RedWater: In-Situ Resource Extraction from Sub-Surface Martian Ice Deposits

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HONEYBEE ROBOTICS
Exploration Technology

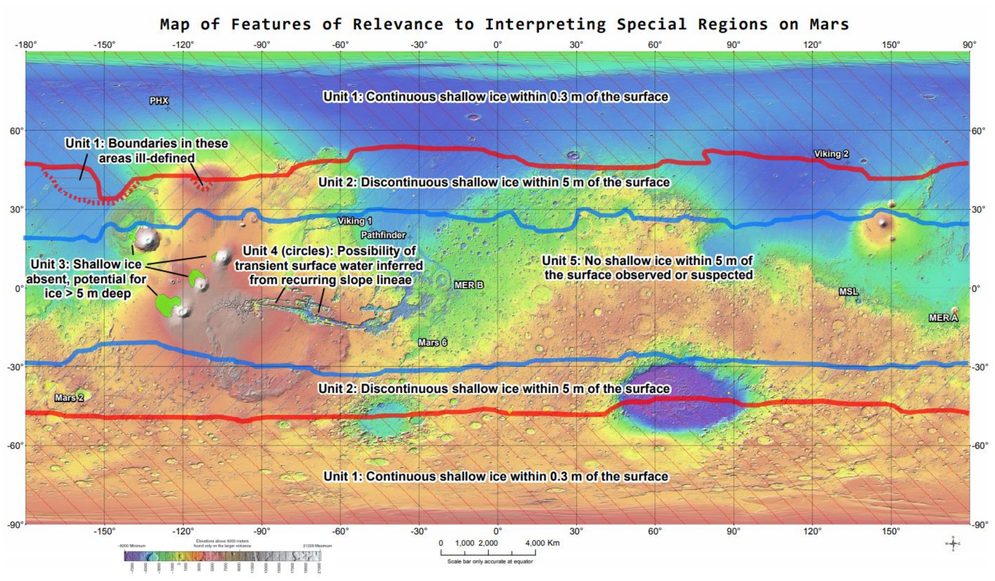
Ten Second Summary

Honeybee Robotics is in the process of developing RedWater as a system that will combine a Coiled Tube (CT) Drill and a Rodriguez Well (RodWell) – two proven terrestrial technologies – to be able to drill down through up to 20 meters of overburden and extract tens of tons of water from Mars' subsurface ice deposits. This system is a cornerstone In Situ Resource Utilization (ISRU) technology that will enable manned exploration of Mars by mining water: the raw material that can be used for everything from life support and agriculture to fuel cells and propellant.

Performance Specifications:
Maximum Depth: 25 meters Power Estimate: ~10-15 kW
Water Extraction Target: 16 metric tons H_2O

In-Situ Resource Utilization

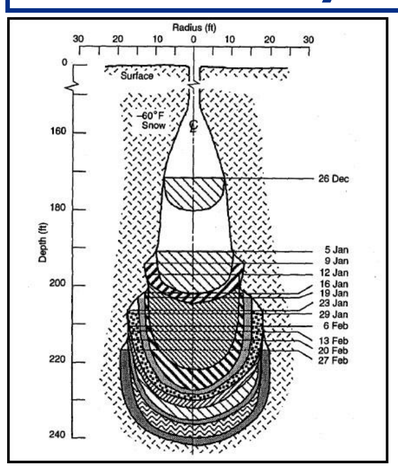
Significant quantities of subsurface glacial ice formations



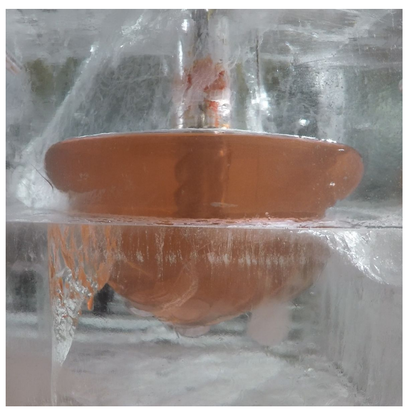
Most promising locations for drilling type extraction (±55° Latitude)

https://www.nasa.gov/sites/default/files/atoms/files/mars_ice_drilling_assessment_v6_for_public_release.pdf

