Rockballer Sample Acquisition Tool

This tool also has application in the medical industry in the removal of tissue samples or tumors from the body.

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It would be desirable to acquire rock and/or ice samples that extend below the surface of the parent rock or ice in extraterrestrial environments such as the Moon, Mars, comets, and asteroids. Such samples would allow measurements to be made further back into the geologic history of the rock, providing critical insight into the history of the local environment and the solar system. Such samples could also be necessary for sample return mission architectures that would acquire samples from extraterrestrial environments for return to Earth for more detailed scientific investigation.

Conventional methods for the acquisition of rock or ice use devices similar to augers, drills, core drills, or hole saws to cut a cylindrical sample from the parent rock. These cylindrical sample acquisition methods suffer from two fundamental problems. First, cylindrical methods tend to leave an uncut circular root that attaches the base of the sample to the parent rock so separating the sample may require significant force. Second, cylindrical methods also do not guarantee that a sample will remain within the cutting tool after cutting. It is possible to add mechanisms to cylindrical mechanisms that may increase the thickness of the cutting tool, which increases the amount of rock that must be displaced ("cuttings") in order for the tool to cut into the rock. The increased volume of cuttings does not increase the amount of sample acquired, but it does increase the time and electrical energy required to acquire a sample, and thus this solution is undesirable.

The Rockballer circumvents the issues of both sample separation and sample retention by eliminating the cylindrical cutting methods in favor of a new spherical cutting method. This spherical cutting method is achieved through the use of two cutting "jaws" that are essentially formed by cutting a thin hemispherical shell into two symmetric parts. The jaws are slowly closed around the sample as the entire Rockballer rotates about an axis normal to the parent rock. As these jaws close, they simultaneously dig deeper into the parent rock and surround the sample, thus achieving sample acquisition and retention with a single process. When acquisition of the sample is complete, the Rockballer is withdrawn with the sample secured within the closed jaws. The Rockballer can then be repositioned, for example, near a science instrument or sample transfer mechanism, and the jaws can be opened to release the sample in a controlled and predictable fashion.

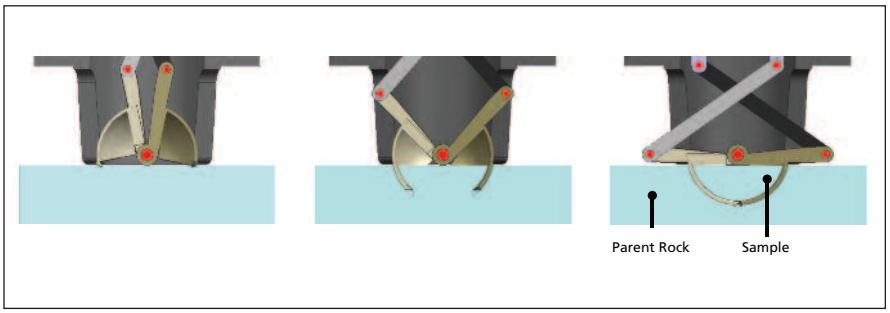

Figure 1. The sequence shows a cutaway view of how the **Rockballer** cuts and retains a sample as the jaws close. The rapid rotation about the vertical tool axis is not shown.

The resulting samples are hemispherical or nearly hemispherical and as a result, the aspect ratio (sample depth relative to sample radius) is essentially fixed. This fixed sample aspect ratio may be considered a drawback of the Rockballer, as samples with a higher aspect ratio (more depth, less width) may be considered more scientifically valuable because these samples would allow for a broader inspection of the geological record. This aspect ratio issue could be ameliorated if the Rockballer is paired with a Rock Abrasion Tool (RAT) similar to those used on the Mars Exploration Rovers. The RAT would be used to first grind into the surface of the parent rock, after which the Rockballer would extract a sample from deeper in the rock than would have been possible without first using the RAT.

The Rockballer has the added advantage of being able to also function as a scoop for acquiring granular dust, regolith, soil, or small rocks. Consequently, the Rockballer is both a minicoring tool and scoop.

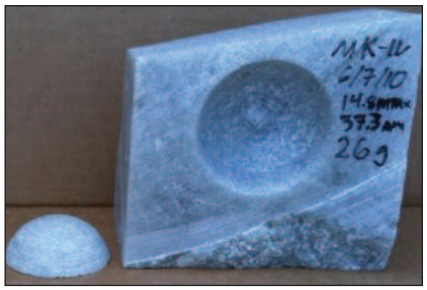

Figure 2. Photograph of **Soapstone Sample** (left) cut from parent rock (right) by the Rockballer prototype; the sample is 14.8 mm deep and has a mass of 26 grams.

The prototype Rockballer successfully cut and retained rock samples from both soapstone and alabaster. The prototype Rockballer was designed to cut rock samples roughly 1.5 cm deep with a mass of roughly 25 g; these dimensions were selected based on a hypothetical Mars Sample Return mission concept; however, the Rockballer can be designed to produce samples of any size. Soapstone and alabaster were selected because these rocks are relatively soft and readily available; however, the Rockballer can be designed to cut samples from any type of rock or ice.

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