

Progress in Simulated Water Well Performance on Mars

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Image from Dundas, et al.

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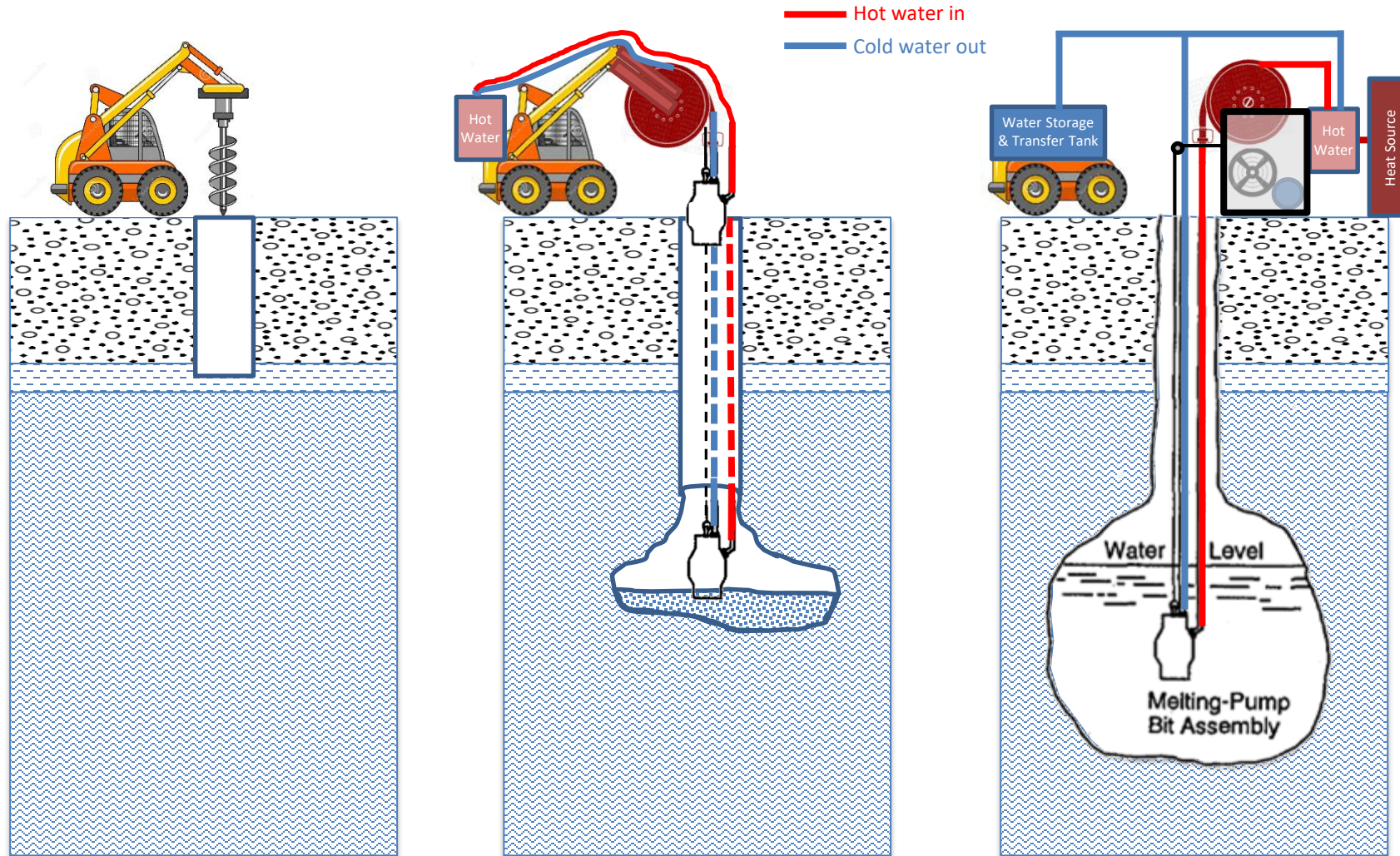
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What Is Motivating This Experiment?

