

NASA Astrobiology Early Career Collaboration Award Report

Inside and underneath: A preliminary study of current Mars rover sampling techniques

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Mars is one of the primary targets for the astrobiology community's search for life, and multiple robotic missions have been launched to Mars to search for organic compounds and other traces of current and past microbial life. In order to help inform where current and future rovers should sample, and where they should use limited, precious reagents for chemical analyses, the FELDSPAR (Field Exploration and Life Detection Science through Planetary Analogue Research) project uses seemingly homogenous barren basaltic icy lava fields as analogs for different Martian environments. These including areas resurfaced by wind, glacial action, and volcanic action. The goals of the project are to explore the distribution of biological activity and biomass at different spatial scales, and to model the relationships between the presence of biological activity and mineral parameters that can be measured by instruments not requiring finite chemical resources. However, so far FELDSPAR's sampling of these environments has explored neither rocks/larger pieces of sediment, nor below the top few centimeters of the sediment – both of which are prime protected areas to look for biosignature preservation in the gamma-radiation heavy, arid environment of the Martian surface.

This year (2019), I wanted to improve the scope of FELDSPAR's final major sampling year in 2020 by coming up with methods for sampling at depth and inside rock. Do biomass and bioactivity in these sediments vary at the same spatial scales when we are sampling several centimeters – or several meters – below the surface? Answering this question depends on collecting a very large number of samples from several different Martian analogs. In order to address this question in 2020, I wanted to develop methods that are good science practice, allow for sterilization between samples, are cost-effective, and above-all are feasible in a harsh environment with bad weather where we to hike to our field sites. Thus, before our 2019 sampling team arrived in Iceland, I traveled to the University of Akureyri to work with Professors Oddur Vilhelmsson and Sean Scully, who are experienced in sampling in harsh Icelandic environments.

Professor Vilhelmsson took us on a hike in the Icelandic highlands where we practiced using different field implements, from his arsenal, in field conditions. We quickly found that the drill bits we had brought were not sufficient for very solid basalt, but that they would do for less dense lava rock full of air pockets. However, we definitely needed chisels and it was a very involved protocol, and it would be impossible to collect a large number of samples during the

limited time we would have in 2020. We also found that using metal implements to try to core at depth in the very rocky conditions of the Icelandic highlands was not the best practice. Metal sampling equipment that was light enough to carry would also be ruined when coming into contact with rock. Professor Vilhelmsson suggested using plastic plumbing pipes – I could sterilize them all beforehand, and if one got ruined by a rock, we could just switch to another one. And that is exactly what I did – I went to the hardware store, bought a selection of pipes, and sealed and sterilized them for transport at the University of Akureyri labs.

These pipes worked perfectly at our field site at Dyngjusandur, and I was able to obtain several depth profiles. Although I eventually hit rock each time, it didn't matter because it was a one-use pipe. Our initial findings are that biological activity is highest 2-3 cm below the sediment surface, and we will be analyzing these samples further for changes in biomass, mineralogy, and microbial community with depth. In addition, Carlie Novak, a PhD student in the Stockton lab, was able to obtain several rock cores at the Fimmvörðuháls eruption site. We can experiment during the fall and winter with different methods of analysis to assess biomass and bioactivity, in order to hopefully build a field experiment looking at how these factors change with depth into rock and position on a boulder.

This was a fantastic and extremely helpful experience – I was able to take time to try different field methods in the environment in which we would be sampling, consult experts, and come up with a new sampling plan. Thank you so much to the NASA Astrobiology Program and the Early Career Collaboration Award for this collaborative opportunity to help improve the final science outcomes of the FELDSPAR project.



Figure 1: Hiking trip to try out sampling equipment in the Icelandic highlands with Professor Oddur Vilhelmsson and sons. Photo credit: Carlie Novak



Figure 2: Metal cores don't work so well in very rocky soil and sediment, and they are hard to sterilize between uses! Photo credit: Carlie Novak



Figure 3: Carlie Novak, first-year PhD student in the Stockton Lab, trying out the drill bits that she obtained for this expedition on Icelandic highland rocks under supervision of Professor Vilhelmsson. Photo credit: Anna Simpson



Figure 4: Taking a depth core at Dyngjusandur – we scrapped the metal sampling pipes, and decided to go with plastic pre-sterilized pipes instead. This worked much better! Photo credit: Erika Rader



Figure 5: Taking 1-cm-interval depth samples, with Dr. Diana Gentry of NASA Ames. Photo credit: Erika Rader



Figure 6: I use the LIBS to measure elemental concentrations of small rocks while Professor Erika Rader of the University of Idaho uses the ASD and XRF to collect X-ray and visible/near IR spectra of the sediment. Photo credit: Carlie Novak



Figure 7: Performing ATP quantification assays at the University of Akureyri with Professor Amanda Stockton of Georgia Institute of Technology. The tubes that we use in the luminometer (which measures ATP activation of the enzyme luciferase) must be handled with bare hands rather than gloves, or they will build up an electrical charge and give inconsistent readings. Photo credit: Erika Rader



Figure 8: Aliquoting depth samples from Dyngjusandur at the University of Akureyri. Photo credit: Erika Rader



Figure 9: PhD student Carlie Novak taking rock cores at Fimmvörðuháls. Driving wind and rain made this difficult! Photo credit: Erika Rader



Figure 10: The view of Vatnajökull – the largest glacier in Europe, measuring three thousand square miles – from the Holuhraun 2014 eruption site, one of our field sites. Photo credit: Carlie Novak