# Student questions: Deanne Rogers colloquium on "Interpreting the Rock Record of Early Mars"

3/27/19

How would alluvial deposits occur if there is no water on Mars?
They can't – but we are certain that there was water flowing across the surface in the past. In fact, there are alluvial fans in other locations of Mars, that I did not show in my talk.

Are there plans to visit any of these bedrock plains for Mars 2020?
The Mars 2020 rover will visit an olivine-rich plain in Jezero crater, which I and others suspect may be similar to the plains I showed in my talk.

If these bedrock plains are in fact fine grained sedimentary rocks, how would the hypothesized formation processes influence the current paleoclimate models of Mars?
It would not influence the models, but it does provide us with additional constraints on surface processes of early Mars. For example, explosive volcanism may have been more prevalent than previously realized.

At the beginning of your talk you said that the channels of Mars were formed from water; do we know this yet or is it still theorized because it looks like channels on Earth?
We are fairly certain that they were carved by water; to my knowledge there is no other fluid that could produce networked channels. There are, however, standing debates about whether they formed from melting ice or rainfall, or under ice, or perhaps even from groundwater sapping.

Is there an area where the small round (olivine) are found in aboundance?
Yes – we find coarse, round olivine grains in dune fields explored with the Mars rovers.

Olivine is an idicator of lava production - but what processes would trigger this?
Olivine can form in intrusive or extrusive volcanic rocks, as well as part of the original crust that crystallized from Mars' magma ocean.

When dating the carving of drainages compared to that of volcanic activity - would these occur at different times or similar times?
The valley networks and the bedrock units that I showed formed at approximately similar times, according to crater age dating.

Have you researched the formation of the sulfate-bearing rocks?
No, I have left that to others. However, I have collaborated on some research looking at the formation of sulfate through acid weathering and magmatic vapor deposits. But the sulfate-bearing rocks on Mars do appear in our bedrock maps.

Have you used terrestrial remote sensing thermal data to analyze terrain on Earth that might be analogous to the material you are studying on Mars?
Great question – no, but I have been thinking about it!

Why didn't you add any spectrums to your presentation?
I did not think it was necessary to convey my points. Plus, I didn't want to put anyone to sleep!

Is there a reason why Mars is cold?
It is farther from the Sun than Earth. The atmosphere is also much thinner than Earth's, providing less of a buffer from cold space and making it less efficient at trapping heat.

Should episodic fluvial transport processes lead to trapped hydrous minerals in the inverted valley fill?
I think it really depends on the duration of the transport event(s) and aqueous activity. I think I would not be surprised if we saw hydrous minerals in these deposits, but I would also not be surprised if we did not see them.

You noticed some lava fields covered in dunes. Is the aeloian sorting process you've described constrained to a particular region on Mars that is different from where these dunes are located?
Aeolian sorting is a process that happens on Earth and likely occurs on Mars. In some places on Mars, we see dune fields that have variable olivine abundance, and the olivine abundance appears correlated with grain size. This suggests that aeolian sorting is happening.

Do you think the bedrock is enriched in olivine homogeneously?
My guess is that probably not, but it is hard to say.

What is the evidence of a transition from explosive to effusive volcanism on Mars?
In the regions of the Hesperian lava plains, there are older central vents that appear to be composed of pyroclastic materials. In addition, some folks have noted that deep channel walls that carved into older terrains, do not shed boulders, suggesting that the materials are mechanically weak, and clastic. They have suggested that this might indicate a transition from pyroclastic activity in the Noachian to effusive activity in the Hesperian.

Why is there a tendency for bedrock to be more exposed between crater fields?
No – it is most commonly found in crater floors.

