A LOW COST, LOW MASS ARCHITECTURE FOR MARS SAMPLE STEP ONE: TARGET SELECTION, CORING AND CACHING. K. Zacny[1], P. Conrad[2], A. Steele[3], [1]Honeybee Robotics - Pasadena, zacny@honeybeerobotics.com, [2]NASA GSFC, [3]Carnegie Institution of Washington.

Introduction: With the cost and mass constraints imposed on the MSR precursors, in situ analytical capability must be traded against sampling capability so that enough can be learned about the rock targets to ensure that they represent as much martian diversity as possible, but that the MER class rover can accommodate the necessary sample acquisition and caching hardware. Here we present an architecture that represents a plausible compromise to do both while leveraging the heritage of both MER and MSL missions.

Returning the samples back to earth is beyond the scope of this proposal. This mission demonstrates only target selection and sample caching, representing the first phase of a two step mission.

Target selection is accomplished by evaluating data from 3 payload instruments: (1) high resolution stereo imaging for promising structure and textural features, (2) A ChemCam-type MSL heritage LIBS instrument with added Raman detector for short range remotely-sensed mineralogical and geochemical characterization and (3) A microscopic imager of the MER or MSL heritage that is integrated with the sample acquisition tools on the arm. By keeping the materials characterization tools on the mast, the available mass accommodation on the arm is made available to our sampling tools.

Our sample acquisition system features four bits: a combined Brushing and Abrading Tool (BAT), a core PreView Bit, a Powder and Regolith Acquisition Bit (PRAB) [2, 3, 4].

The BAT uses the same approach as the Rock Abrasion Tool on the Mars Exploration Rovers to brush and abrade rocks. The PreView bit acquires a 2.5 cm long core which can be viewed through the slot inside the bit or placed onto an observation tray. The PRAB acquires soil or rock powder for analysis.

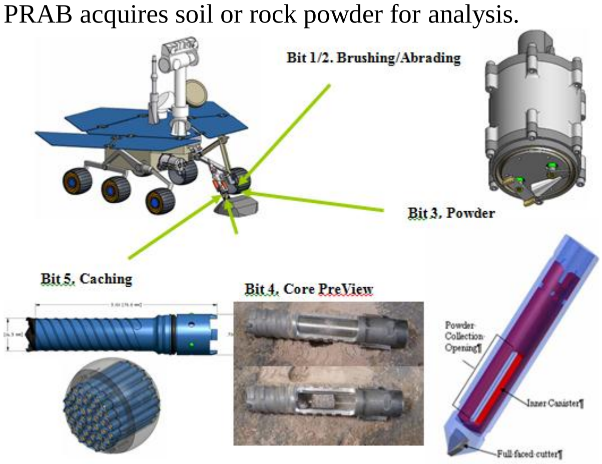

Figure 1. 5in1 approach: 5 unique bits for different tasks deployed form the same drill.

In summary, the sample selection tasks for the mission may include (see Table 1):

1. Brushing rocks for in situ analysis (as done on MER and MSL)
2. Abrading rocks for in situ analysis (as done on MER)
3. Acquiring a 1 cm diameter by 2 cm long preview core for in situ analysis and/or sample return
4. Acquiring rock powder and regolith for in situ analysis and/or sample return (as done on MSL)

Table 1. Possible rock interrogation scenarios.

Step	Action	Bit Type
1	Analyze a rock surface	
2	Brush and Analyze a rock surface	Brushing Bit (e.g. DRT on MSL or RAT on MER)
3	Abrade and Analyze a rock surface	Abrading bit (e.g. RAT on MER)
4	Take a short core and Analyze the core	Preview Bit
5	Take powder and Analyze powder	Powder bit (e.g. MSL drill)

Brushing and Abrading Tool (BAT): We tested a number of grinding bits and brushing bits [4] and developed a concept based on the MER RAT (Figure 3). An advantage of using the RAT-like approach is its flight heritage and quantifiable performance on Mars in various rock types, ranging from soft to hard (the RAT Spirit performed 15 grinds in harder rocks, the RAT Opportunity performed 38 grinds in softer rocks).

The BAT creates a surface ~35 mm in diameter, weights ~ 360 grams (this can be further optimized), and fits within a 30 mm diameter and 55 mm tall cylinder. An estimated life of the bit based on the RAT-data and increasing the grinding bit volume is 45 operations in hard rocks and 120 operations in softer rocks. The RAT on MER Spirit performed close to 100 brushings, hence BAT will be able to perform at least as much.