- Using local resources for future human missions to Mars means reduced transportation requirements from Earth and a larger source of materials than might otherwise be available
- Of the many resources available on Mars, perhaps the most valuable is water
- One facet of NASA's current Mars Exploration Program is a search for the locations and quantities of water in various forms.
 - Subsurface liquid water aquifers
 - Hydrated minerals
 - Surface and subsurface water ice and icy soils
 - "Average regolith"
- Access to massive quantities of water could change surface mission concepts of operation and drive site selection
- A "Rodriguez Well" is one well-established technique for acquiring water from ice here on Earth
- A computer simulation developed by the U.S. Army Cold Regions Research and Engineering Laboratory (CRREL) is used to estimate Rodriguez Well performance
- ***This simulation incorporates empirical terms for heat transfer based on terrestrial environmental conditions – terms specific to Mars are needed***

Subsurface Water Well Development: Rodwell Approach



Phase 1: Drill through overburden into top of ice.

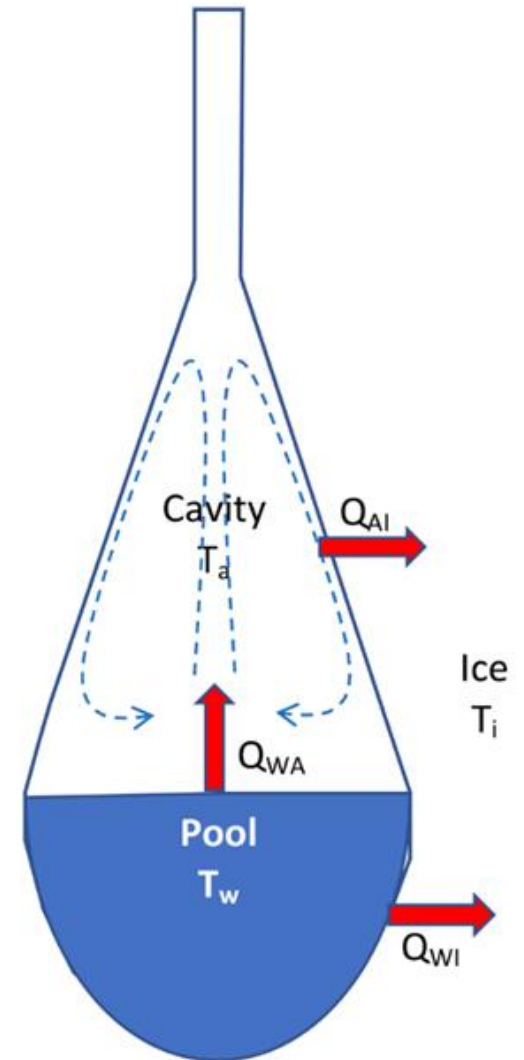
Phase 2: Melt into ice. Begin forming water pool.

Phase 3: Steady state operation.