Well Analysis

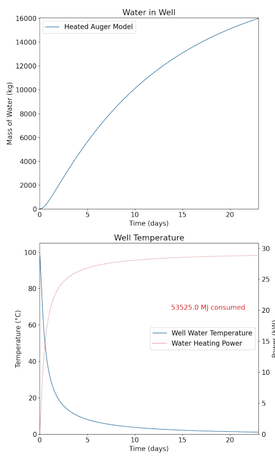


Rodriguez Well (RodWell)
- Proven terrestrial technology
- Developed for subsurface water extraction from ice
- Continuous melting and extraction via circulating pumps and heater



https://www.southpolestation.com/trivia/rodwell/rodwell.html

Trade Study: One Large Well vs One Deep Well

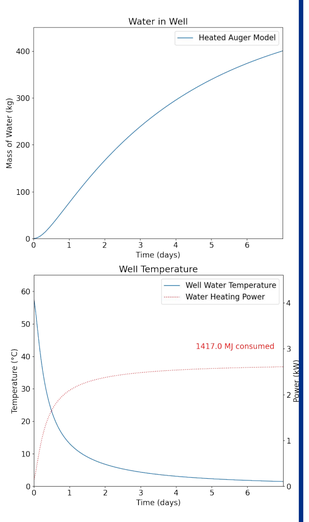


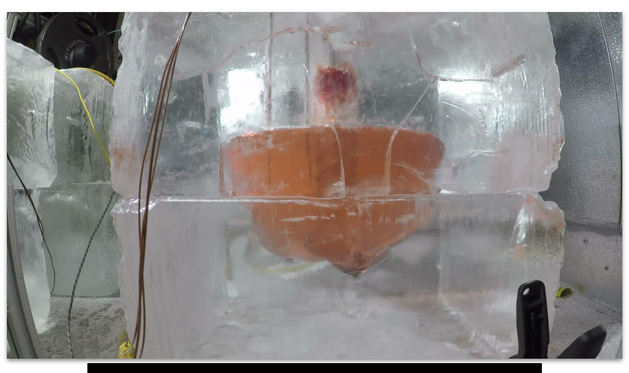
Larger Heated Auger
- ❑ Auger is 4" OD x 16" tall
- ❑ Auger surface held at 100°C

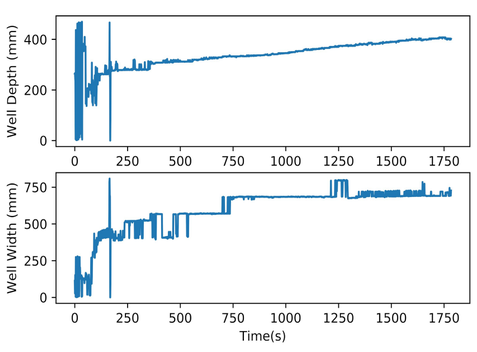
Smaller Heated Auger
- ❑ Auger is 2.5" OD x 4" tall
- ❑ Auger surface held at 60°C

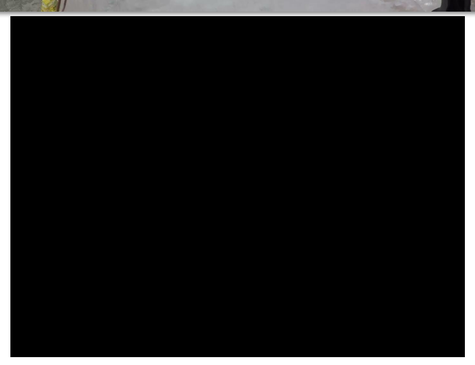
	One Big Well	One Long Well
Initial melt quantity	16000 L	400 L
Days to 16000 T	24	280
Total Depth (excl. Overburden)	2.5 m	22 m
Peak Power	28.8 kW	2.5 kW
Total Energy	14 MW-hrs	15.7 MW-hrs
Thermal Efficiency	14.7%	14%

