Resource Prospector Drill

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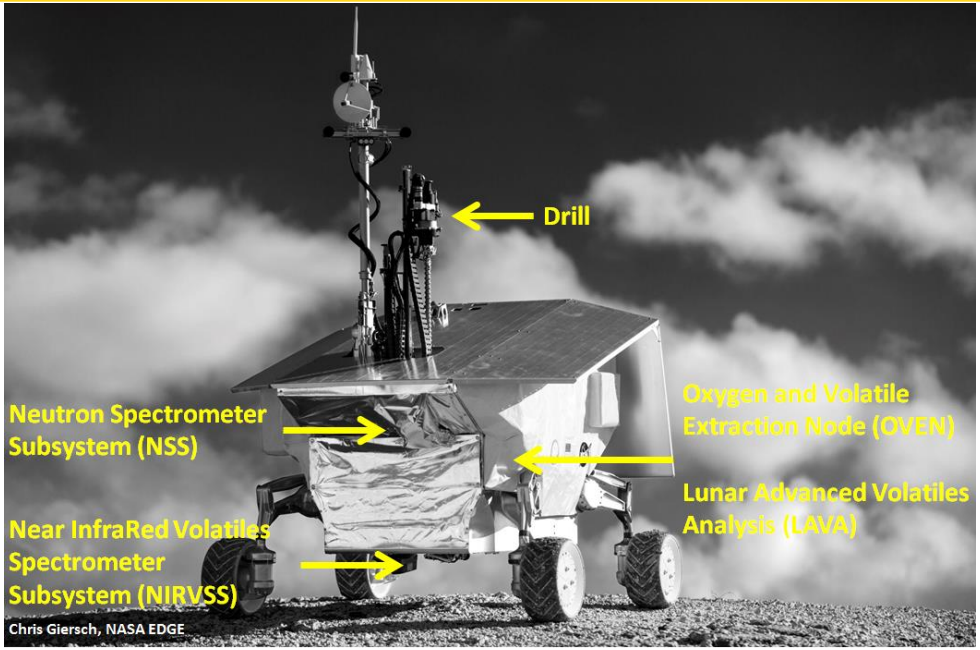
Background: The Resource Prospector (RP)

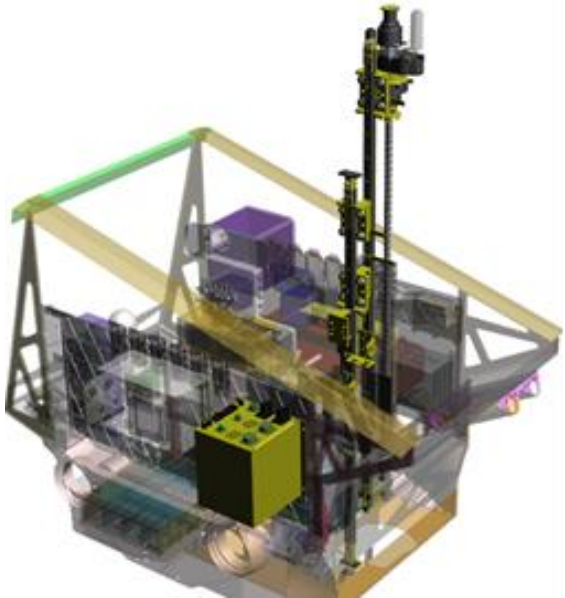
Goal:

- ISRU demo: Prospecting for volatiles, extraction of O2 from lunar regolith

Instruments:

1. The Neutron Spectrometer Subsystem (NSS)
   1. Localizing elevated H2 concentration
2. The Drill Subsystem
   1. Capture samples from up to 1 m
3. The Near InfraRed Volatiles Spectrometer Subsystem (NIRVSS)
   1. Characterize hydrocarbons, mineralogical context for the site, nature of water ice
4. The Oxygen and Volatile Extraction Node (OVEN) Subsystem
   1. Evolve the volatiles in sample by heating and transfer to LAVA
   2. Demo hydrogen reduction process (H2 reacts with iron oxide to produce water)
5. The Lunar Advanced Volatiles Analysis (LAVA) Subsystem
   1. quantities and species of volatiles via GC/MS
   2. Water Droplet Demonstration (WDD)