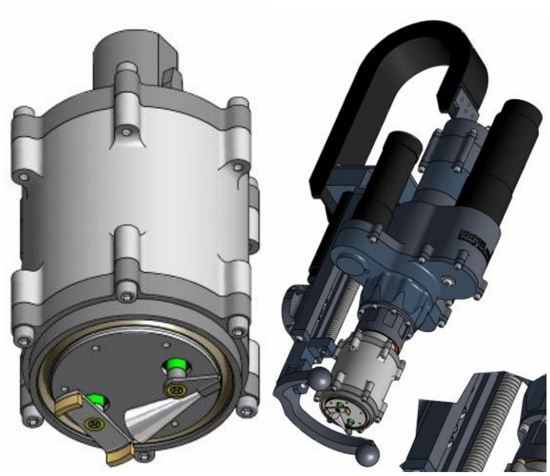

Figure 3. Concept of Brushing/Abrading Tool (BAT) based on MER Rock Abrasion Tool.

Core PreViewBit. The PreView bit acquires short cores for in-situ analysis by the mast-mounted LIBS/Raman probe. The PrewView Bit has side slots in the break-off tube and the auger tube as shown in Figure 4. The bit takes advantage of the Honeybee break-off system utilizing two rotary-systems: an inner rotating sleeve to shear and capture the core and outer auger/bit. During drilling, the internal break-off tube is rotated to open the side slot. During the break-off stage, the inner tube is rotated so as to close the side slot (and at the same time shears and captures the core). Hence the captured core cannot fall out. During the core dispensing stage, the break-off tube is rotated to open up the slot. The advantage of this bit is that the core can be viewed while inside the bit i.e. in a known location. The bit can incorporate a BigTooth design for dispensing a core onto an observation tray [4].

Figure 4. The Preview Bit. Left: after reaching the target depth, break-off tube is rotated to shear and capture the core. Once the tube is fully closed (Center), the core cannot fall out. To view the core, the inner break-off tube is rotated back to expose it. (Right)

Powder and Regolith Acquisition Bit (PRAB): The Powder/Regolith Bit can be used to acquire rock cuttings during the drilling process (as is done by the MSL drill), and it can also be used to acquire regolith. \(see Figure 5). Once the bit acquires rock powder or regolith, the sample can be either dispensed into an observation tray or cached for earth return along with rock cores. Bit operation is very similar to that of the PreView bit in that there are slots within the break-off tube and the auger. When the slots are aligned, the regolith or rock powder can flow into the inner cavity. When the slots are closed (the inner tube is rotated with respect to the outer auger) the powder inside the bit is retained.

The PRAB has integrated sieves and can either acquire particles below sieve size or retain particles above certain sieve size, depending upon mission requirements.

If an original, unsorted sample is desired, the bit could then dispense a sample having various particle sizes.

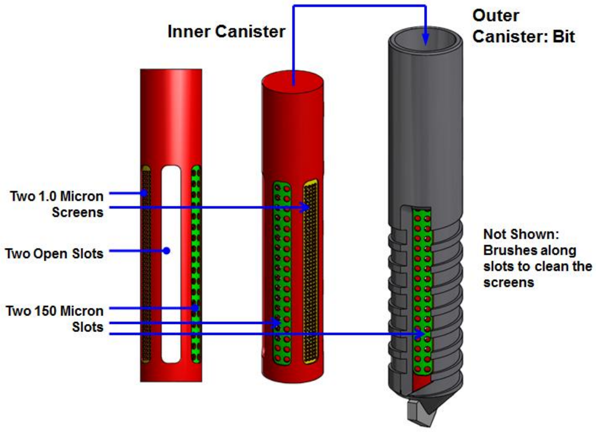

Figure 5. Powder and Regolith Acquisition Bit (PRAB) with integrated sieves.

References: [1] Beaty et al. (2010) Proposed Mars Astrobiology Explorer-Cacher (MAX-C) Rover: First Step in a Potential Mars Sample Return Campaign, LPSC. [2] Zacny et al., (2011) Approach to the Sample Acquisition and Caching Architecture for the 2018 Mars Sample Return Mission, Paper #1573, IEEE [3] Zacny et al., (2011), Prototype Rotary Percussive Drill for the Mars Sample Return Mission, Paper #1125, IEEE [4] Zacny et al., (2011) Development of the Brushing, Abrading, Regolith, Core PreView and the Coring Bits for the Mars Sample Return Mission, AIAA Space.