CORE DRILL FIELD KIT AND ITS APPLICATIONS. K. Zacny[1], J. Atkinson[1], H. Rideout[1], S. Indyk[1], J. Spring[1], P. Morrison[1], N. A. Cabrol[2], K. Young[3], T. Graff[3], D. Lim[4], [1]Honeybee Robotics, [2]SETI Institute Carl Sagan Center, [3]NASA JSC, [4]NASA ARC

Introduction: We developed a hand-held coring drill system that can be used with little to no training, to capture rock cores from rocks as hard as basalt. The core bit was designed to capture a 1 inch diameter and 4 inch long core. However, other diameters and lengths are possible. The technology has been adapted from Honeybee's robotic drills and modified for human deployment. Honeybee assembled two Pelican cases with the coring systems. These cases can be requested from Honeybee (free of charge) for the duration of field deployment. Figure 3 shows an inside of a Pelican case with all the parts that would be required to capture a core. **Figure 2** shows instructions. Scientists would be required to bring their own sterilization equipment (e.g. flame torch, hydrogen peroxide, alcohol etc.) and storage containers for the cores.

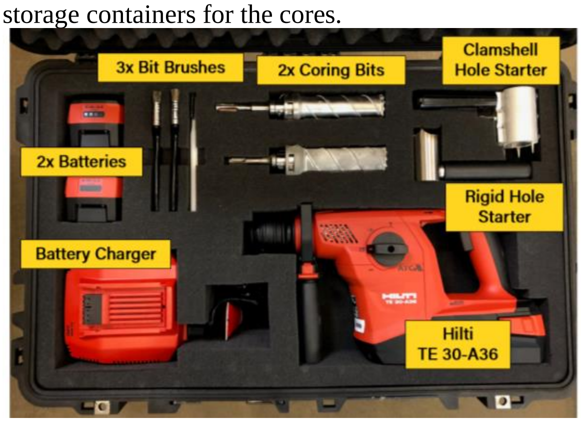

Figure 1. The Core Drill Field Kit available to the science community, should be requested from Honeybee (POC: Kris Zacny).

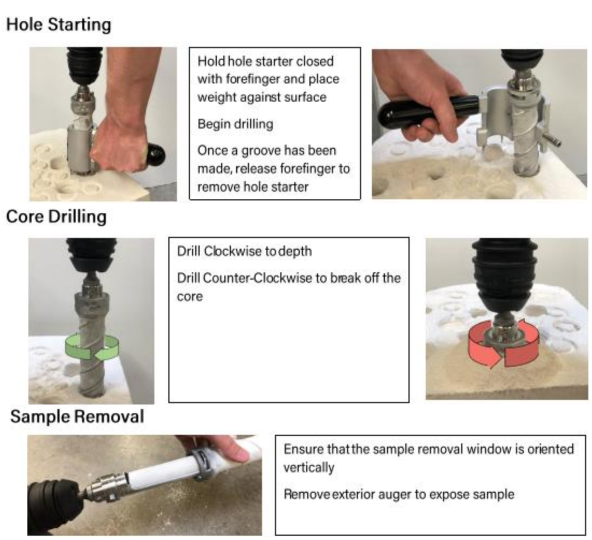

Figure 2. The Core Drill Field Kit instructions.

Description of a coring bit assembly: The coring system (Figure 3) includes five parts 1. Auger Bit, 2. Core Breakoff Tube, and 3. Bit Adapter, 4. Hole Starter, and 5. Hammer Drill.

1. Auger Bit: The purpose of the auger bit is to cut the rock and move cuttings out of the hole. These cuttings can be retrieved at the surface and analyzed.

2. Core Breakoff & Release: To capture the core and retain it inside the coring bit, the core bit requires a core breakoff tube. We employed "eccentric tubes" method [1] where, the bit and the breakoff tube each have bores slightly offset from center by the same distance (**Figure 4**). During drilling, the two tubes are aligned. To break the core, the breakoff tube is rotated relative to the bit. This shears the core at the base.

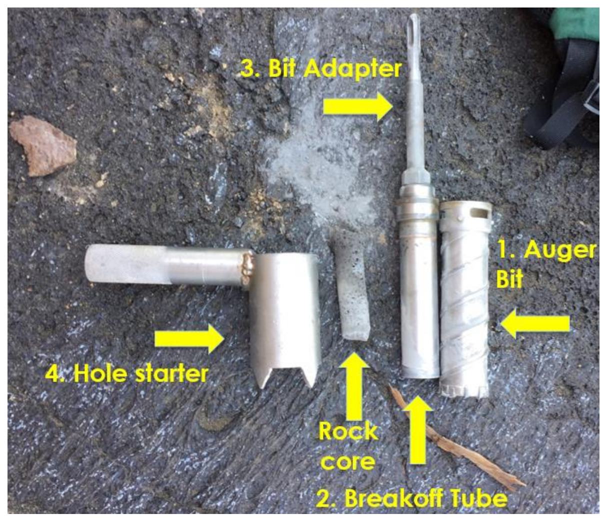

Figure 3. Coring bit assembly.

