SIMULATED ROVER FIELD TEST AT THE HAUGHTON-MARS PROJECT IMPACT CRATER FIELD STATION.

H. E. Newsom[1], A. M. Ollila[1], N. L. Lanza[1], P. King[1,2], Z. Gallegos[1], G. R. Osinski[2], S. M. Clegg[3], R. C. Wiens[3], D. Vaniman[3], P. Lee[4,5,6], B. J. Glass[6], E. Walker[4], S. Thackrey[4,7], J. Parnell[7], [1]Institute of Meteoritics, MSC03 2050, 1 Univ. of New Mexico, Albuquerque, NM 87131, U.S.A. (newsom@unm.edu), [2]Univ. of Western Ontario, Canada, [3]Los Alamos National Laboratory, Los Alamos, NM. U.S.A., [4]Mars Institute, [5]SETI Institute, [6]NASA Ames Research Center, Moffett Field, CA 94035, U.S.A., [7]Univ. of Aberdeen, Aberdeen, AB243UE, UK.

Introduction: Simulated field tests of robotic operations provide useful operational lessons [e.g., 1, 2]. The simulations, including the Slow-Motion Field Test of the Mars Science Laboratory (MSL) instrument packages in 2007 (e.g. [3]), help us to understand the role of new instrumentation (such as the use of ChemCam and CheMin). In general, earth-based field tests simulating Mars operations offer advantages over the Mars Exploration Rovers (MER) in that the interpretations can be checked for accuracy by a human field geologist, and can utilize the new instruments that will be available to MSL. A new set of rover science simulation tests using the Haughton impact crater as a test site was therefore funded by the NASA Moon and Mars Analog Mission Activities (MMAMA) program. The Haughton tests are complementary to an ambitious set of Science Activity Plan Exercises (SAPE) run by Joy Crisp at JPL utilizing MER data and the MSL software "MSLICE" to practice MSL operations. The conduct of the SAPE tests in the Fall of 2008 provided both additional lessons learned, and also a framework for use of the Haughton data set for additional tests early in 2009.

Fig. 1. This interior view of the 23 km diameter Haughton impact structure, Devon Island, Canada, shows the grey impact melt breccia deposits (image H. Newsom).

Haughton crater: The 23 km diameter Haughton impact structure is located on Devon Island, Nunavut, in the Canadian High Arctic (75°22'N, 89°41'W). The crater formed 39 million years ago and lies in the polar desert environment (see [4] for an overview). Its surviving geologic features are exceptionally well preserved due to the slow erosional processes in the high Arctic, because of the extreme seasonality in the availability of liquid water and continuous permafrost. The absence of virtually any substantial vegetation cover also limits the weathering of surface materials, while it optimizes the site's exposure for geologic surveys from the ground and by remote sensing. At Haughton, the lithologies are complex and diverse, reflecting excavation of 2 km of Paleozoic sediments and gneissic basement. The predominantly carbonate-sulfate sedimentary rocks provide an important Martian analog, considering the discovery of carbonate rock signatures in CRISM data from Mars [5] and in the Martian regolith by the Phoenix lander.

Particularly distinctive at Haughton is the crater's allochthonous impact melt breccia (**Fig. 1**); a deposit resulting from the melting and mixing of rocks within the initial transient crater. The Haughton breccia formation may represent a first-order physical analog to impact crater deposits on Mars and the lunar poles.

MSL instrument suite: The MSL contains a suite of new and improved analytical instruments, dramatically changing the paradigm for rover activities. The new ChemCam LIBS instrument is capable of probing samples up to 7 m from the rover mast. Laser-Induced Breakdown Spectroscopy (LIBS) uses a pulsed laser to create a plasma on the surface of the target, which in turn emits light of wavelengths characteristic of the constituent species [6-8]. Both chemical composition and rock type are determined using multivariate analysis (MVA), which exploit matrix effects and can also identify carbonates and organics [9-12]. The APXS is an improved version of the instruments used on Pathfinder and MER and has the capability of analyzing samples during the day. The new CheMin X-ray Diffraction instrument provides mineral structural information and limited chemical information on samples obtained by drilling (also a new capability).

2008 Field season at Haughton Crater: Field work was accomplished in July-August 2008 by H. Newsom and G. Osinski. Planning on site was provided by P. Lee and field guidance provided by J. Parnell, S. Thackrey, and E. Walker. Hundreds of images were taken with a Nikon D-80 and zoom lens to simulate the field of view of the two Mastcam imagers (5.1 degree and 15 degree). The collected samples have been photographed in the laboratory with a macro lens to simulate the ChemCam remote imager and the MAHLI high-resolution arm camera. Archetype samples are being analyzed by laboratory versions of the MSL instruments and by conventional XRF/XRD, and thin sections will be used for textural and microprobe analysis as needed. Three specific locations were sampled for the purposes of supporting slow-motion tests.