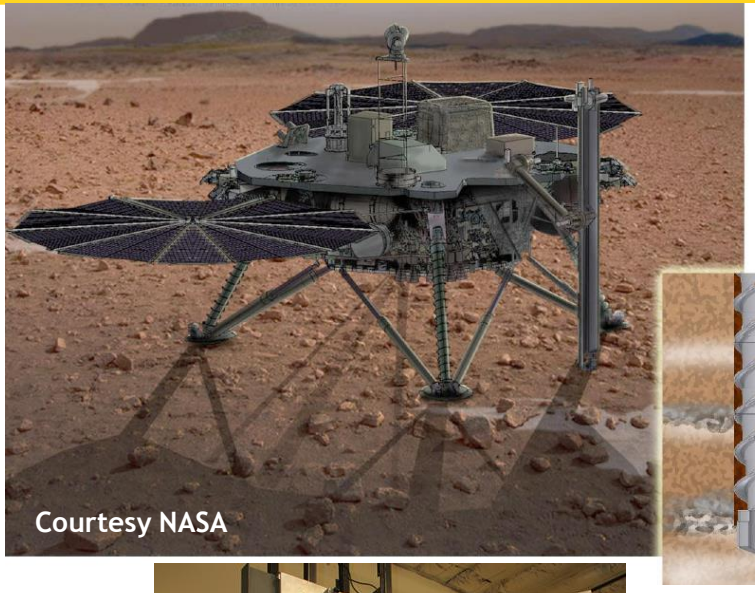


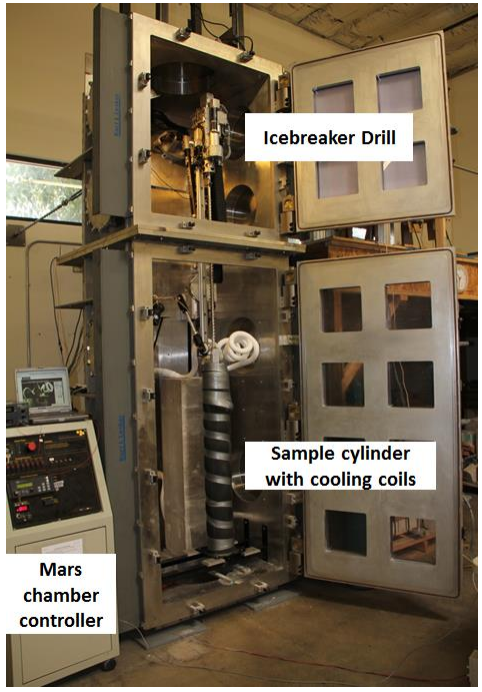


Andrews et al., 2014

The Drill Subsystem: Background

- **The Icebreaker drill**
  - Developed for acquisition of Ice/Ice Cemented Ground at the Mars Poles
  - 1 m depth, 10 kg
  - Tested in Antarctica, Arctic, Greenland
  - Tested in Mars Chamber
  - TRL 5/6
- **Goal:**
  - "Turn" Mars drill into Lunar drill
- **Mars vs Moon Drill**
  - Mars:
    - Planetary Protection
    - Perchlorate in Ice (freezing point depression)
    - Sticky Sample (Relative humidly up to 100%)
    - Full autonomy (long communication delay)
  - Moon
    - Extreme Temperatures (40K – 400K)
    - Hard Vacuum (Ice sublimation >106 K)
    - Teleop/supervised autonomy





Drilling Approaches

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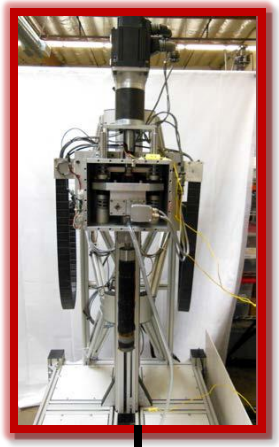
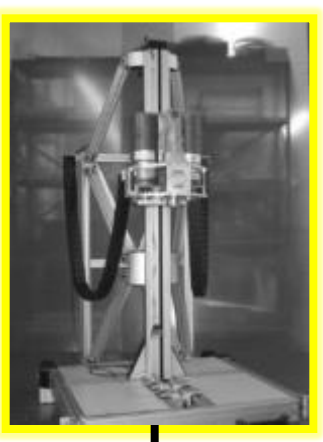
SONIC

