

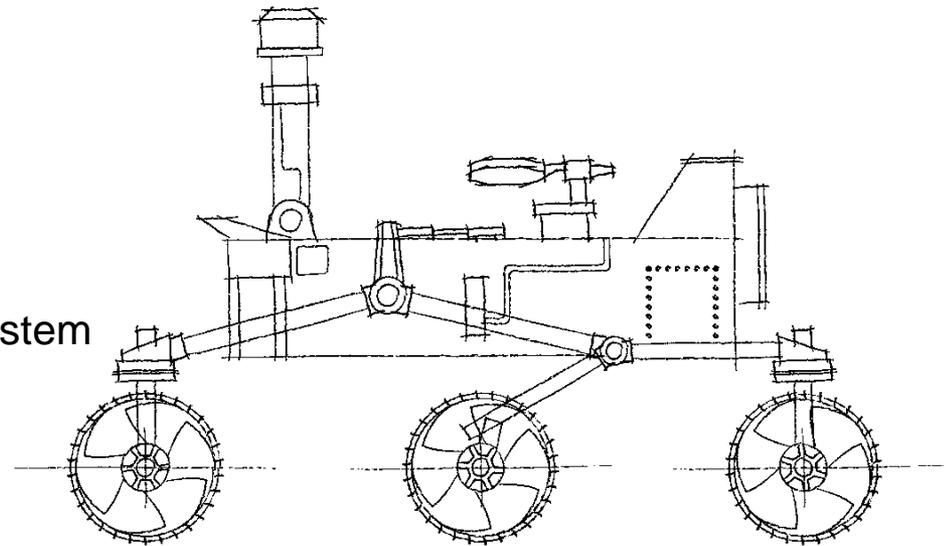


Mars 2020 Sampling and Caching Subsystem Environmental Development Testing – 10 ft Space Simulator Preliminary Results

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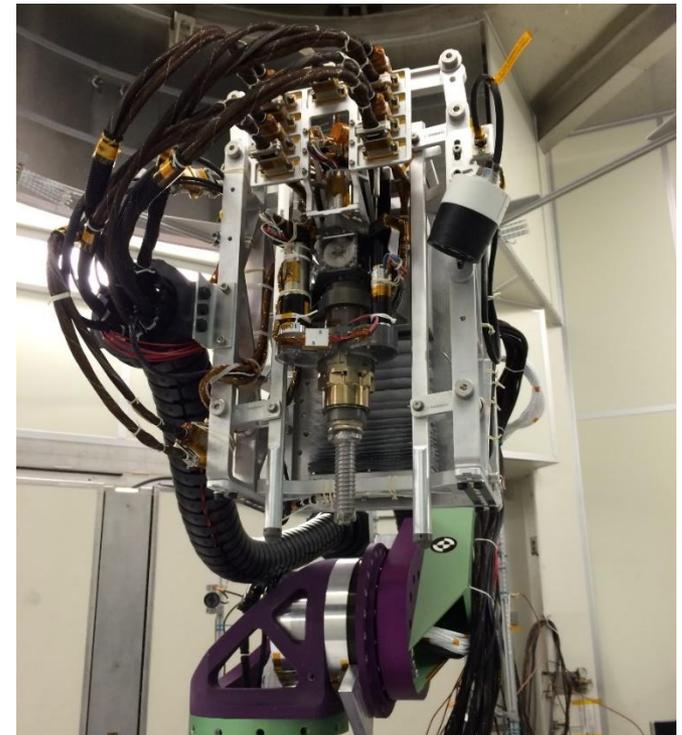
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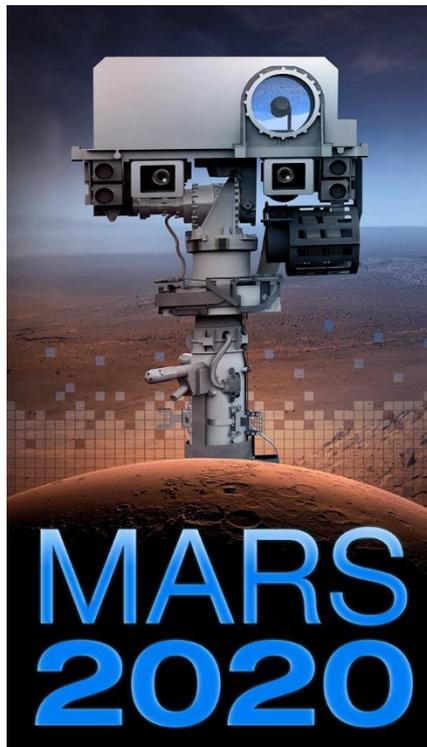
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Mars 2020 Project