Fig. 2a. Breccia Cliff sample location (image, G. Osinski). Note the lack of scale or slope information.

Fig. 2b. Image of the Breccia Cliff location with ~ 2 m tall person for scale (image, H. Newsom). The remarkably steep slope is not apparent from the image in **Fig. 2a**.

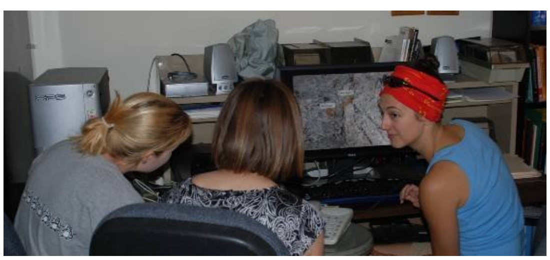

Fig. 3. Initial (Sol 0) science operations meeting. Present from the left are Ann Ollila (science team), Penny King (SOWG chair), and Nina Lanza (science team). Not shown are Gordon Osinski (remote field science team) and photographer Horton Newsom (field science team).

Breccia Cliff – This location was sampled early in the field season by Osinski and later by Newsom, and provided the initial samples and images for the first test session. This site sampled the basal impact mega breccias in the interior of the crater, consisting of blocks of carbonate and silicate basement rock up to several meters in size, in many cases with shatter cones, embedded in a fine grained impact melt-bearing breccia.

Trinity Lake – This site contains a number of different types of materials that could be encountered on Mars, including polygons and a hydrothermal deposit with Fe-hydroxide alteration. This site was also drilled by B. Glass during the 2008 field season and samples of the drilled material will be used as part of the remote test activities involved with this site.

Camp hydrothermal site – This site contains fault breccias, as well as a prominent hydrothermally cemented deposit with oxy-hydroxide alteration and calcite cementation.

Initial science team test and lessons learned: Science Operations Working Group (SOWG) meetings for the Haughton project were conducted using the initial data from Osinski (**Fig. 3**). One of the important lessons learned is illustrated in the comparison between, **Fig. 2a** and **Fig. 2b**. The lack of even a single blade of grass resulted in a substantial misinterpretation of the slope and scale in **Fig. 2a**. It was deemed possible to rove up the slope to acquire samples; however, the reality as seen in **Fig. 2b,** acquired later in the field season by Newsom, is that the slope is at the angle of repose, and would be impossible to ascend.

The science team misinterpreted the scale of the outcrop in this and other images by about a factor of two. A similar problem occurred during the recent SAPE test, suggesting that some kind of live scaling tool should be available in future rover software in addition to the rulers currently available.

The remote science team also did not appreciate the large diversity of the impact breccias from the imagery, although shatter cones were identified. A need was also identified for a way to determine priorities for sampling soils and rocks for habitability assessment.

These examples emphasize the value of the Haughton site for these kinds of tests and also indicate the necessity of using appropriate tools and stereo imagery during a real mission to fully understand and interpret a given site.

References: [1] Newsom H. E., et al. (2001) *JGR 106*, 7713-7720. [2] Stoker C. R., et al. (2001) *JGR 106*, 7639-7663. [3] Wiens R. C. et al. (2008), *LPS. XXXIX*, Abstract #1500. [4] Osinski G. R., et al. (2005) *MAPS* 40:12:1759–1776. [5] Ehlmann, B. L. et al., (2008) *Science 322*: 1828-1832. [6] Arp, Z.A. et al. (2004) *Applied Spectroscopy 58*, 8, 897-909. [7] Radziemski, L. et al. (2005) *Spectrochimica Acta Part B 60*, 237-248. [8] Cremers, D.A. and Radziemski, L.J. (2006). *Handbook of Laser-Induced Breakdown Spectroscopy*. [9] Clegg S.M., et al. (2008) *Spectrochimica Acta B*., submitted. [10] Lanza N. L. et al. (2008) *LPS XXXIX*, Abstract #2299. [11] Wiens R.C. et al. (2009) this meeting. [12] Forni O. et al. (2009) this meeting.

Acknowledgements: Supported by NASA MMAMA grant NNX08AR87G (HEN) and NASA/JPL/Los Alamos National Lab/MSL/ChemCam (R. Wiens, P.I., H. Newsom, Co-I. Thanks to P. Akeegok, J. Schutt, S. Braham and N. Wilkinson for support at HMP.