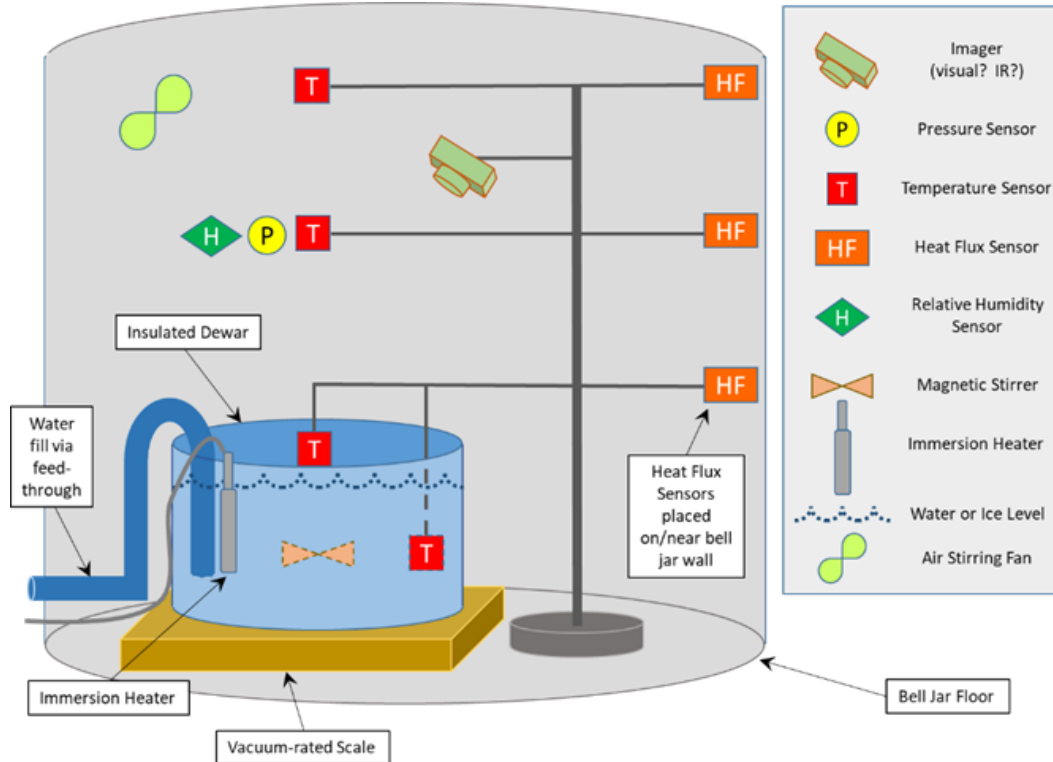
Dimensionless Scaling Parameters



- CRREL computer simulation is built around an energy balance for the well.
- Relies on heat transfer at interfaces
- Heat transfer coefficients are empirically derived
- Use scale model to derive Mars-appropriate values
- Laboratory test results at small scale can be compared to actual scale with these dimensionless parameters
 - Rayleigh Number
 - Sherwood Number
 - Nusselt Number



