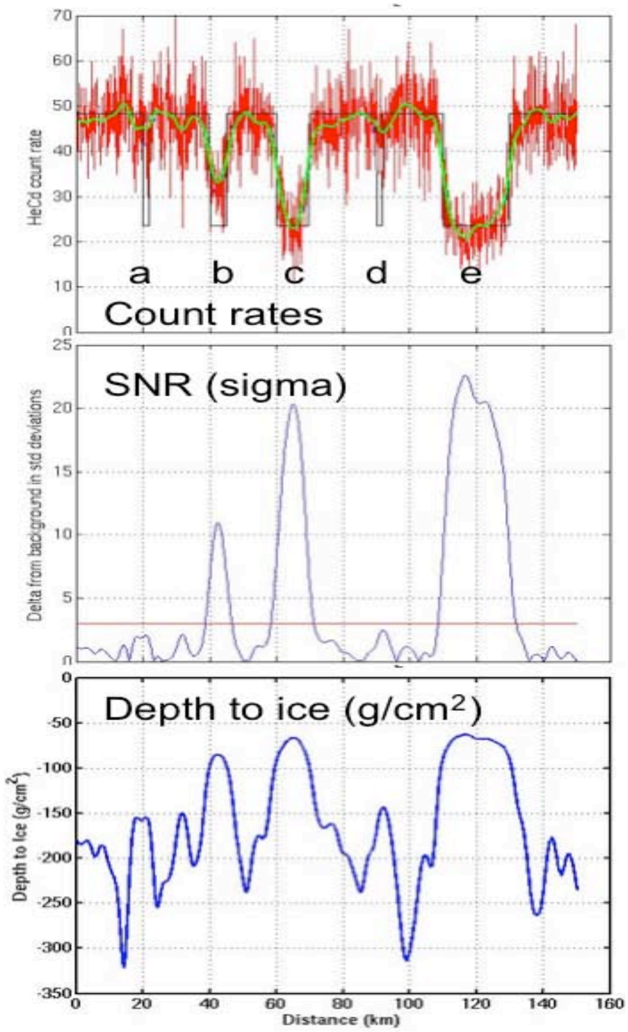

Figure 1. Simulated measurements of 10 wt% WEH deposits from a Mars airborne platform.

or equivalently 10 wt% WEH, the surface resolution of the airborne instrument is approximately 2 km.

Detection of 50 wt% WEH: Figure 2 shows a flight profile over several deposits with 50 wt% WEH. As before, the deposits a, b, c, d, and e have sizes of 2, 5, 10, 2, and 20 km, respectively. The top panel of the figure shows the original raw count rate data in red, the time-smoothed average of the raw count rate in green, and idealized count rate of an infinite signal-to-noise (SNR) instrument in black. The middle panel shows the SNR for the measurements, in terms of their difference from the expected 2 wt% epithermal count rate of the surrounding soil. The SNR is expressed in units of the standard deviation expected from counting statistics – 3-sigma is considered a certain detection. The lower panel shows the corresponding depth to pure ice (under a 2 wt% WEH Pathfinder soil) in gm/cm^3. The depth in cm can be obtained by dividing by the soil density. Note that both 2-km deposits are close to 3-σ detections, while the larger deposits greatly exceed 3-σ. Thus, for such a depth to ice, or equivalently 50 wt% WEH, the surface resolution of the airborne instrument is approximately 2 km.

Conclusions: An airborne neutron spectrometer can hugely improve the surface resolution of hydrogen abundances on Mars on regional scales. Such an instrument is sensitive to several wt% WEH variations against the typical 2 wt% WEH background. It should be possible to investigate a large number of km-scale features thought to be associated with relict ice. These include glacial deposits such as drop moraines, the smooth facies of the Tharsis glaciers, viscous flow features and the dissected terrain at higher latitudes, and features like the Hourglass crater deposits on the eastern rim of the Hellas basin.

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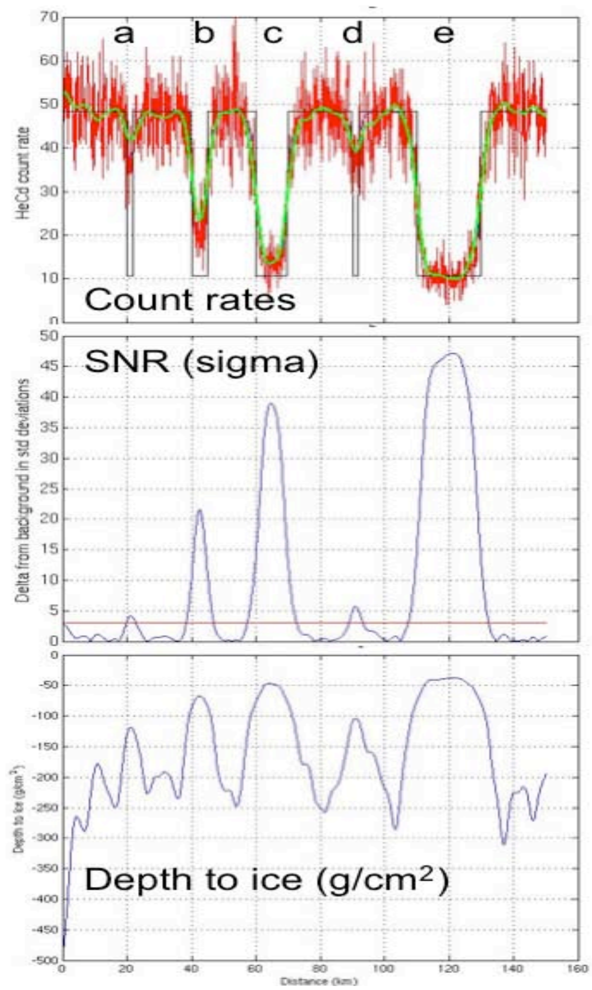

Figure 2. Simulated measurements of 50 wt% WEH deposits from a Mars airborne platform.