- Mars 2020 Motivation
- Sampling and Caching Subsystem
- EDT Objectives
- 10 ft Chamber Layout
- Brassboard Corer
- Types of Tests
 - Coring Test
 - Core Breakoff
 - Cores
 - Abrading Test
 - Regolith Test
- Preliminary Results and Challenges
- Upcoming Testing
- Summary





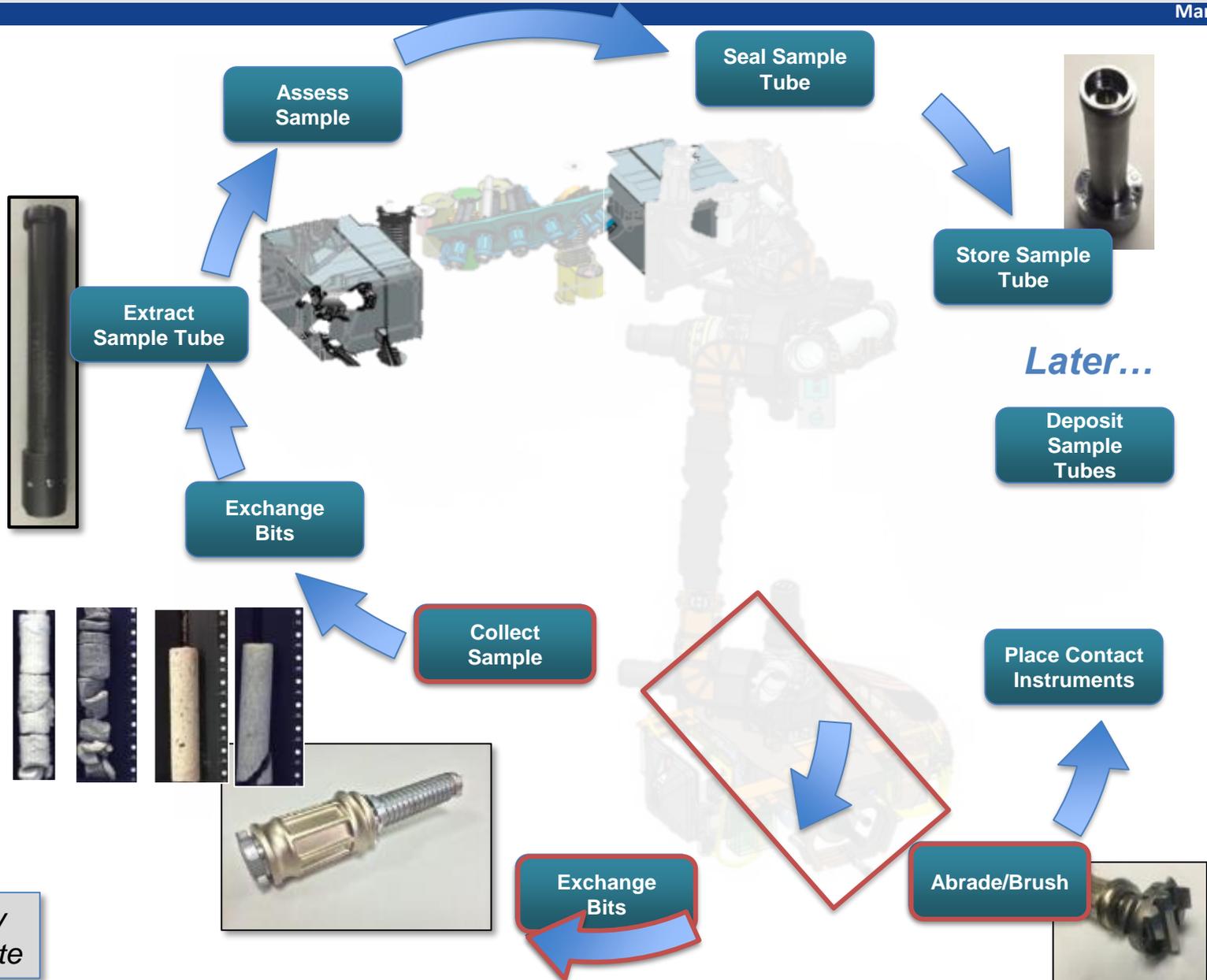
- The Mars 2020 mission proposes to explore a likely previously habitable site on Mars, **seek evidence of past life**, and **demonstrate technology** needed for future Martian robotic and human exploration efforts
- The Mars 2020 rover has been tasked with constructing a cache of **samples of Martian surface material** that is potentially returnable to Earth at a later date
- New Sampling and Caching Subsystem (SCS) includes a **rock coring drill** and **~40 sample tubes** to encapsulate each Martian specimen
- Tubes will be deposited at select locations on the surface of Mars for return on a potential **future sample-retrieval mission**
- In Earth laboratories, specimens from Mars may be analyzed for evidence of past life on Mars and possible health hazards for future human missions