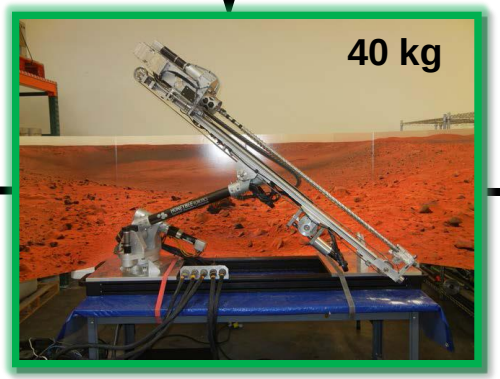


ULTRA SONIC

PERCUSSIVE



ROTARY



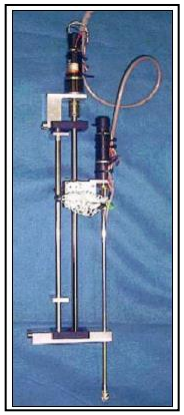
Final Selection:
ROTARY-PERCUSSIVE

Lander

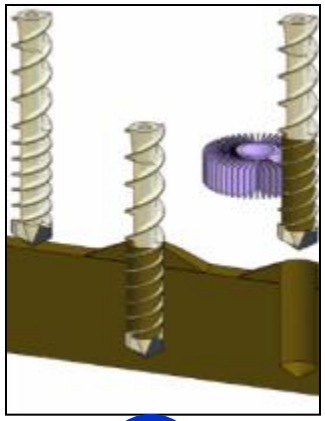
Rover

Sampling Trades

1. Embedded Sensor
Step 1: Drill
Step 2: Analyze



2. Sniffer
Step 1: Drill
Step 2: Acquire Sample
Step 3: Analyze



3. Sampling Auger
Step 1: Drill
Step 2: Transfer Cuttings
Step 3: Analyze

4. Bit Sampler
Step 1: Drill
Step 2: Pull Out
Step 3: Transfer Cuttings
Step 4: Analyze

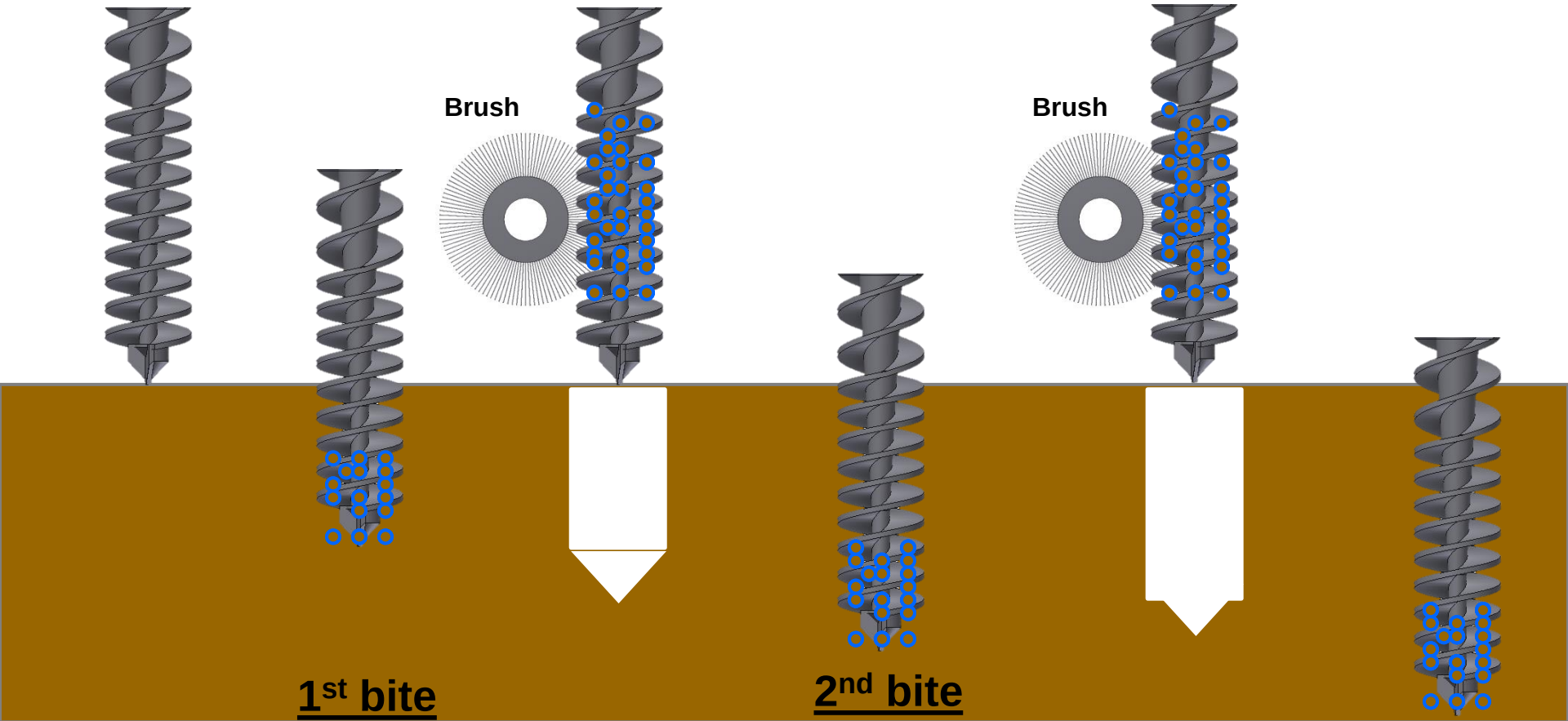
5. Core
Step 1: Drill
Step 2: Break-off core
Step 3: Capture Core
Step 4: Pull out
Step 5: Eject core
Step 6: Process core
Step 7: Analyze

