DRILLING FOR DATA: SCIENCE RESULTS FROM 2015 ROBOTIC DRILLING FIELD TESTS AT RIO TINTO SPAIN. C.R. Stoker[1], B. Glass[2], V. Parro[3], E.Z. Noe Dobrea[1] [1] Space Science Division, NASA Ames Research Center, Moffett Field CA, [2]Exploration Technology Division, NASA Ames Research Center, Moffett Field CA, [3]Centro de Astrobiología (INTA-CSIC), Madrid, Spain

Introduction: The Rio Tinto is an acidic river system sourced in the Iberian Pyrite belt in Southern Spain. The region is recognized as an important Mars analog for unique mineralogy similar to minerals found on Mars. The origin of the acidity in the system is a massive sulfide deposit mined for its associated precious minerals since Paleolithic times. The sulfides, when exposed at the surface are oxidized to sulfates, releasing acids. The recognition of the analog value of the site mineralogy followed from the identification on Mars by the Opportunity Rover in 2004 of the mineral Jarosite that is only formed in acidic environments, and is common at Rio Tinto.

Objectives: The study objective was to demonstrate in the field key elements of the payload for the Mars Icebreaker mission [1] including the drilling and sample transfer system, as well as the Signs of Life Detector (SOLID) a biomolecule analyzer based on Floresence Sandwich Immunoassay[2].

Methods: In the summer of 2015 the NASA/MMAMA- funded LMAP project conducted a shallow drilling activity in a sedimentary structure upgradient from where mineral saturated acidic springs are sourced. The drill was deployed on a sediment bench with a backdrop of poorly sorted materials that were moved to this location as a result of mining activities. Samples were collected by the Icebreaker III drill [3] attached to a mockup of a Phoenix-style Mars lander. The drill could reach a maximum depth of 1m. Cameras were mounted on the underside of the lander deck and on the robotic arm imaging the scoop to document the operations. During drilling, cuttings were transferred up auger flights and collected by a scoop on the robotic arm as they came out of the hole. Then the scoop was moved to locations to dump the cuttings into the inlet port of the SOLID instrument and a mockup of the WCL instrument. Since this procedure tended to spread the sample over a large area, for science purposes, in the first of 5 holes all cuttings were collected into sterile tubes before entering the scoop so that aliquots could be analyzed by different methods. Samples were extracted by the field version of the SOLID instrument and analyzed with the Life Detector Chip (LDChip). A subset of samples were sent to a commercial laboratory for Phopholipid Fatty Acid Analysis (PLFA), a method that determines viable microbial number density and broad community structure. Samples were also analyzed for mineralogy with a Terra X-ray diffratometer, a commercial field portable version of the CHEMIN instrument on MSL.

Results: The drill penetrated the soil in 10 cm increments and reached a hard layer at a depth of 57 cm, where a fault was encountered that caused the drill to back out of the hole. Repeated attempts to drill within a few cm of the first hole had the same outcome. LDChip data showed highest concentration of positive biomarker detections at the depth intervals 0-13 and 50-57 cm. Proteins and sugars were also highest in these two layers. The depth intervals at 30-40 and 40-50 cm produced relatively low signatures of fluorescent intensity from the *Gammaproteobacteria* group. In the surface samples, LDChip identified *Acidithiobacillus spp. and Actinomycetes.* The PLFA data show that microbial number densities were $1x10^7$ at the surface and $5x10^5$ at deeper levels. Biological diversity also changed with depth. In the surface samples, where *Acidithiobacillus spp. and Actinomycetes* were seen PLFA identified a group of organisms associated with sulfate and iron reducing bacteria. XRD data show that all levels are dominated by the minerals Quartz, Muscovite, and Jarosite, with the highest percentage of Jarosite (10.4%) at the surface and lower concentrations subsurface (1-5% depending on level).

Discussion: The synthesis of the drill, SOLID, PLFA and XRD results suggest a harder layer at the deepest depth forms an aquitard that water flows along when rain saturates the overlying sediment. Acids released by weathering of sulfides produced jarosite that was deposited throughout the layer. Higher pH rain events do not remove less soluble Jarosite from the sediments but more soluble salts are carried down gradient where they eventually are transported along with the water by capillary action to the surface where they form efflorescenses that were observed at lower elevations nearby. Acid tolerant and iron and sulfur oxidizing/reducing microbes left biosignatures in these sediments, with maxima at the surface and at the interface with the aquitard where nutrients for these metabolisms are maximized.

References: [1] McKay et al. (2013) Astrobiology 13, 334-353. [2] Parro et al. (2011) Astrobiology 11, 15-29. [3] Zacny et al. (2013) Astrobiology 13, 1166-1198.