Sampling & Caching Subsystem



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Mars 2020 Project



Slide by
K. Rosette

EDT

(Environmental Development Testing)

- M2020 “Brassboard” Corer on 5 DOF robotic arm
- Ambient and low pressure testing
- 10-ft diameter vacuum chamber



- Primary test objective: Stress the **sample acquisition process** across the range of rock types and environmental conditions to identify sampling system architecture solutions and ranges of operational parameters that result in ***robust operation*** and ***consistently high quality samples***



10 ft Chamber Layout

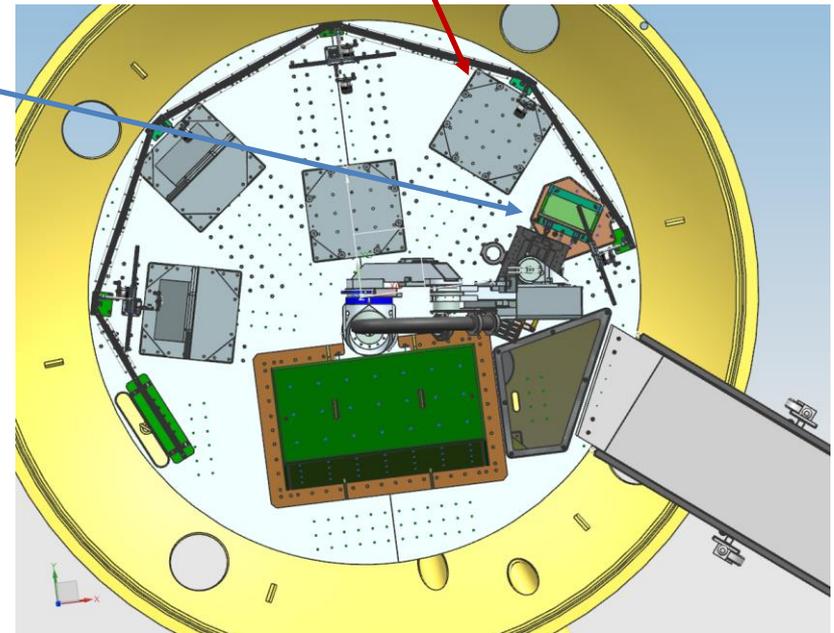
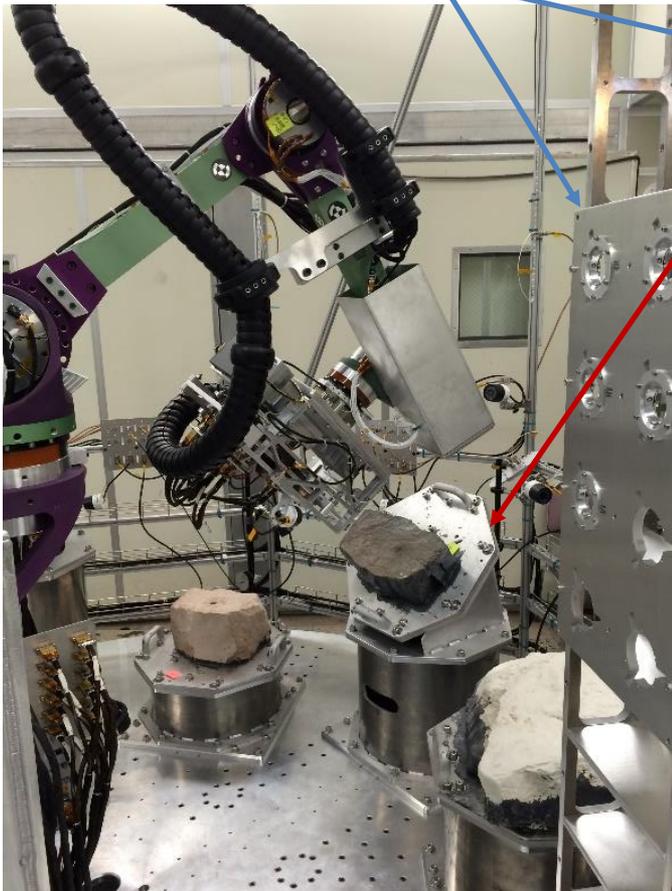


