Chat transcript
Video: https://youtu.be/iMfLQG4qpYM

Human Landing Sites Study HLS2
Welcome, everybody. Please submit questions and comments here and we will answer as many as we can throughout the event.

Pan Conrad
As I recall, there were also advocates for higher latitude ice, which would have presented a challenge for actuation. Are we going to hear a prediction for abundance of reserves of ice at mid-latitudes?

Cesare Guariniello
About the reserves, the assumption is that each observed surface will have at least 5cm deep material (RASSOR [*Regolith Advanced Surface Systems Operations Robot Excavator*] excavation depth). How comfortable are we with this assumption, since we have only remote sensing, except for 3-4 sites?

Fred Calef III
Did the study consider adsorbed water on regolith fines as were found at Rocknest in Gale Crater?

Pan Conrad
However that is to distinguish between structural and adsorbed in specific minerals. The SAM (*Sample Analysis at Mars*) work, that is.

Fred Calef III
Yes, that's what I'm trying to get at. The minerals may have ~3% WEH (*Water Equivalent Hydrogen)*, but there may be an additional ~3% WEH from adsorbed water that will release at very low temperatures. That's what I remember, Pan

Fred Calef III
From the SAM Rocknest paper.

Doug Archer
We (SAM) only saw 1-3 wt% total from Rocknest. It's possible there was more adsorbed water that was lost when the sample was in CHIMRA, but the 3wt% number is from minerals and whatever was adsorbed
Pan Conrad
Yep-- that was in the RN paper. As Doug can tell you, it's tough to get abundances because we don't precisely know the amount of sample (mass or volume)

Doug Archer
Rick, my question is similar to what we're discussing now. The assumption was made that the geotechnical cases B, C, and D were "sand--easy" but this isn't entirely accurate.

Doug Archer
It's true for gypsum dunes in case B, but a lot of the orbital info on polyhydrated sulfates indicates they are rocks/veins.

Doug Archer
And the phyllosilicates we've seen on Mars are also rocks, not loose/granular material.

Doug Archer
How much of an impact do these geotechnical properties have on your assessments?

Fred Calef III
Thanks Doug! I thought the Leshin paper had up to 6%?

Doug Archer
3wt% max from SAM

Fred Calef III
ok, thanks!

Pan Conrad
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Pan, did we address the sub-surface ice question you had?

Pan Conrad
I think so, Rick, although it suggests we need to think on a site by site basis unless we assume an average for those latitudes

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Basically a lot of work remains to be done on that. We are parameterizing the problem...assuming it exists at 0.5, 1, 2 and 3 meters of depth and seeing what that does to production costs.

Doug Archer
Basically: B and C are listed as "granular material" but I think a lot of our evidence shows that's not the case. For B (poly-hydrated sulfates), you can have sulfate dunes, but a lot of our evidence shows that they are present as veins or for the clays, cemented into bedrock.

Pan Conrad
True, Doug.
Cesare Guariniello
Doug, is the evidence you mention coming from visual (HiRISE), thermal inertia (TES/THEMIS), or something else? Asking because this is what I am using to evaluate kaolinite deposits
Doug Archer
Both visual and thermal inertia. Visible because we see them in discrete layers, indicating that they are consolidated rocks, not loose material. And the thermal inertia backs that up.

Fred Calef III
There are gypsum dunes near the north polar cap, but they're above 79 deg N, so not even close to the landing site constraints of 50 deg. See Szumila et al., 2013, LPSC 44.

Doug Archer
I thought there were some more equator-ward but could be completely wrong about that. But yeah Fred, that's kind of what I was poking at. And I don't think there's any evidence for granular clays.

Email Feedback

Alfred McEwen
Gypsum was evaluated as the (just barely) polyhydrated sulfate, but spectroscopy indicates higher levels of hydration are present (4 to 6 H2O rather than 2 in gypsum). Those minerals will provide more water per volume of material and extracted at lower temperatures.
We clearly see alluvial fans associated with massive sulfates in Valles Marineris, so it is available in granular form (although the sulfate concentration may be lower than in the bedrock). Plus the bedrock is likely very soft, as shown by enough wind erosion to erase all small impact craters and create deflation hollows.
We know that ice is present within less than 0.5 m depth within the 39-50 N latitude region based on ice-exposing impacts, so removing several meters of overburden is not necessary.
In other words, the analyses presented were overly pessimistic. You could call it "worst-case" but it doesn't make sense to choose the worst-case scenarios when we know that better choices exist.