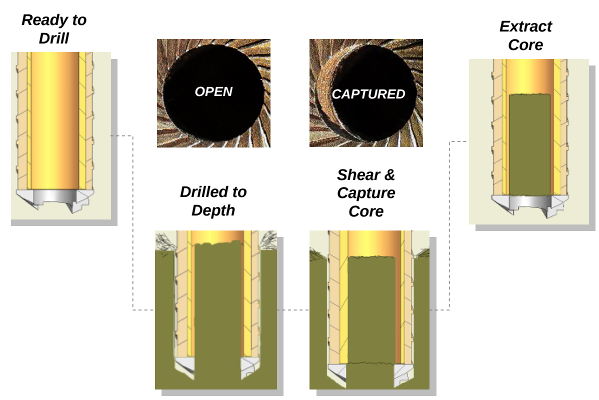

Figure 4. Honeybee Robotics patented "eccentric tubes" core breakoff approach.

3. Bit Adapter: The bit adapter is essentially a rod attached to the Breakoff Tube and the Hammer Dill. The adapter transfers drilling forces and hammer percussion from the drill to the bit.

4. Hole Starter: Coring bits have peripheral cutters, which produces destabilizing forces causing the drill bit to "walk". Our hand-operated solution is the core bit stabilizer, used for the first few seconds of drilling until the coring bit cuts a few millimeter-deep groove, sufficient to center the coring bit.

5. Hammer Drill: we use off-the-shelf rotary-percussive cordless drills. The type of bit chuck determines how the Bit Adapter will look like. We use drills with chucks for SDS+ bits.

Field Deployments: The tools have been designed specifically for the SETI Institute NAI team (N.A. Cabrol, PI), and field tested in the Atacama in 2016, 2017, 2018, and 2019 [2, 3]. Figure 5 shows example where the coring bit reached the target depth. To extract the core, the breakoff tube was pulled out of the coring bit – this allowed the core to be viewed before being transferred into a bag or a container (Figure 6). As shown, the breakoff tube is actually a half tube – one half is cut out to allow the core to be viewed and extracted. This particular architecture has been developed after drill testing in very cohesive (sticky) materials. A core of a sticky material (e.g. fumarole) will stick to a breakoff tube and won't come out.

Figure 5. Testing in the Atacama.

Figure 6. The core is being viewed while inside the breakoff tube.

Additional field opportunities presented themselves for testing different generations of these bits [4]. The modified bits were used to capture samples of coral during the 2017-2019 NEEMO tests [5]. The bits have also been used to capture cores within the Hawai'i Volcanoes National Park as part of two PSTAR projects: BASALT: Biologic Analog Science Associated with Lava Terrains (Darlene Lim, PI)[6] and SHyRE: Scientific Hybrid Reality Environments (Kelsey Young, PI). This allowed the coring technology to improve since in each location different formations had to be drilled (e.g. altered and unaltered fumarole - Figure 7, Young and old volcanic flows - Figure 8).

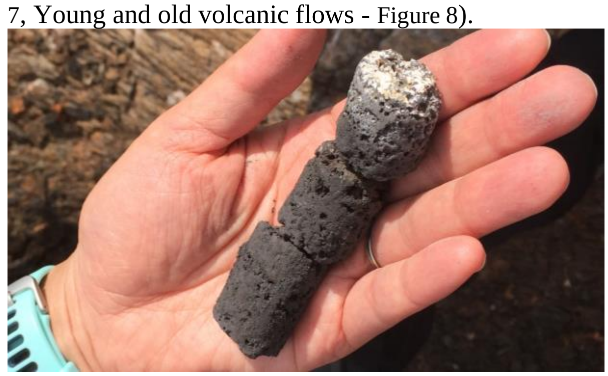

Figure 7. Core of altered fumarole from Mauna Ulu.

Figure 8. Basalt core from Hawaii's Big Island.

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References: [1] Zacny et al., (2013), IEEE Aerospace Conf., [2] Cabrol et al., (2017). AbSciConf., [3] Rehnmark et al., (2017) AbSciConf., [4] Zacny et al., (2017), LPSC. [5] Young et al., (2020) LPSC. [6] Lim et al. 2019 (https://doi.org/10.1089/ast.2018.1869).