Bit box

- Five bits for up to five tests per pumpdown

4 Rock Stations

- Options for 0°, 45°, and 90° drilling orientation
- Rocks mounted to risers of varying heights to complement arm workspace

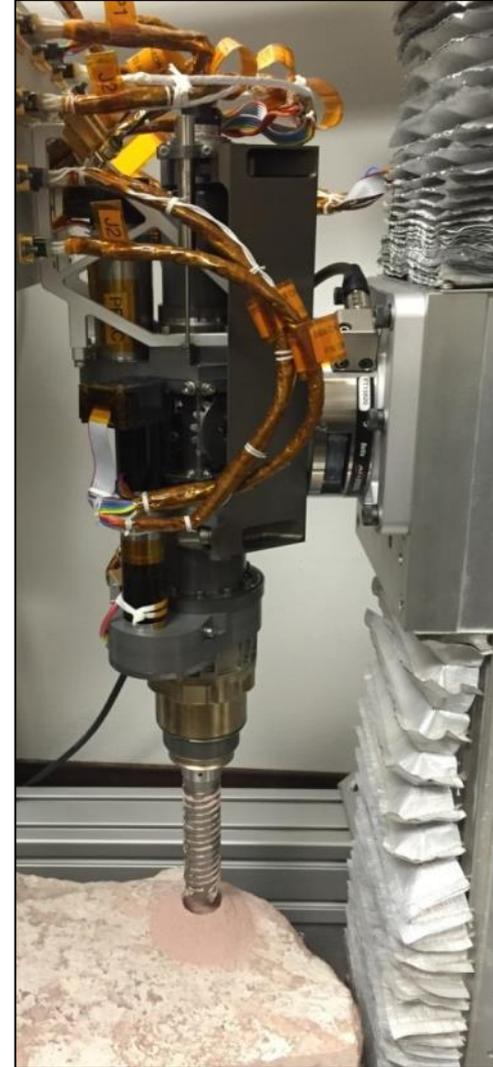


- Security cameras
- LEDs
- Humidity measurements by RGA
- Witness plate tests for monitoring contamination

Brassboard Corer (BBC)



- Highest fidelity prototype coring drill to date for SCS architecture
- Focus on hardware development
 - Eccentric Sample Tube
 - Motor-driven percussion
 - Geometry and materials in bit, tube, chuck, anvil, and percussion
- Telemetry used for flight motor sizing