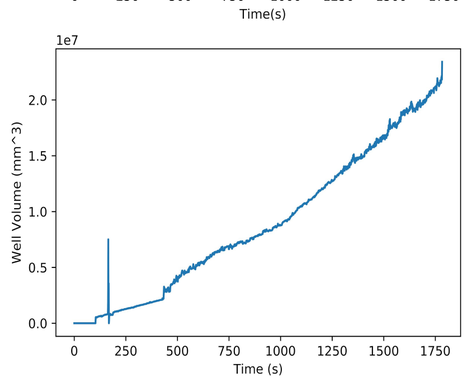
Many smaller wells found to be most power efficient







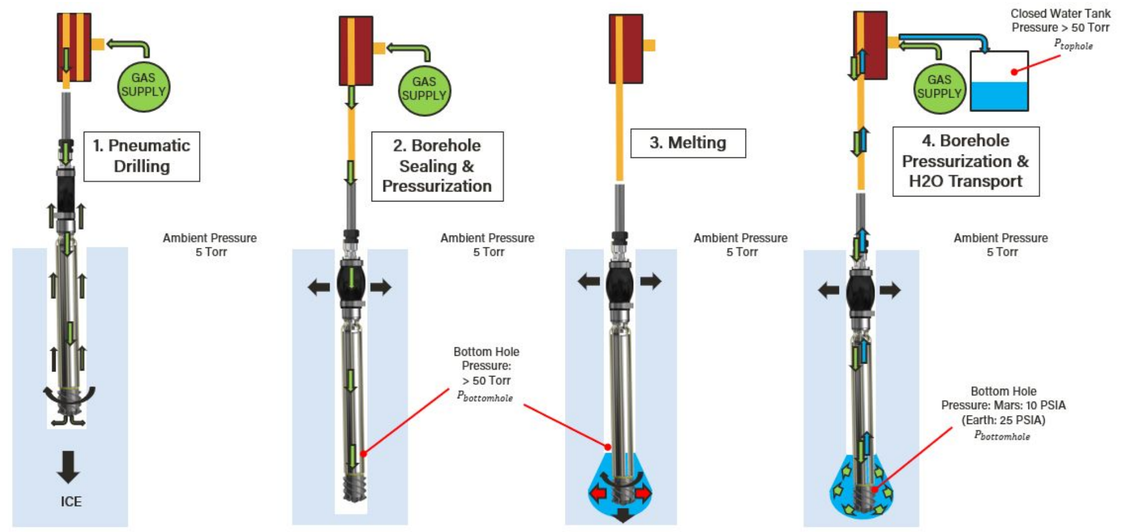




Python OpenCV Image Processing
- Calibration to camera observing well
- Distortion correction of images
- Tracking of well depth and width
- Disc method estimation of well volume

- Order of magnitude estimation
- Depth estimation most accurate
- Width estimation semi-accurate
- Volume est. needs refinement