Where exactly on Mars can the best exposures be found that most obviously provide insight into the early rock record? In other words, there are no readily exposed road cuts the way there are on Earth, so where do we find the best evidence of sedimentary deposits rather than igneous?
There are places that are cut by deep channels or graben that expose older rocks. In addition, there are ancient crustal rocks and stratigraphy exposed in the Nili Fossae / Northeast Syrtis region of Mars. This was one of the top three Mars 2020 landing sites because of its access to the ancient record, as well as strong evidence for hydrothermal activity, but it lost out to Jezero crater.

Is there evidence of both aeolian dunes as well as fluvial river deposits, or is one explanation favored more strongly over the other, and will evidence either way impact future missions to Mars?
Fluvial deposits would be more interesting for Mars missions do to the biosignature preservation potential and the critical role of water in supporting life.

Since olivine is found in lava flows, do you believe the olivine on mars is produced the same way as on Earth or is it also part of the sedimentary deflation process?
I think it is produced the same way as on Earth, but potentially concentrated at the surface through sedimentary deflation. This is something we are trying to test by mapping out sand deposits and seeing if there is a correlation with olivine abundance.

Talking about fluvial transport, have you hypothesized how "short and episodic deposition" might have occured?
Not as much as I should have. But I think it would be consistent with either rainfall or snowmelt.

What are some of the things we can only learn from examining rocks on mars through data from an orbiting spacecraft?
Orbiting spacecraft provide critical global context and global coverage. This helps us to put detailed observations from rovers into larger context.

What is the reason behind the rock distribution being dense around the equator?
We think they are densest at equatorial latitudes because at higher latitudes, freeze/thaw processes and near-surface ice have disaggregated ancient bedrock and converted it to boulders and regolith.

Are the processes that form rock structures (fluvial/aeolian processes, volcansm, etc)i on mars similar to those that occur on the earth?
Yes, very similar.

Is the geologic timescale similarly identified on mars as it is applied to rocks on the earth?
No. The Martian geologic timescale is most finely divided in the first billion years, whereas the Earth's geologic timescale is most finely divided in the last ~600 million years. The Mars timescale is most finely divided in the first billion years because it appears that this is when the most rigorous and varying activity occurred and produced a range of different geologic features. In contrast, the last 3 billion years of Martian history is harder to subdivide, due to the relative lack of energetic activity. Earth's geologic timescale is most finely divided in the last ~600 million years, because those rocks are the best preserved and because of a rich fossil and environmental record that allows us to subdivide smaller time periods.

Has the depth of the Mars regolith been measured ?
Not globally. But there are places near Cerberus fossae (large graben) where we have vertical exposure of regolith and the underlying rock. The regolith has been estimated to be tens of meters thick in that location. We also have estimates of regolith thickness from Bonneville crater, which was observed with the MER Spirit rover. I believe it was a few meters thick in that location.

If it of any significance if the some portions of Mars have a greater depth of regolith than others?
It depends on what your science question is. For example, the InSight Lander heat probe experiment needs a regolith thickness of 3 meters to be able to safely deploy the probe.

How thick does the Martian dust have to be to in order to block bedrock thermal signature?
This is something we can model, but offhand I would say around 10-20 cm.

Do both impact and maar craters contain olivine sands?
Yes, they can.

How old are the "young" lava flows on Mars?
The youngest lava flows are around 20 Ma, I think.

Does Mars have tectonic plates and if so, could those cause inverted valleys?
Mars does not have tectonic plates like Earth.

When analyzing remote sensing data for other planets, what is the degree of accuracy given the technology today with calibrating and correcting for atmospheric effects?
Atmospheric effects do affect accuracy (even after we try to correct for atmosphere), but from comparisons with lander measurements, we think we can predict mineral abundance to within ~10-15% absolute. It varies from location to location, however. Most robust are relative comparisons of abundance rather than absolutes. In my talk, I showed relative comparisons.

Have machine learning algorithms shown any progress or insights into image reconstruction or remote sensing data analysis and calibration methods?
People have been looking into this, but as mentioned above, the first problem is atmospheric correction.