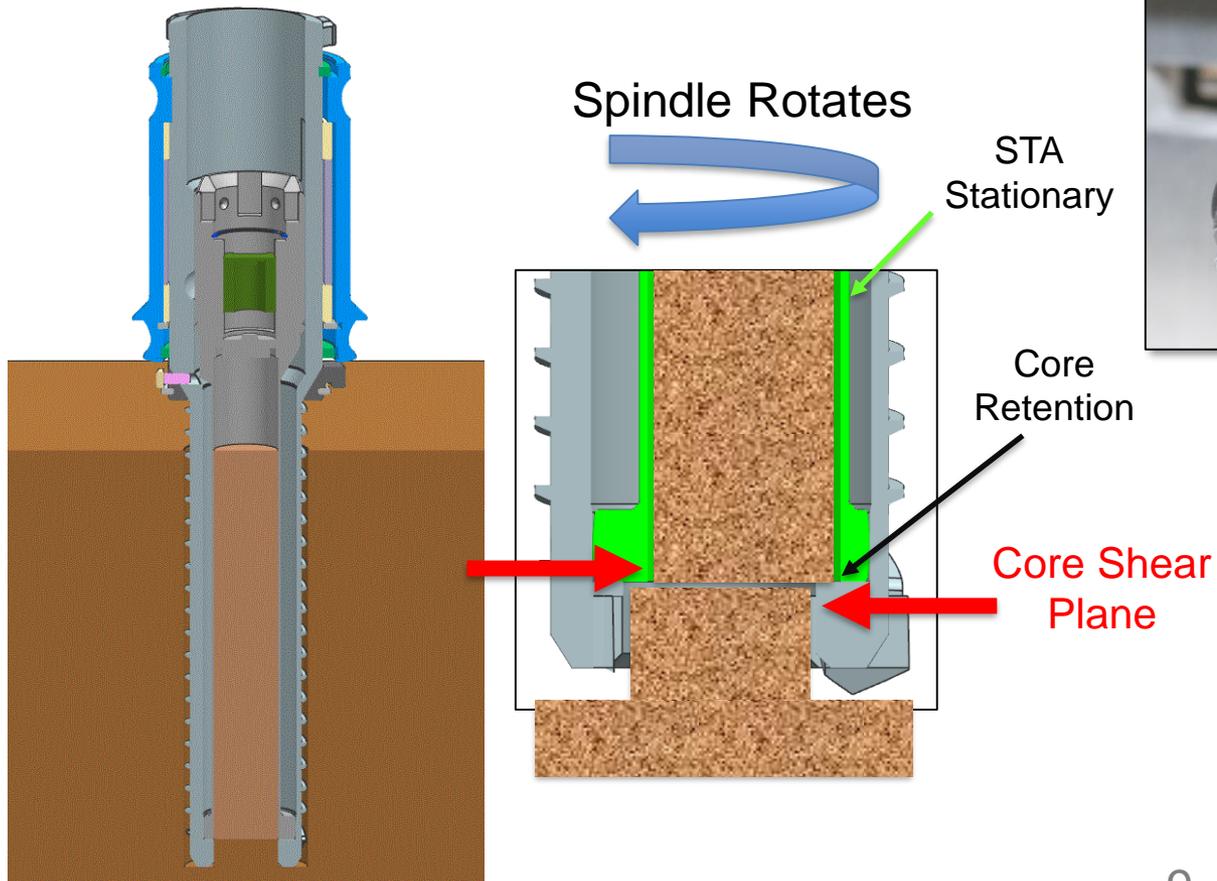


Mars 2020 Sampling and Caching System Environmental Development Testing

Core Breakoff



- The spindle rotates the Coring Bit Assembly, causing the eccentric tube to become misaligned. This produces a force couple that fractures the core in shear
- The core is retained inside the STA due to the misalignment of the eccentric tube and bit opening



(CRG Core PEC067)

