Comparing spectroscopy techniques for investigating potential biomediation in palagonite
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Over the summer, I've been carrying out an independent research project using my funding from the Astrobiology Society of Britain's internship programme. I managed to connect with other academic departments, find new mentors, and produce fairly in-depth results over the course of a few months. I've particularly enjoyed the creative freedom I've had to do research, and it's been a great way to exercise and further develop my skills for upcoming projects and a potential career.

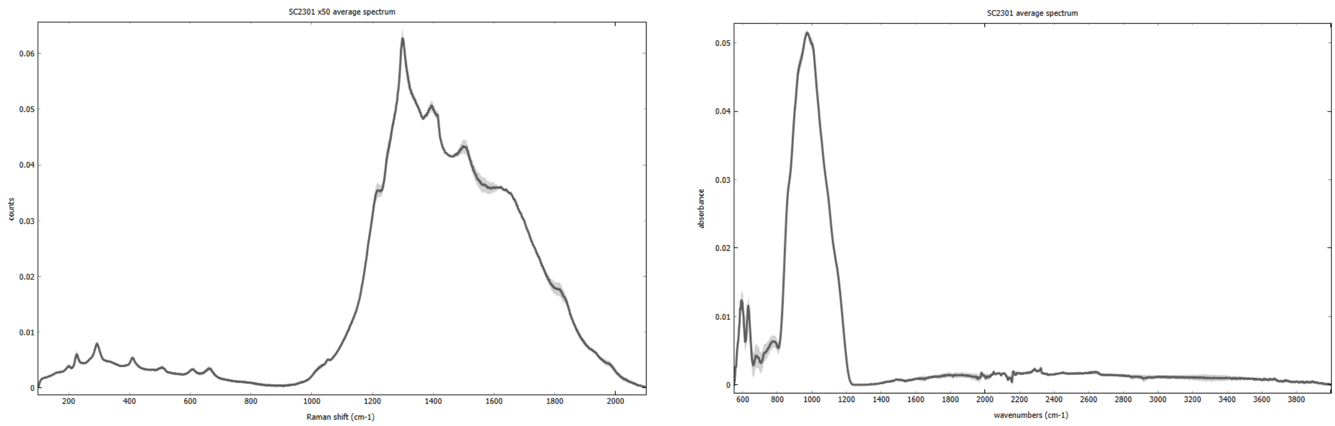
I was thrilled when I heard that I had been awarded an ASB internship - the summer project I developed with the help of my supervisor was focused on samples of palagonite (an altered igneous rock) from Lanzarote. These kinds of rocks are often considered an analogue for Martian material, and it is recognised that some examples are altered by certain bacteria, giving them a special astrobiological significance.[1] My goal was to investigate their composition using two different spectroscopy techniques to see whether they displayed any signs of past microbial activity, such as organic molecules or structurally-disordered minerals. I was aiming to compare the results I got from both analyses to determine which technique would be better suited to potential further studies of similar rocks on Mars itself.

Learning how to use different pieces of equipment was a crucial part of the project, and I was lucky enough to be able to work with labs at both University College London and Birkbeck. The first method I used was Fourier Transform Infrared (FTIR) spectroscopy, and I found this quite a quick and easy technique to learn and use. On the other hand, figuring out how to use a Raman spectrometer effectively was a lot more complicated. It required substantial training and lots of test runs before I finally achieved a useful set of results. In order to get an even better idea of the constituent minerals of the palagonite, I used a scanning electron microscope and electron probe system, which although daunting at first, I managed to use after a few tries. But I would say that the biggest learning curve for this internship was actually the project management itself; contacting and meeting new people, dealing with issues as they arose, and planning my time were a huge part of the experience.

Pictured: a piece of the palagonite used for this project before being thin-sliced.

Pictured: the SEM/EPMA lab with a slice of the palagonite being examined.

Comparing the Raman spectra of the palagonite samples and a basalt sample confirmed the many similarities between the two, with the relatively most intense peaks likely due to silicate materials or fluorescence from basaltic glass.[2] Interestingly, the double peak around 605 and 661cm^{-1} could be attributed to altered hematite, alongside other potential hematite signals.[1] I found that the FTIR spectra provided less detail than the Raman, but also indicated the presence of Si-O bonds in silicate materials.[3] There doesn't appear to be any kind of organic signature in the FTIR data, but small amounts of disordered carbon could have been represented in the Raman spectra.[4]
While my results did show a few possible signs of alteration overall, there didn't appear to be any spectral features that definitively showed that these rocks underwent biomediation. This result highlights the difficulties of determining whether geochemical processes in general are biotic in origin. Even though abiotic mechanisms are usually more likely, biological activity can't be ruled out either.



Pictured: combined average Raman spectrum for SC2301 under x50 magnification (left), combined average FTIR spectrum for SC2301 with 32, 64 and 128 scans (right).

In terms of comparative use of the two analytical tools, I found that Raman spectroscopy provided a lot more insight into the composition of the palagonite than the FTIR. Sample preparation was also much easier for this machine, given that a whole sample could be inserted whereas the FTIR spectrometer required the rock to be powdered first. I later read that FTIR might be more useful for astrobiological studies in certain rocks with informative morphological features, given that this method is non-destructive.[3] If FTIR were to be utilised for future Martian investigations, it is my opinion that using the same type as I did might not yield sufficient data, and that a machine with the capacity to scan intact samples would be more practical.

As I've mentioned, running this project myself really pushed me to take initiative and make important logistical decisions as to how to utilise my time efficiently. Given the time constraints on this project, spending enough time on each piece of equipment was definitely a bit of a challenge, and if I'd had more time, I think I would have used the electron probe more. It would have also been great to learn some other operations on the Raman spectrometer that could have given my results greater clarity. But in the future, I am thinking of discussing my results with more experienced users of these machines so that I can ensure my interpretation is accurate. For my next project, I am definitely going to practice interpreting results from the scanning electron microscope and applying them to other data for an even more in-depth geochemical study. So, I really think this internship has been an excellent way to both practice using these techniques and discover where I need to take extra care in future.

Once I had learned how the equipment operated with the help of my supervisors, I had a lot of fun using them and trying to interpret the results I obtained from them. This internship has been completely worthwhile, and contributing something relevant to the field of astrobiology has been very fulfilling. I am extremely grateful to the Confocal Unit in the UCL Division of Biosciences and the Biological and Earth and Planetary Sciences departments at Birkbeck for all of their support and guidance. I'd also like to thank the ASB for offering me this internship opportunity, and would certainly recommend the experience to other young researchers looking to try out an astrobiological research project.

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