Complexity

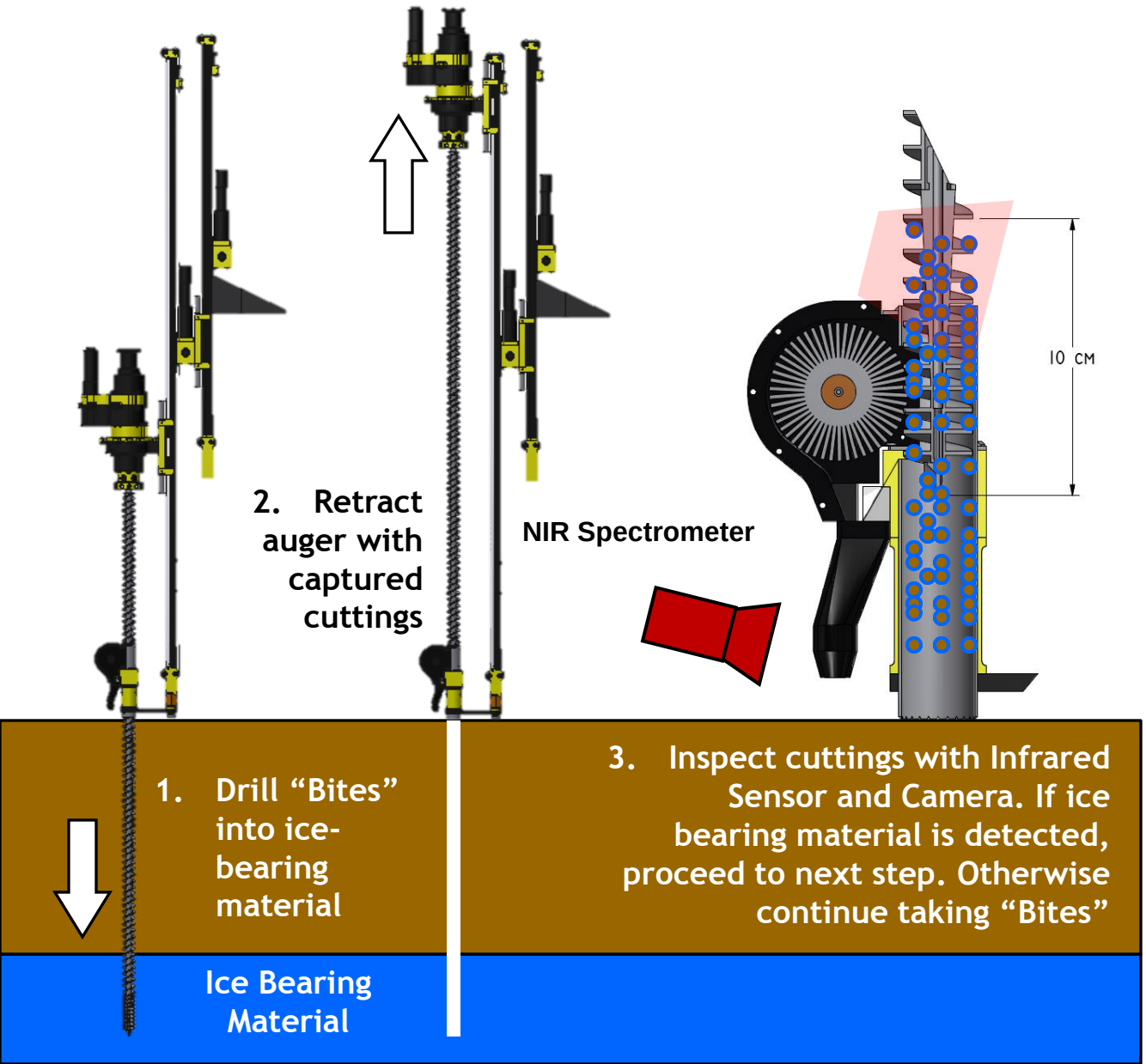
Science Payoff

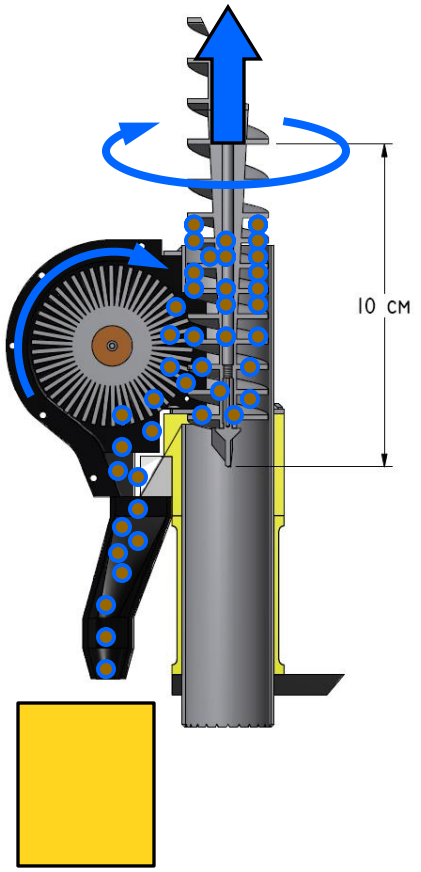
“Bite” Sampling Concept

- Drill to 1 meter in short (~ 10 cm) “bites”
- Preserve stratigraphy in “bites”
- More accurate strength measurement of subsurface
- Lower risk (“graceful failure”) – if stuck at 60 cm, 5 bites d
- Time for analysis while drill in ‘safe’ place (above the hole)
- Time for subsurface to cool down