Cores from

EDT

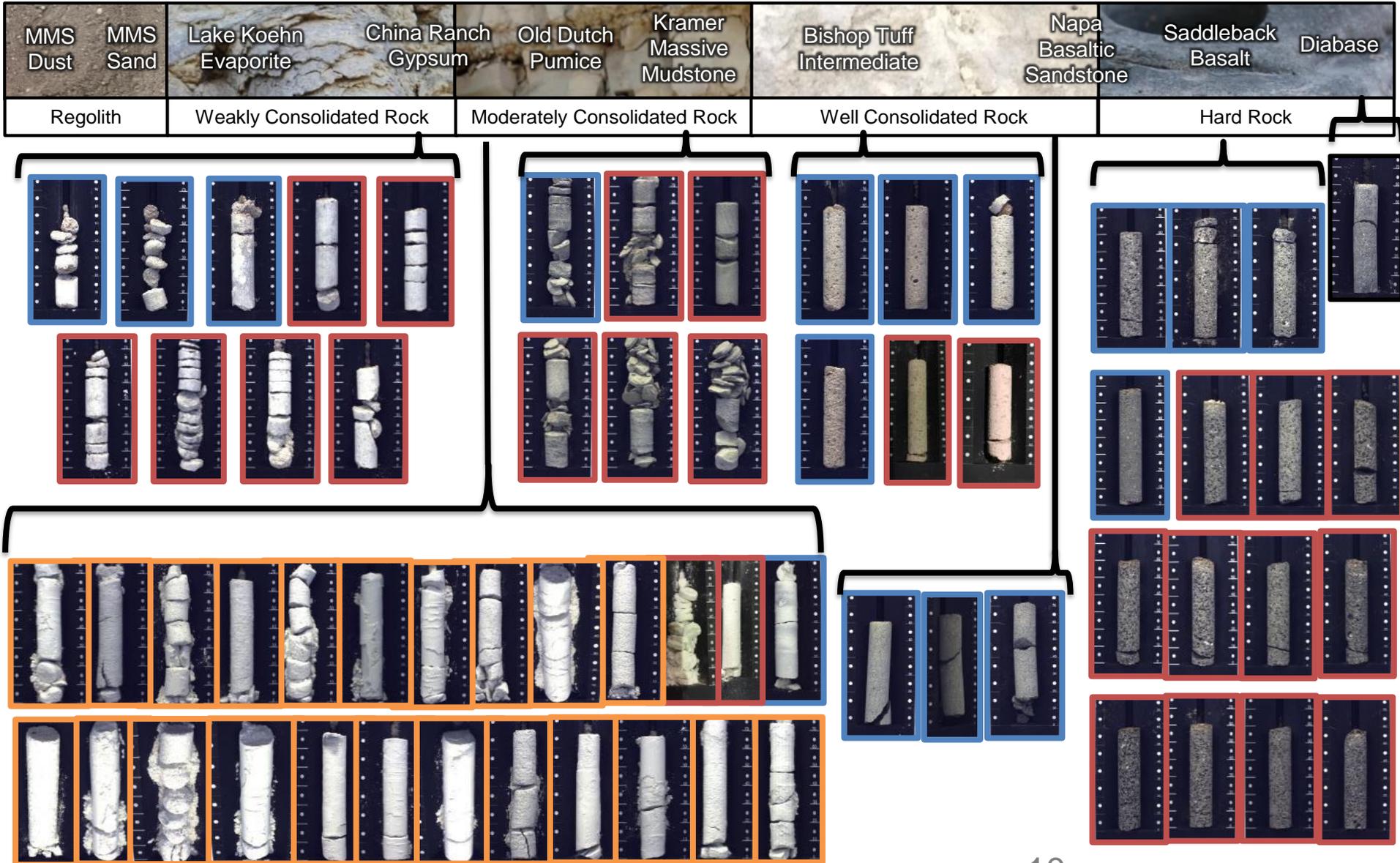
PEC

RCTB



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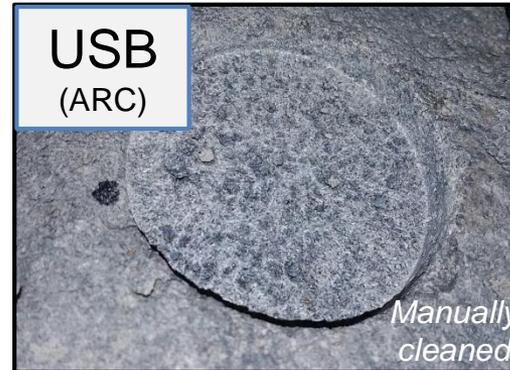
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Abrasion Test in EDT



- Abrasions create flat depressions a few millimeters deep for analysis by the Mars 2020 PIXL (Planetary Instrument for X-Ray Lithochemistry)



