PLANETARY VOLATILES EXTRACTOR (PVEX) FOR IN SITU RESOURCE UTILIZATION (ISRU) ON THE MOON. K. Zacny[1], S. Indyk[1], K. Luczek[1], A. Paz, [1]Honeybee Robotics, 398 W. Washington Ave, Suite 200, Pasadena, CA 91103, zacny@honeybeerobotics.com, [2]NASA Johnson Space Center,

Introduction: In Situ Resource Utilization (ISRU) uses local resources to sustain operations (either human or robotic) on extraterrestrial bodies [1]. In a conventional ISRU approach, feedstock is mined, transported to a processing plant, and resource is extracted. Planetary Volatiles Extraction (PVEx) offers an alternative approach that combines mining and extraction into one step and eliminates energy intensive and time consuming transport. We investigated three approaches: "Sniffer", Mobile In Situ Water Extraction (MISWE), and Corer. All three use a drill to penetrate subsurface; which can successfully penetrate regolith saturated with water-ice (worst case material) [2].

Sniffer: The Sniffer is a deep fluted auger with perforated walls. Walls are heated and holes allow for water vapor to flow into the auger and up into a volatiles collection system on the surface.

MISWE/Auger: The MISWE approach, consists of the Icy-Soil Acquisition and Delivery System (ISADS) and the Volatiles Extraction and Capture System (VECS) [3]. The ISADS is a deep fluted auger that retains material within the flutes. The VECS consists of a cylindrical heat exchanger and volatiles transfer system (a reactor). The material on the deep flutes is heated; water sublimes away and flows into a water collection canister, where it re-condenses.

Corer: The Corer is a dual wall coring auger [4]. The outer wall is an auger with shallow flutes, made of low conductivity composite. The inner cylinder is perforated and covered with heaters. The corer penetrates subsurface and captures a core. Heaters are turned on, heat up the core and sublime volatiles within the core. Volatiles then flow within the annual space and into a cold trap on the surface.

Test Results: We perfromed many tests inside a vacuum chamber with a JSC-1a lunar analog simulant. Sniffer did not work well; volatiles escaped through the soil and into the vacuum. MISWE was better in terms of water extraction efficiency and energy conversion efficiency. However, the Corer was the best.

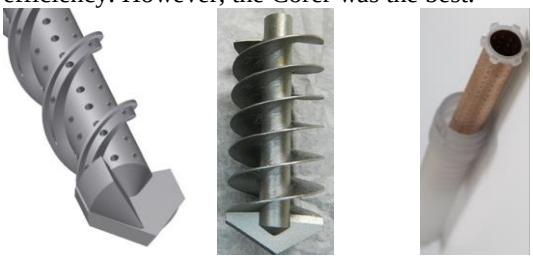

Figure1. Sniffer, MISWE, Corer.

Table 1. Trade study

		Sniffer	MISWE	Corer
Energy Efficiency [Whr/g]	**Min**	1.8	1.3	1.5
	Max	83	5.4	4.4
	Avg	**36**	**2.6**	**2.2**
	StDev	30	1.0	0.8
Water Recovery [%]	**Min**	0.1	18	31
	Max	4.6	78	87
	Avg	**1.2**	**44**	**65**
	StDev	1.7	16	17

Figure 4. Captured water from Corer.

PVEx Corer: The Corer takes advantage of many components developed for the Resource Prospector (RP) drill. With a goal of 30 kg per day the system would need one rover with four Corer systems assuming in-situ material has 12 wt% water saturation (maximum for JSC-1a). The energy per daily operation would be approx. 3.7 kWh supplied as heat (3.4 kWhr) and electircity (0.3 kWh) from MMRTG [4].

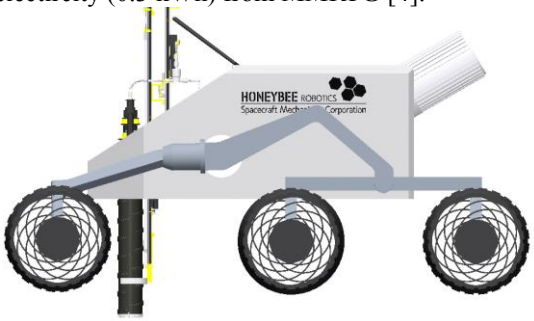

Figure 5. PVEx-Corer Design.

References: [1] Sanders et al. Comparison of Lunar and Mars In Situ Resource Utilization for Future Robotic and Human Missions, AIAA Aero Science, 2011. [2] Paulsen, et al., Testing of a 1 meter Mars IceBreaker Drill in a 3.5 meter Vacuum Chamber and in an Antarctic Mars Analog Site, AIAA SPACE 2011; [3] Zacny et al., Mobile In-Situ Water Extractor for Mars, Moon, and Asteroids ISRU, AIAA Space 2012; [4] Zacny et al. Planetary Volatiles Extractor (PVEx) for In Situ Resource Utilization (ISRU), ASCE Earth and Space 2016.