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Using the Transient Electromagnetic (TEM) Method for Mapping Deep Groundwater Tables in Mars Analog Environments: a Baseline Field Study.

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INTRODUCTION: The purpose of this study is to explore the use of electromagnetic geophysical techniques for mapping deep groundwater tables in Mars analog environments. In order to provide a baseline for such studies, and to evaluate the appropriateness of the Transient Electro-Magnetic (TEM) method in mapping deep groundwater tables, a field study was carried out in an area in the desert approximatelt 30 miles southwest of Tucson Arizona. The field area was chosen for its convenient logistics and access to technical support, as well as for its appropriateness as a baseline Mars analog site. DISCUSSION: The surface conditions at the site are less than ideal if the main motivation is to look for analogs for surface working conditions on Mars, due to a fairly dense cover of cacti and thorny brush. However, in a situation like in the present study, where the subsurface analog is of more interest, vegetation cover is only a logistical issue. The subsurface in the field area is quite conductive, a result of its clay-rich soil, and this may at first thought seem to make it a less than ideal location for Mars analog studies. The contrary is the case, however: In having to deal with the very conductive environment at the field area location for this baseline study, it is ensured that results and conclusions drawn from this work regarding issues such as working in a conductive environment and achieving certain depths of investigation can indeed be applied to planning field studies elsewhere. Further, the study is also designed to observe the effects of powerline noise on electromagnetic data, again presenting a very-difficult case, and further aiding in building a baseline case that is overall appropriately more difficult than most field studies will be (in terms of achieving good signal-to-noise ratios and depths of investigation). The field survey consisted of 40 in-loop TEM stations, divided into 3 lines, for 4 line-km of data. The survey was carried out by a crew of one person, with square Tx wire loops 100 m on a side, and a ferrite-core magnetic coil Rx antenna in the center of each Tx loop. Maximum useful depth of investigation achieved was ~600 m. For control, there are 4 USGS test wells in the area, that have shown water levels from 116.27 m to 124.68 m. In order to evaluate the best frequency to use for the survey, several test soundings were collected at two locations: Station 50 (first station) on Line 1, and again at Station 650 (seventh station) on Line 2. At Line 1/ Station 50, test soundings were collected at 8 Hz, 16 Hz, and 32 Hz. It is clear from the test data that 16 Hz provides the cleanest data out to the latest decay times. At Line 2/ Station 650, test soundings were collected at 8 Hz and 16 Hz. Again 16 Hz provides the cleanest data out to the latest times. Based on the results from the test soundings at Line 1/ Station 50, 16 Hz was used as the sounding frequency throughout the survey, with the additional test soundings at Line 2/ Station 650 confirming the soundness of this choice. CONCLUSIONS: TEM provides a cost-efficient way of mapping deep groundwater, and can be carried out with very small crews and relatively low-cost equipment. The very conductive subsurface environment and abundance of powerline noise sources in the field area makes this an appropriately difficult environment in which to carry out these continued baseline studies. Data from

Lines 1, 2, and 3, all show resistivities in the range of 10 to 100 ⊥ Um from the surface down to the water table, consistent with the clay-rich soil in the area. The resistivity gradient seen at ~120 m roughly matches the USGS well data.

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