Regolith Collection Test in EDT



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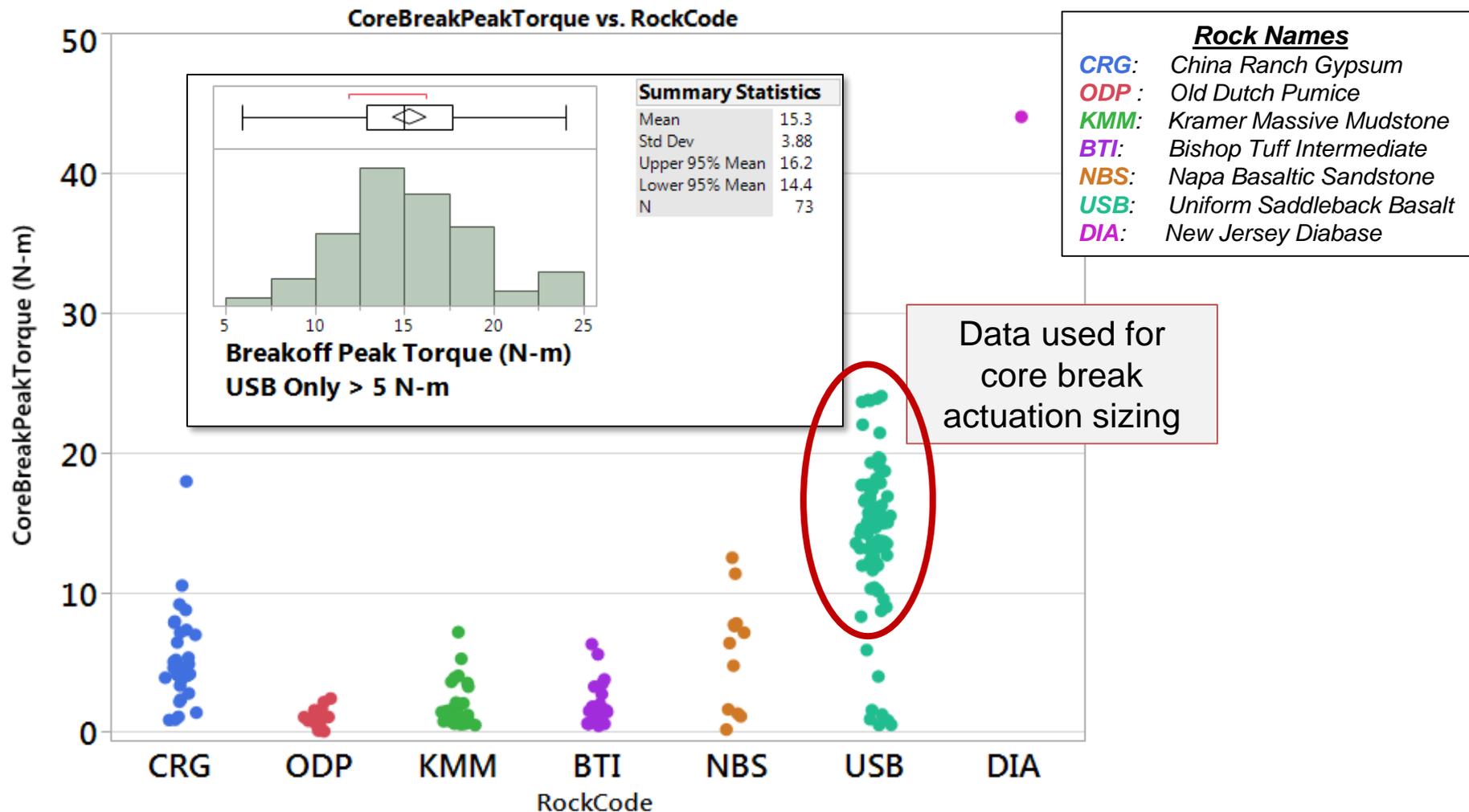
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Operation:
Move to Acquisition Target

Speed: 5x

Preliminary Data: Core Breakoff Torque



Hardware Challenge: Core “Mushrooms”



- Pieces of core stuck in bit teeth after tube extraction are a threat to reusability of coring bits
- Hardware design and operational mitigations are being explored



EDT014 mushroom
removed by percussion



Science Requirement Challenge: Under- and Over-collection



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- **Nominal operation:** Drill to specified depth, breakoff, retain core
- **Under-/Over-collection:** Sample acquisition process causes variation in the effective volume of the caged sample