Response from Dave Beaty
There is a critically important trade-off between exploration and production on these kinds of issues. Requiring exceptionally good deposits (relative to the population of what actually exists) would make the production job easier, but the exploration job harder. The converse is also true: Allowing for deposits of lower quality (i.e. a larger fraction of what is actually present would be judged acceptable) make the exploration job easier, but the production job harder. Both exploration and production cost money, and it is quite unclear, given what we know now, how to optimize this trade.

The reference cases we studied were not intended to be the best that exists on Mars. They represent a starting point to open the conversation about the above trade. Our goal was to begin with reference cases for which a reasonable case could be made that deposits at least as good as this have the potential to exist in multiple places (multiple places is important, because there are lots of other constraints on human landing sites that also would have to be satisfied). If this work were to continue, we could obviously set up additional cases whereby we evaluate the implications of tightening the acceptability thresholds. Clearly, however those thresholds end up, it is always possible (and desired!) to make discoveries better than the minimum. I am encouraged that you can make the case that the potential for such discoveries exists in the case of both ice and granular materials.
The other subtlety is that exploration costs near-term money, and production costs far-term money, so the optimization of this trade has an (unfortunate) time dimension. We have seen too many examples here on Earth where natural resource companies push cost off to the future, by minimizing exploration, and thereby raising the total overall cost.

Fred Calef
While I've read the report before, it was good to hear a few technical details brought out.

I guess I have one follow-up question, but a different subject: the results of the initial studies indicate collecting loose material/regolith are more energy and cost effective (whatever that last metric may mean) than 'traditional' mining using explosives and grinding material? Are such technologies off-the-table for ISRU at Mars?

Response from Dave Beaty
The engineers we are presently dealing with cannot envision a scenario where the delivery to Mars of the equipment needed for blasting and crushing is viable. These things tend to be very heavy! If options exist, as it appears they do, to find water resources in materials that don't need blasting/crushing, they clearly would be a preferred solution.

The other problem with blasting/crushing is that they are very hard to automate. There is not a single mine on Earth that has succeeded in robotic operation.

Andy Spry
I enjoyed today's session.
One further comment: I didn't see that the effect of dust was considered? Terrestrial surface mining operations are notorious for generating large amounts of dust that plague their neighbors (unless they take specific steps to mitigate it). In this context, proximity would be a "bad" thing. But as I understand it from the breakout session in the PP Knowledge Gaps workshop, we have a pretty poor understanding of martian weather at a local scale, and might find it difficult to predict what would happen to any dust raised by the excavation operations.
Also it's unclear how sensitive a martian surface installation would be to dust, since it hasn't been fully defined yet, but for example solar power systems might be expected to be more sensitive than nuclear ones…

Response from Rick Davis
We did not address the issue of dust yet, but it needs to be looked at for a lot of reasons as your note points out.

Sheri Klug Boonstra
Great Hangout! Towards the end, Dave B. got stuck buffering. Not sure if it was just my computer. Wow! The info that you guys have collected is great! Especially the comparisons of the 4 different categories! I have a college senior (for his Senior Thesis) looking at the JMARS Glacial Forms Layer to start to quantify the ices forms in the middle latitudes in terms of size. The depth calculations you all had were very interesting.

Pam Conrad
There's so much to learn to make this happen and it's good to have a sandbox to play in. I think that the discussions at the October workshop indicate that the community is ready to dig a little deeper (perhaps literally). From working with Paul Van Susante, it became clear that everyone is ready for more regular

conversation so we can build better shallow subsurface models of potential resources. One thing we know from DAN is that the estimate of subsurface water in the footprint is a function of the amount of Cl (and which isotopes) as well as the way in which the H is accommodated (either in minerals or in ice) and we need to do a lot more to get higher resolution models so the ISRU guys can refine estimates of potential abundances, much less potential yields after extraction!

Response from Dave Beaty

Yes, this is the opening of a much bigger conversation. At the end of the M-WIP report, there are 6 pages of recommendations for future work that involve a number of different sectors of our enterprise. I just hope we can get some money moving in this direction.