Implementation of "Bite" Sampling





4. Rotate and retract auger to deliver ice-bearing material still within sampling system

Tests at NASA GRC

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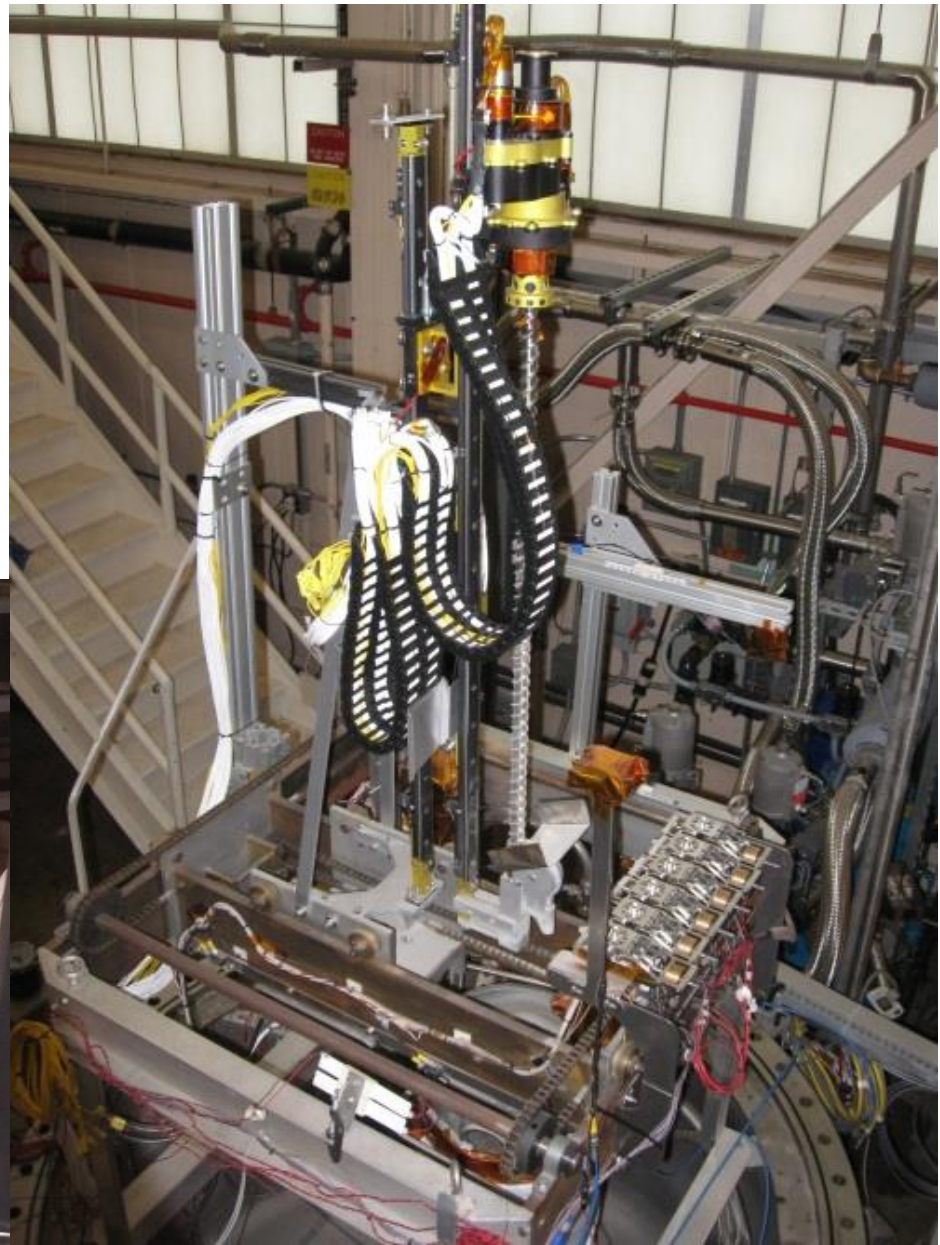
Background:

- Soil:
  - NU-LHT-3M with 4-5 water wt%,
  - Vibratory compacted to ~1.5 g/cc
  - Temp: -140 C to - 90 C
- Chamber P: ~10^-6 torr
- Crucible T: -85 C to - 50 C (+10 C)

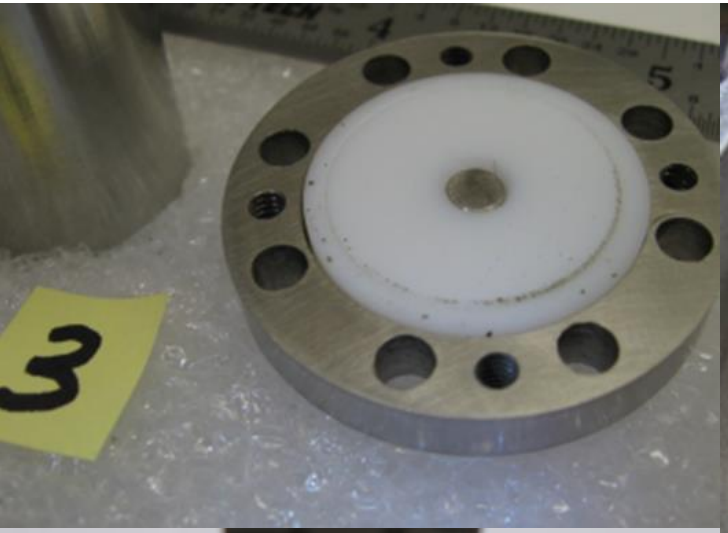
Goal:

1. Capture sample from 40 - 50 cm
2. Deliver to crucible
3. Seal



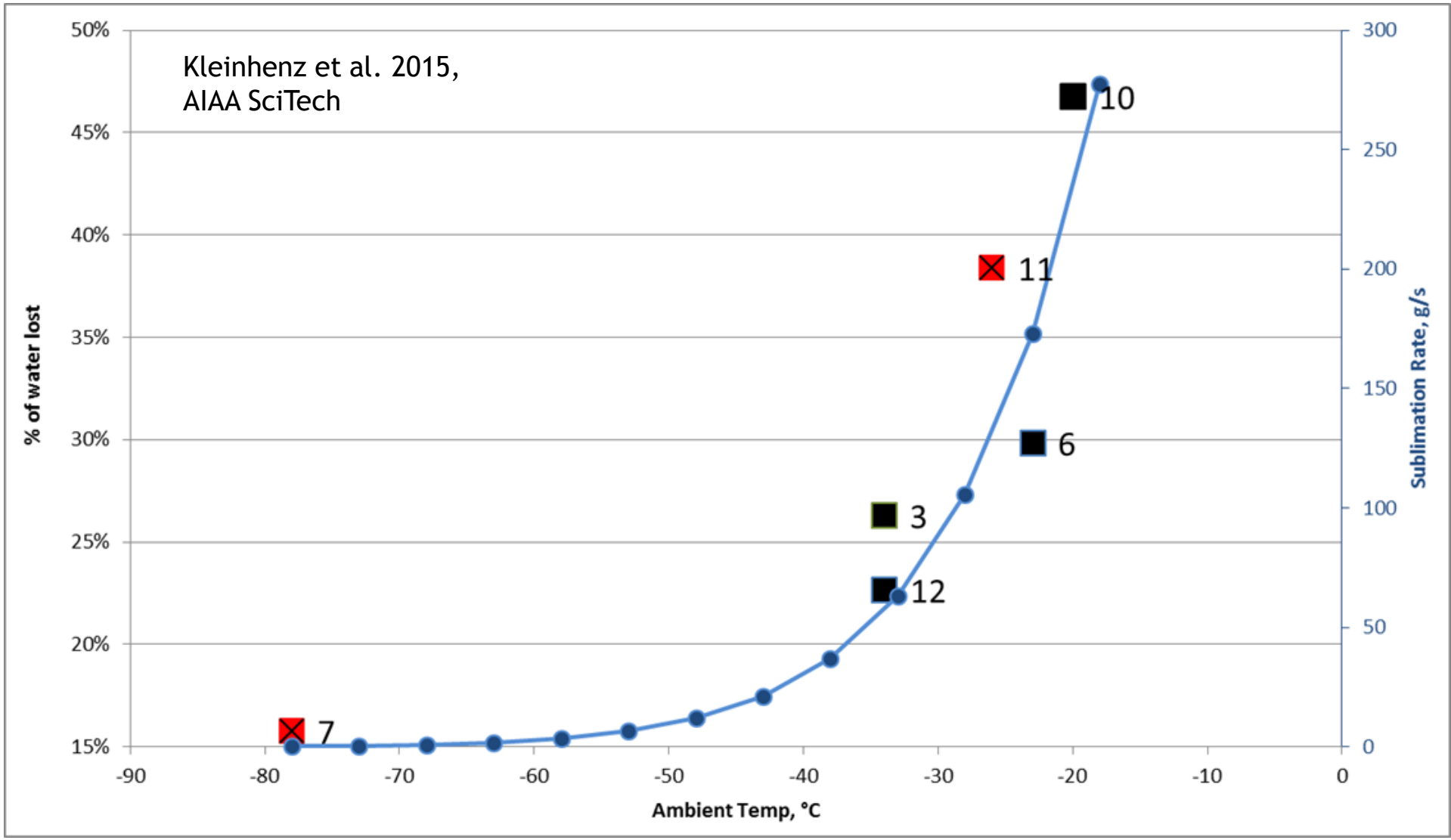
Cameras

Drill holes and crucible



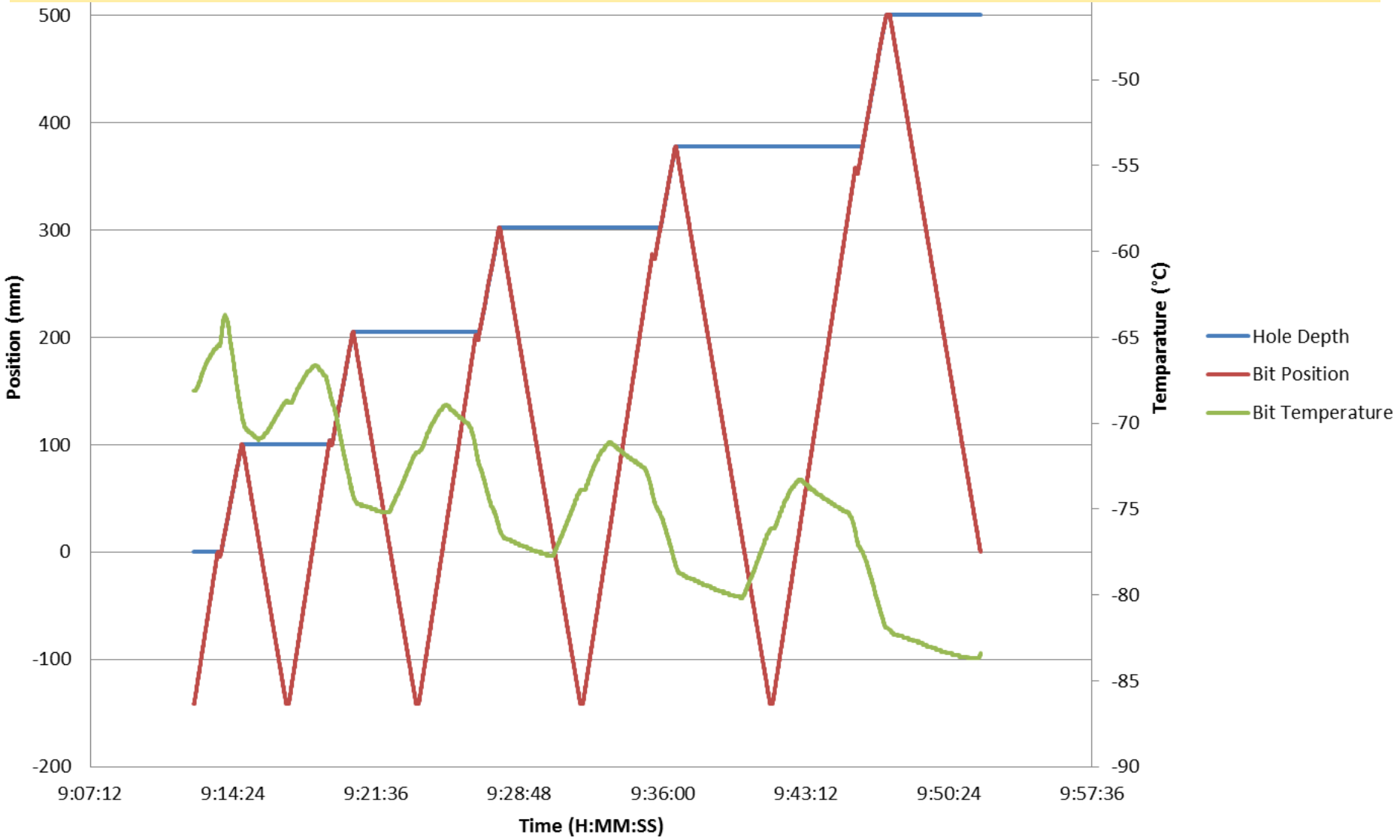
Results

- **Water wt% = function(Temperature)**
  - Can preserve all water if T kept low



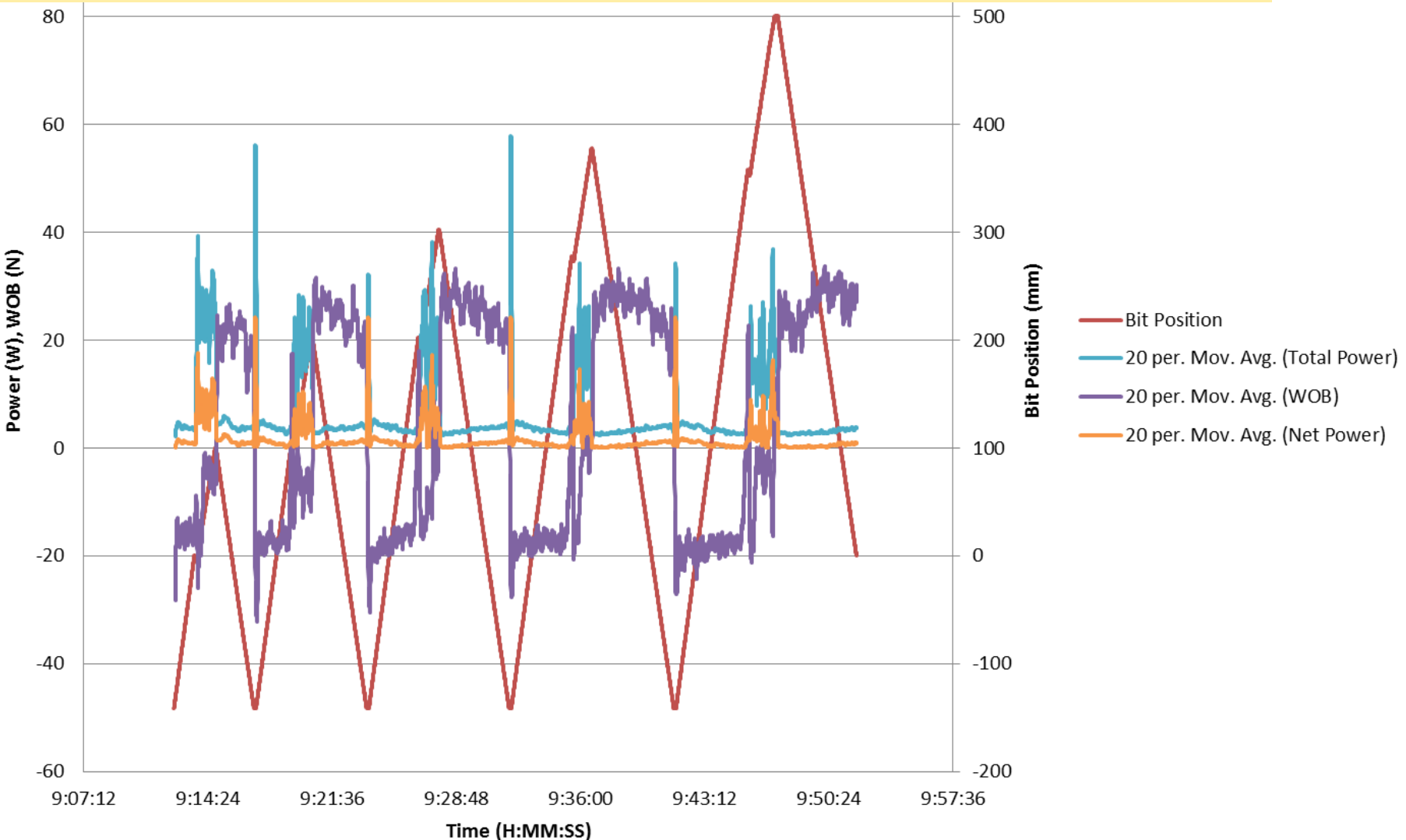
Drill Data

- Bit T was dropping during drilling because soil T was lower with depth