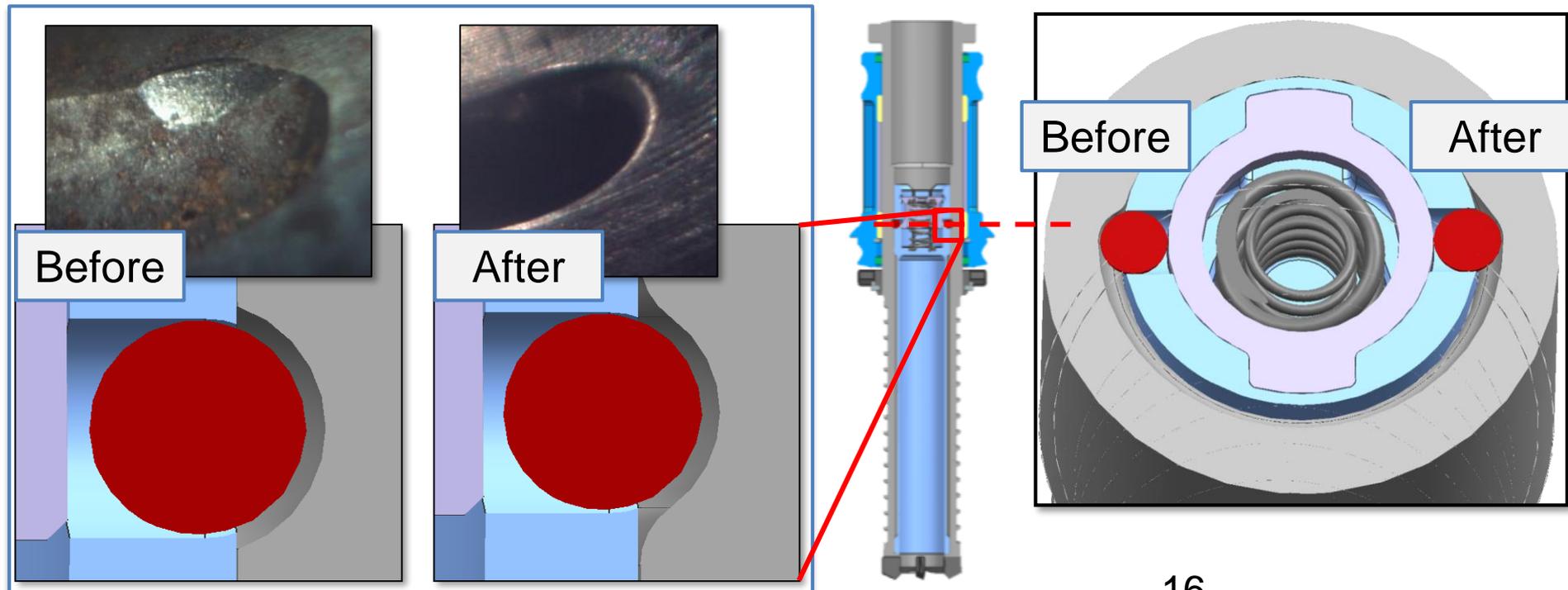


Reasons for Variation in Sample Volume

- Pieces become re-oriented resulting in more volume than the “idealized pencil core”
- Cuttings are ingested and retained resulting in increased volume, due to rock type, coring parameters, or coring orientation
- Ingestion of mushroom results in an additional 1cc variation



- Issue
 - Spindle frequently stalled after zero motion during core break
- Root cause hardware issues
 - Top edge of bit ball groove deformed during coring and contacted sample tube
 - Tube balls jammed rotationally against the ends of the bit ball groove
- Resolution
 - Ball groove contact geometry was successfully modified to continue testing
 - Next design will include lead-out features and conformal contact geometry to minimize contact stress

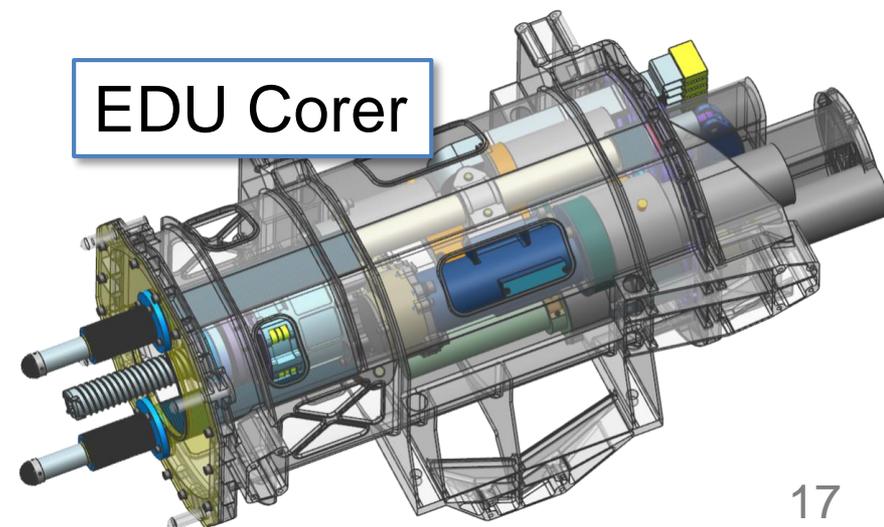


Tests In Progress

- Follow-on tests
 - Use statistical software results to improve test planning
 - Over-collection as a function of coring orientation
- Mushroom mitigation by iterating hardware design and operating procedures
- Abrading and dust removal by compressed gas
- Algorithm development

EDU (Engineering Dev. Unit)

- Next generation prototype
- Includes first prototypes of certain corer mechanisms
- Flight-like brazing and PP/CC processing
- Simplified turret structure
- Compatible interfaces to exchange sample tubes between Corer and Cache
- Flight-like algorithm for optimizing core quality based on telemetry



Summary



- The results from EDT and other development testbeds are informing the hardware and operational design of the Mars 2020 SCS, especially the next iteration of the corer, the Engineering Development Unit
- Core quality analysis and observations of drill performance will influence improvements to mechanical design and operational procedures
- Visit us! Test demos are performed for tours by NASA visitors, Congressmen, JPL Open House, James Cameron...