Experiment Equipment and Layout

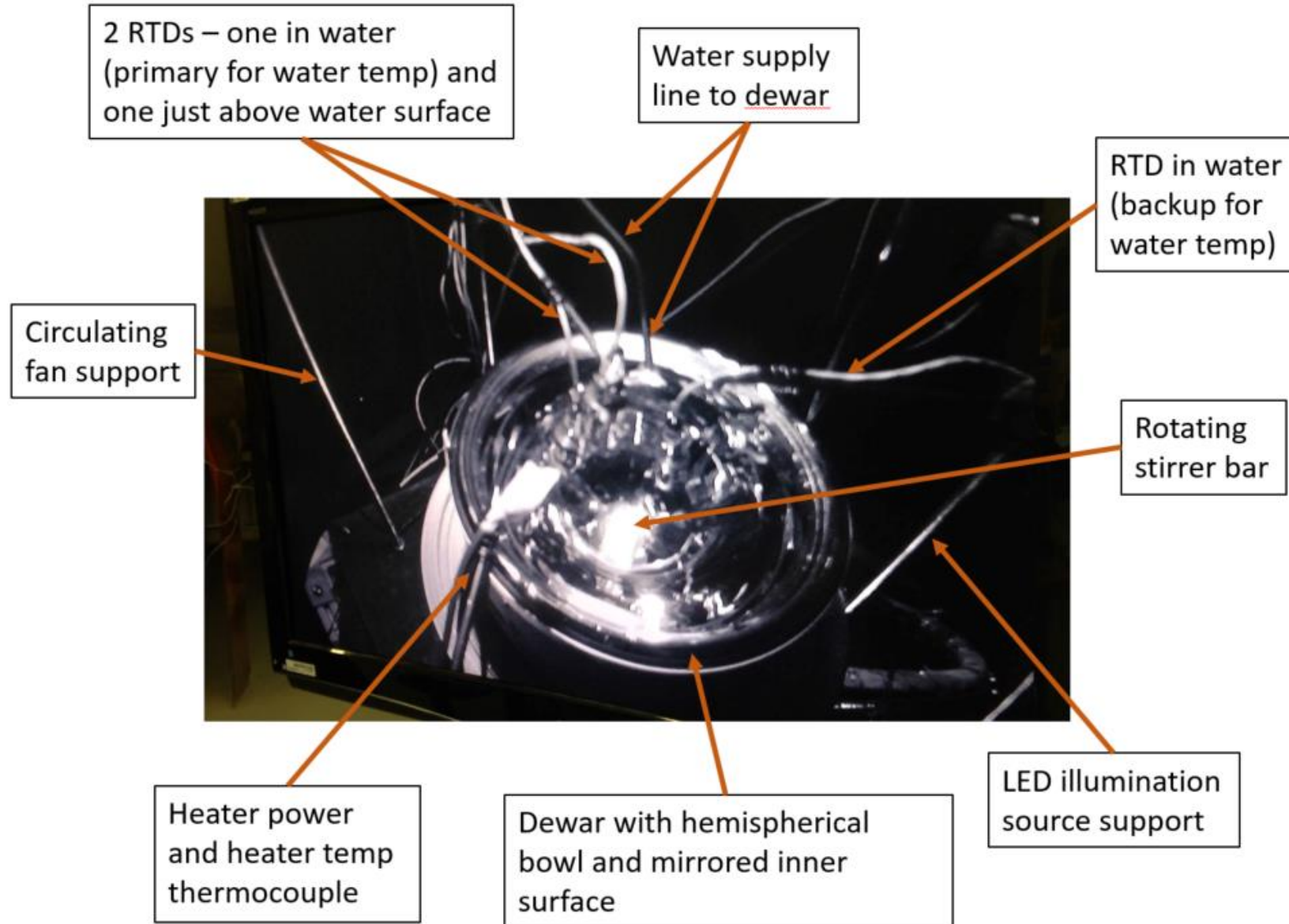


- Twelve test points – combinations of
 - Two dewar diameters (4.5 and 6.0 in)
 - Six chamber pressure (1000 – 8 mb)
 - Two chamber temperatures (-20 C and -40 C)
- Evaporative loss measured using a load cell
- Total heat transfer measured via immersion heater power