- Approx. 10 min to capture 10 cm “bite”



Drill Data

- Drilling Power ~20 Watt (percussion hardly ever used)
- Weight on Bit < 30 N
- Left drill in a hole for 45 min - no problem



Drill tests at JSC. Controls in Pasadena.

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Strength of Material from Drilling SE

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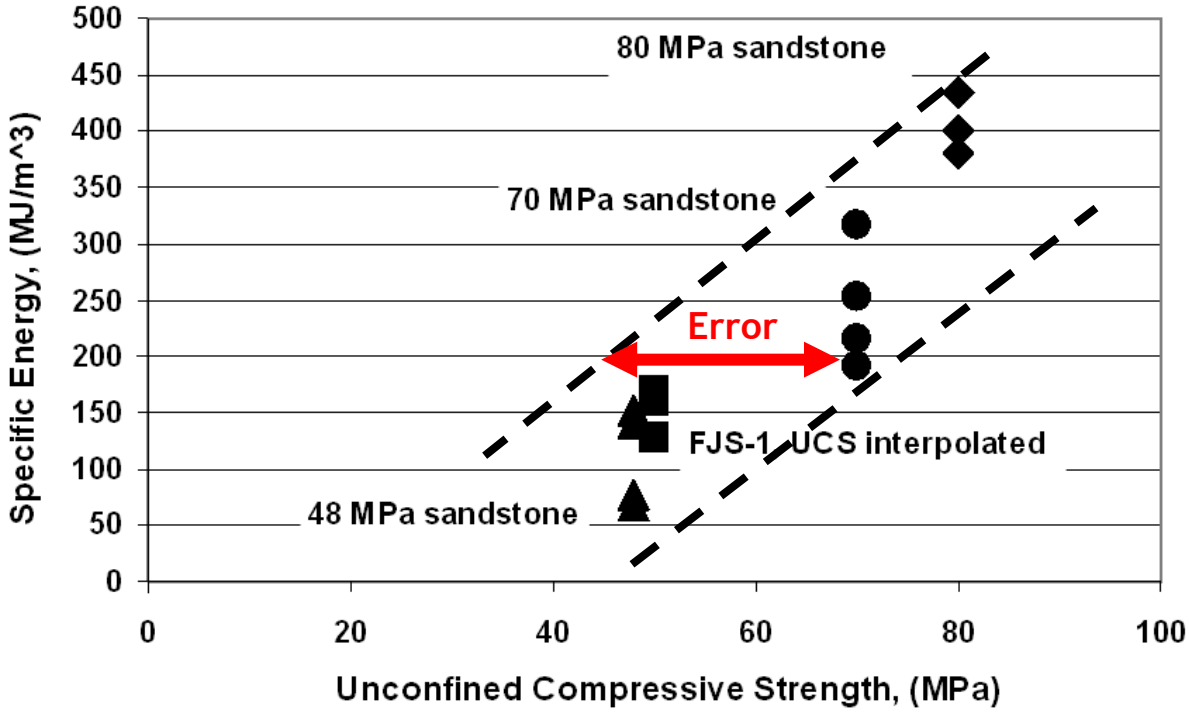
Strength value from drilling telemetry

- Drilling in three known sandstones and FJS-1
- Extrapolating UCS of FJS-1 based on SE of FJS1 and the three sandstones
- UCS ~ 48 MPa

Strength value from UCS tests

- UCS=43 MPa,
- std=11 MPa



Dave Cole, CRREL

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Thank You!

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