How might something like rover exploration provide a finer timescale of the evolution of the bedrock plains?
If we could analyze exposed scarps we might observe structures or stratigraphy that would help with interpretation. Petrographic information (e.g. grain size, and chemistry/mineralogy at the grain scale) would also reveal critical information about the origin of these materials.

Any good research study should receive constructive criticism, but did you find that you received any more or less criticism on the bedrock plains work because you had changed your position?
No – the revised hypothesis has been received favorably and I think people understand why we got it wrong the first time.

Is it difficult being a woman in this industry? (Do people dismiss you?)
Happy to discuss my experiences over email.

Why did you want to learn about early Mars?
I think it is the complexity that continues to hold my interest so far. The presence of an atmosphere, clear evidence for ancient surface water and sedimentological processes, and abundant volcanic and impact activity all make for a complex geologic history that is fun and challenging to work on. I am also interested in early Mars because of the related questions about habitability and whether life ever existed on Mars.

Is mars still volcanically and techtonically alive like earth?
We do not know. The most recent lava flows are 20Ma, but there is nothing to say that all volcanic activity has ceased forever. The InSight Lander has a seismometer that will measure any seismic activity due to active tectonics.

Could you look deeper into valles Marineris to study older bed rocks like we do with the grand canyon?
Yes – but we don't see as much stratigraphic detail as is present in the Grand Canyon. Much of the walls are covered with sediment and dust.

What portions of Mars have impact craters?
Impact craters are everywhere, but they vary in size and spatial density.
Would other high density minerals be present with the olivine?
Yes, that is very possible.

Is it possible to get a scan of the exposed face from an impact crater in the future?
Yes, we have measured the walls of some impact craters with the MER rovers.

What are some ways in which you might continue this research and what do you expect to find?
We are trying to test the hypothesis that the olivine is concentrated in lag deposits, and also trying to understand the timing and mechanisms of rock exposure through analysis of crater frequency distributions and modeling wind erosion potential.

Do you think that it's possible for us to determine processes of Mars' early magnetic field based on the geologic record?

Because the rocks on Mars are primarily easily erodible, would evidence of erosion by water not be easily visible?
Not necessarily. The rocks are easily erodible relative to lavas, but some of them are still quite competent as evidenced by higher crater retention.

What role has wind activity had on the exposure of Mars' rocky surfaces?
We are working on modeling this to see how wind erosion potential relates to exposure.

Earth's crust is predominantly composed of granite and basalt; what are the predominant rocks that make up the outermost layer of Mars?
Basalt.

In general, how do weathering rates of rocks on the surface of Mars compare to weathering rates of rocks on the surface of Earth, due to the current lack of liquid water on Mars?
Likely very slow weathering rates, because we commonly see minerals like olivine, and glass, in Martian surface materials. These alter quickly to other minerals in water.

What kind of spacecraft/instrument(s) is (are) needed to confirm clastic rock origins of the bedrock plains?
A lander with ability to conduct petrographic analysis (e.g. microscopic imaging and chemistry/mineralogy).

What is the closest Earth-analog to Martian bedrock plains?
Tuff or loess deposits.

Do we know any of the rock types that make up Mount Sharp?
Yes, sandstones and mudstones are the most common rock types.

Can you expand on what it means that we don't find any carbonates in the rocks on Mars?
Water is required to form carbonate minerals, so the lack of carbonates (or other minerals that require water) suggests that limited water duration was involved in the formation of these rocks.

How will Jezero help your research?
Jezero crater has an olivine-bearing rock unit that is very similar to the units I discussed. We can test our hypothesis through detailed analyses of this unit.

Why there are so many exposed rocks on Mars?
Our hypothesis is that the exposed rocks are easily broken into fine particles that are carried away by wind.

Since there are lot of kinds of textures of rock, have you made any classifications?
No. The textures depend somewhat on wind activity, so it could be tricky to compare one location to the next, because there are multiple variables (wind and rock type).