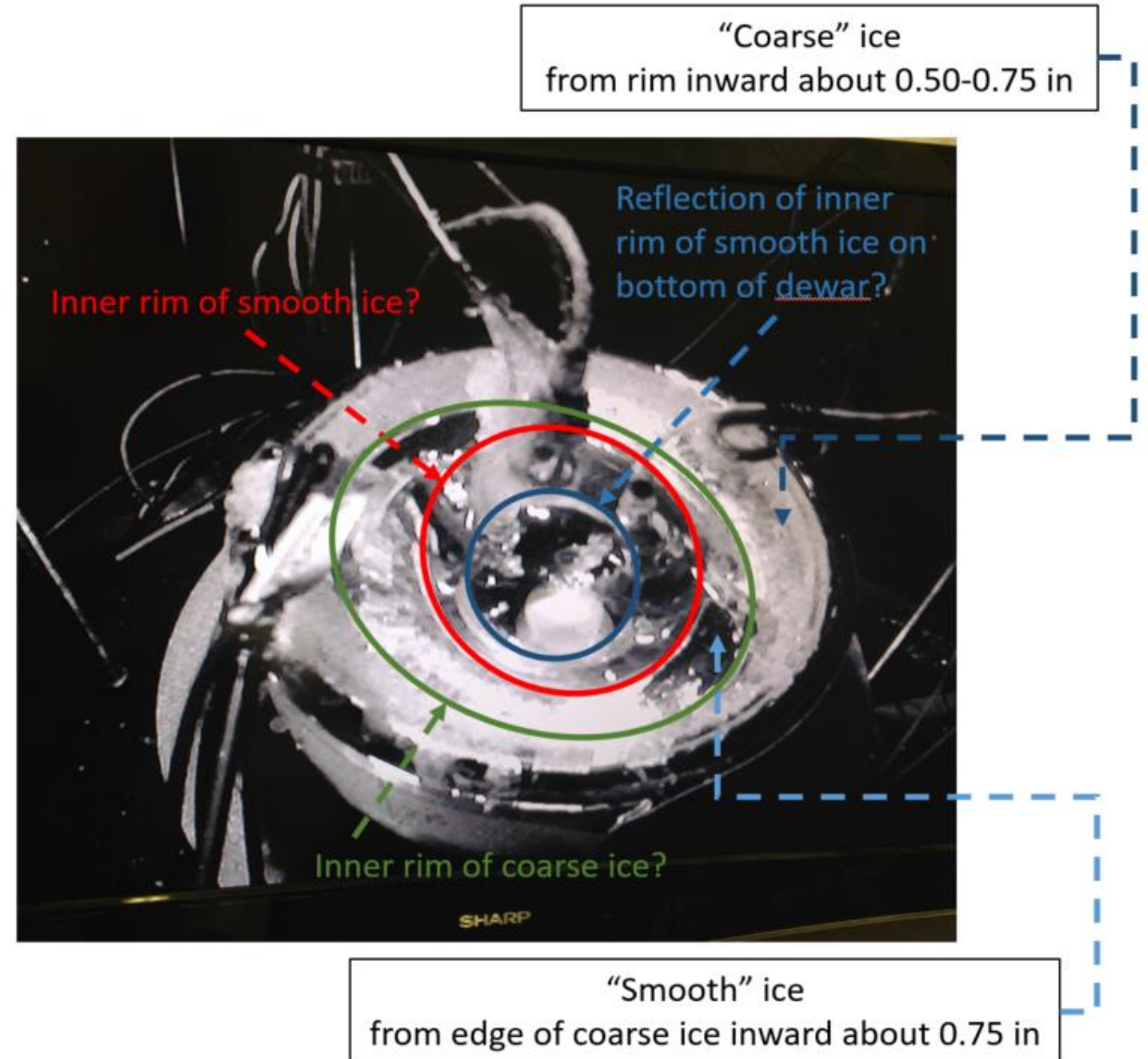


JSC 2-foot bell jar

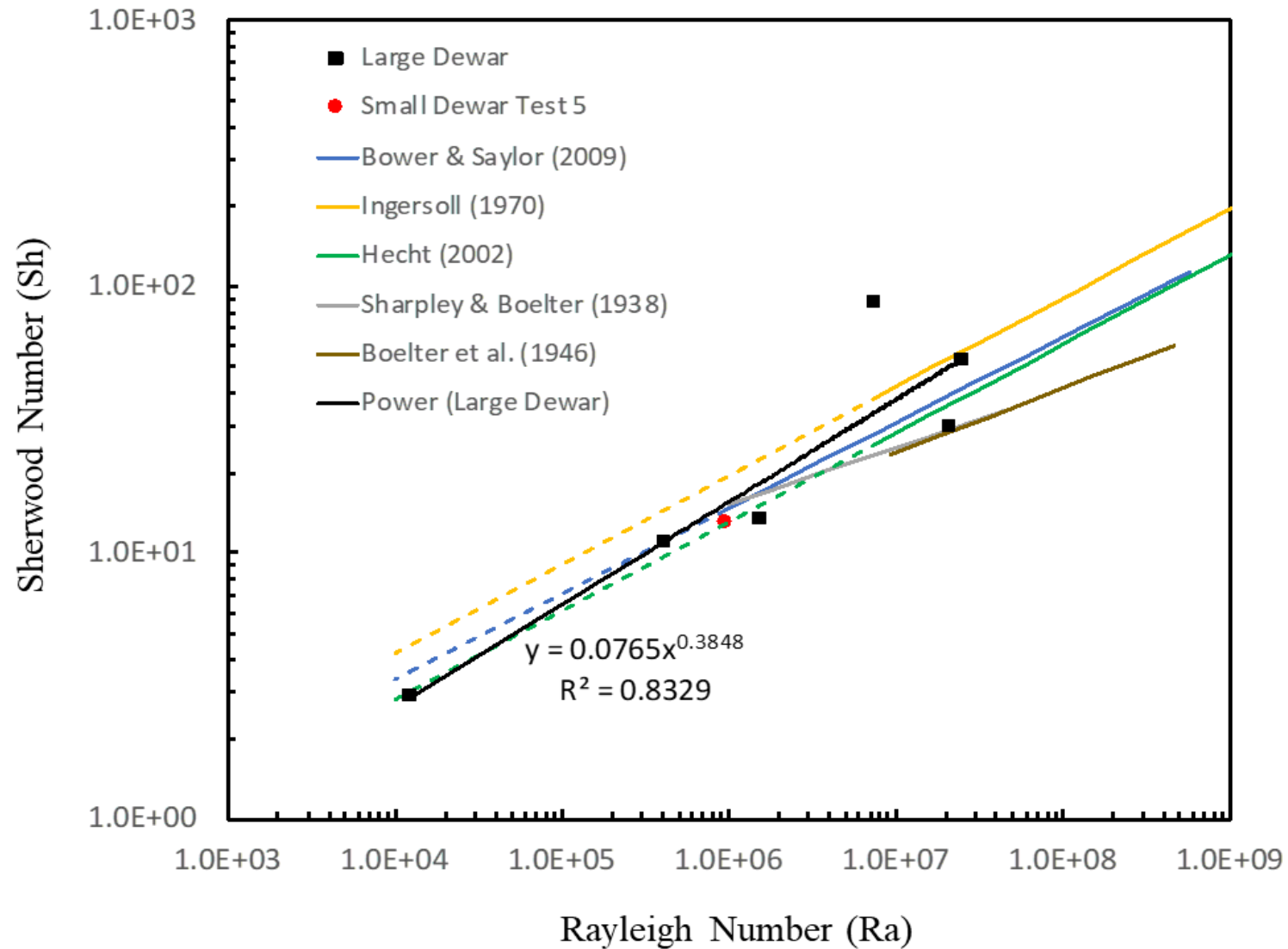
Key Items Appearing in Video



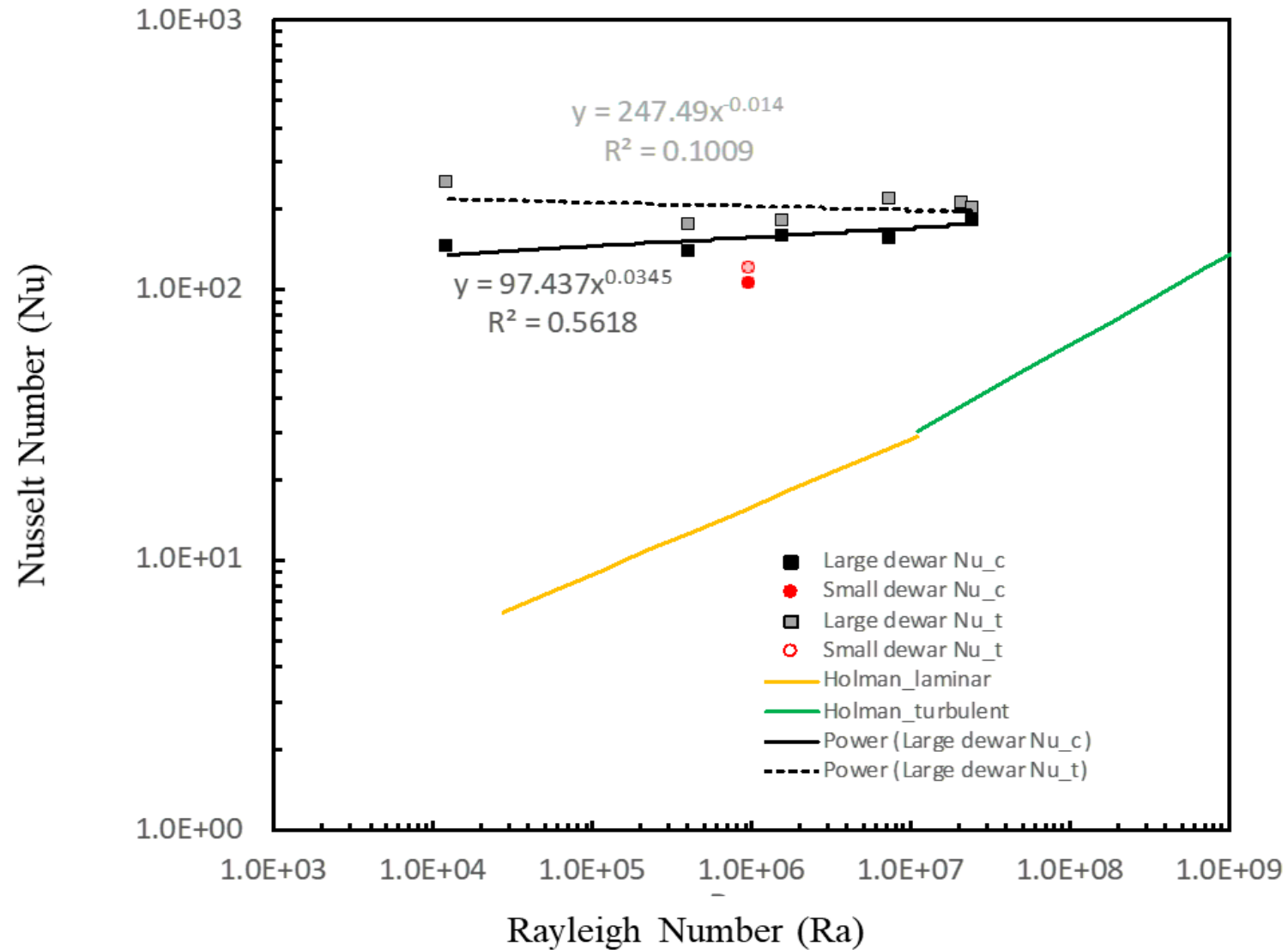
Short Video: CO₂ at 8 mb (6 torr) and -20° C, Water at +1° C



Sherwood-Rayleigh Relation for Water with Convection-Driven Evaporation



Convective Heat Loss from Water to a Gas



- Water will likely be an important resource for future human missions to Mars
- Recent discoveries of exposed ice sheets on Mars supports the theory that extensive buried ice sheets exist at mid latitude locations
- The Rodriguez Well technique offers one means for extracting significant quantities of water from these ice sheets
 - Extensive history of use in terrestrial applications
- Recent experiments at the NASA Johnson Space Center indicate these wells can be formed under ambient surface conditions on Mars
 - Water pools can be sustained with water held near freezing conditions
 - This approach is used in terrestrial Rodwells
 - Water pools under these Martian conditions found to exhibit structural characteristics similar to terrestrial Rodwells
 - For example: ice shelf formation
 - Evaporation follows power law trends observed for terrestrial water pools at Earth ambient conditions
- Total heat loss rates will be used to adapt CRREL simulation models for use in predicting Martian Rodwell performance