ConOps & System Architecture

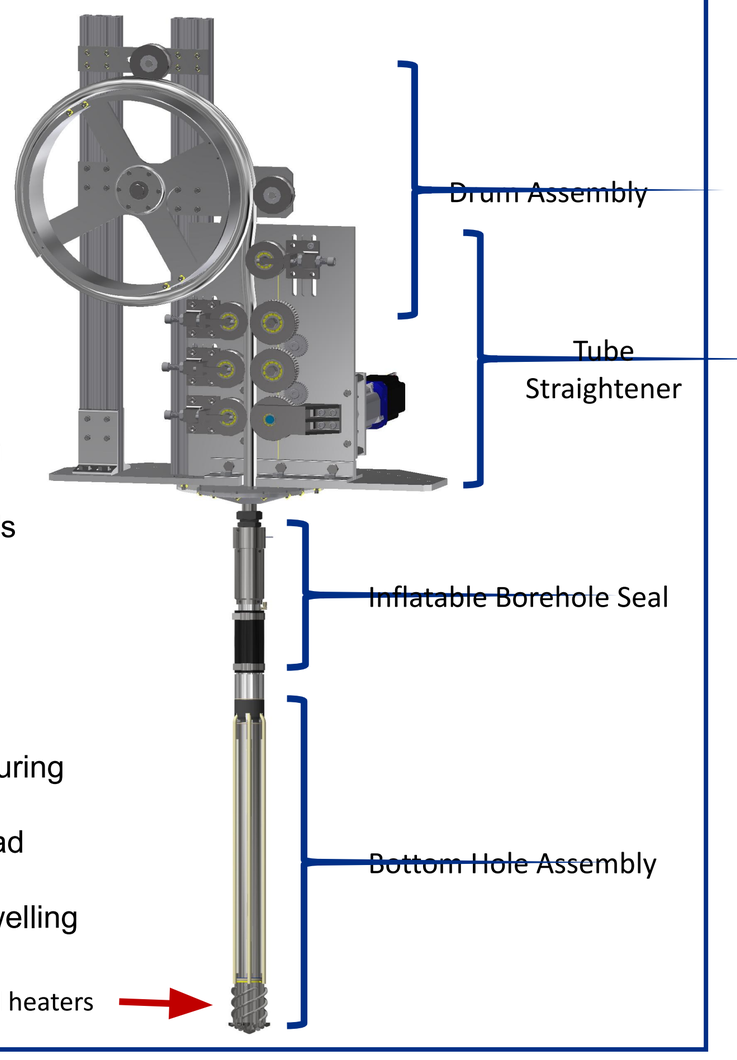


CT Mechanism
- Solid tubing minimizes moving parts, provides anti-torque
- Drill string carries power, pneumatics, signal and returns extracted water
- Drum holds coiled tubing
- 304SS tube (60% elongation at break)

Straightening Mechanism
- Maintains WOB
- 2 passive straightening wheels
- 2 toothed driven wheels

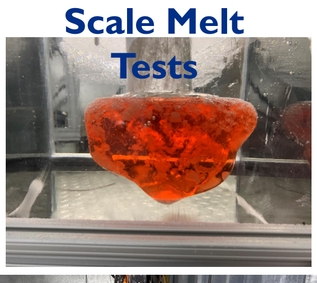
Bottom Hole Assembly
- Pneumatic packer seals borehole
- Pneumatic chip clearing during overburden removal
- Rotary-percussive drill head
- Integrated body heaters
- Drill head enables faster welling via stirring

RP drill head with integrated heaters

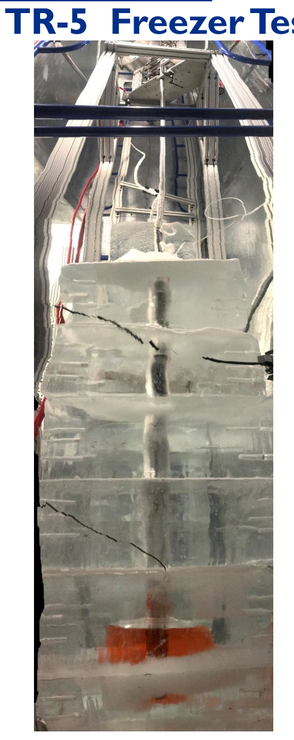


TRL Development

TRL-4 Large Scale Melt Tests



TR-5 Freezer Test



TRL-5 TVAC Test

Commercial Applications & Scientific Potential

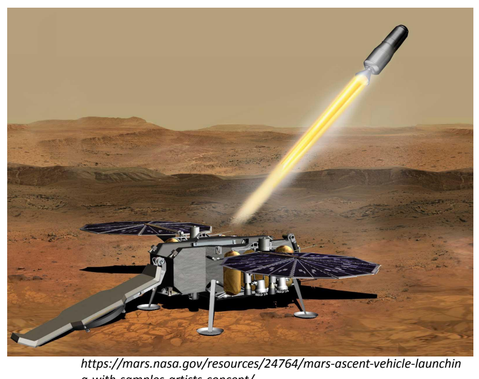
Propellant Production

http://marsforthemany.com/project/living-on-mars/getting-around-on-mars/

Martian Agriculture

C: 20th Century Fox

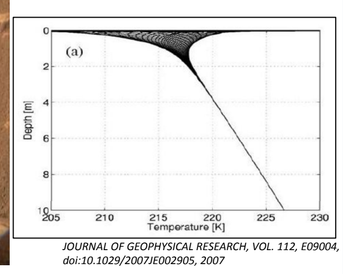
Geotechnical Science



https://mars.nasa.gov/resources/24764/mars-ascent-vehicle-launching-with-samples-artists-concept/

NASA/JPL/University of Arizona/Texas A&M University

Characterization of Ice Resources



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Heat Flow Measurements