Deep Drilling Using the Biologically Inspired Auto-Gopher

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Introduction

- Increasingly, as part of its exploration missions, NASA is seeking to acquire samples for in-situ or return analysis.
  - The objectives include search for evidence of life and resources, and understand the history of the Solar system.
  - For deeper drilling the possible missions are Mars and Flagship mission to Saturn's moon, Titan and Europa (icy satellite of Jupiter).

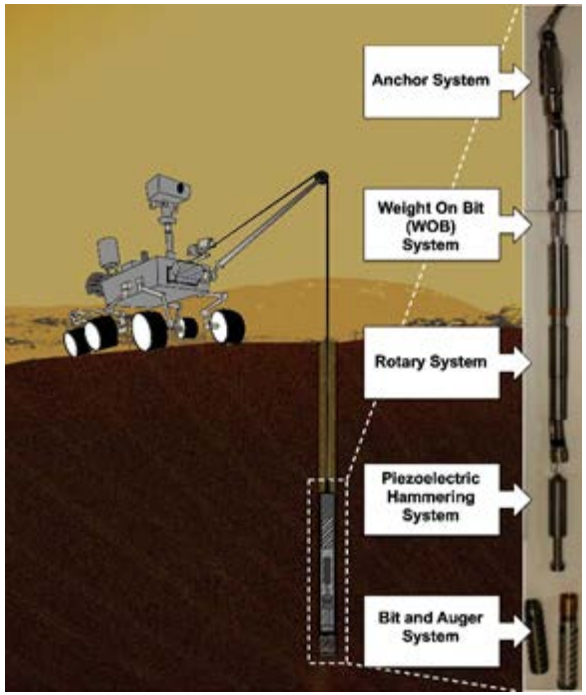
- In the Phoenix Scout and MSL planetary exploration missions, sample acquisition from as short depth as 5 cm has been identified as a major challenge.

- On such planets as Mars, drilling as deep as 2 meter or more would allow acquisition of pristine samples from below the reach of harmful UV and surface radiation.

Inspired by the Gopher's holes making

The gopher makes holes by removing soil along its path to form underground tunnels.

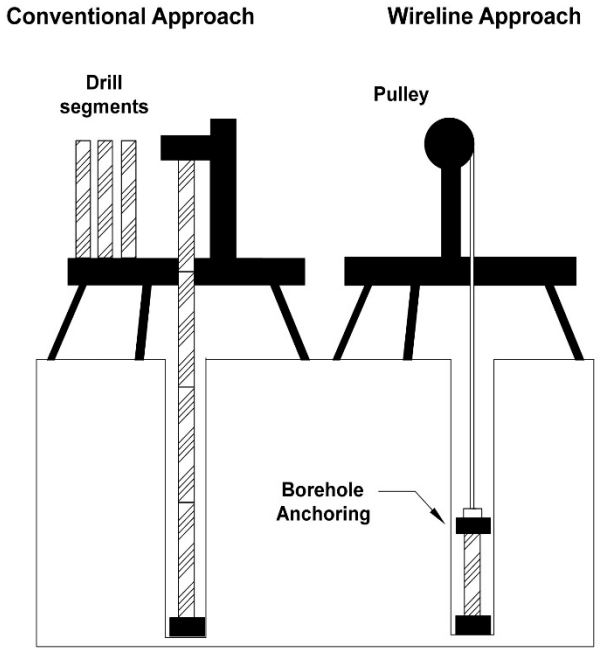
Image reference:
http://www.ancpestsolutions.net/gophers/



The Auto-Gopher concept as a deep drill.

The initial version of the deep drill technology--the Auto-Gopher-1. The drill is shown with the cores that were acquired from reaching 3 m deep.

The Auto-Gopher is a Wireline drill

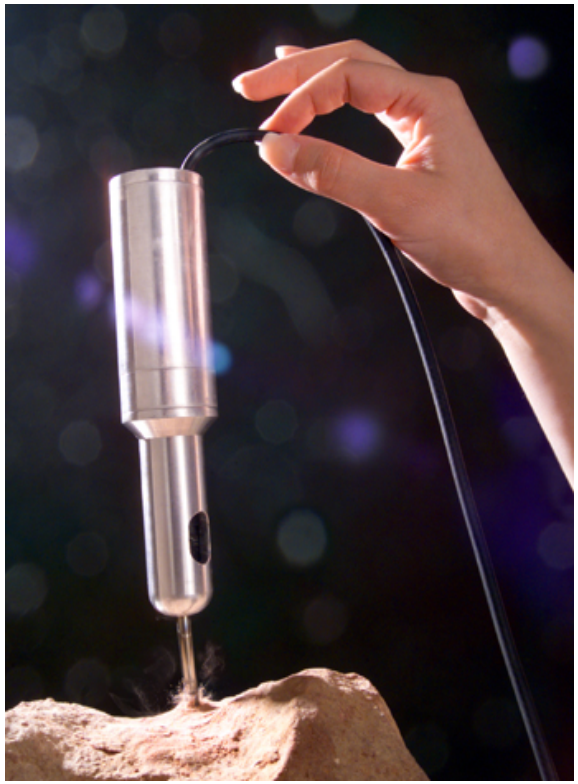


- The Auto-Gopher is a wireline drill that is lowered and raised via a tether.
- It creates cores and then the drill is pulled up to remove them.
- The process is repeated to reach the desired depth.
- It is superior to the conventional drilling approaches since the deployment mechanism is lighter, less complex mechanism of downloading, and great depths can be reached with a relatively compact system.

The hammering mechanism is generated by piezoelectric actuation

The drill is driven by a piezoelectric actuator that creates vibrations for hammering the bit.

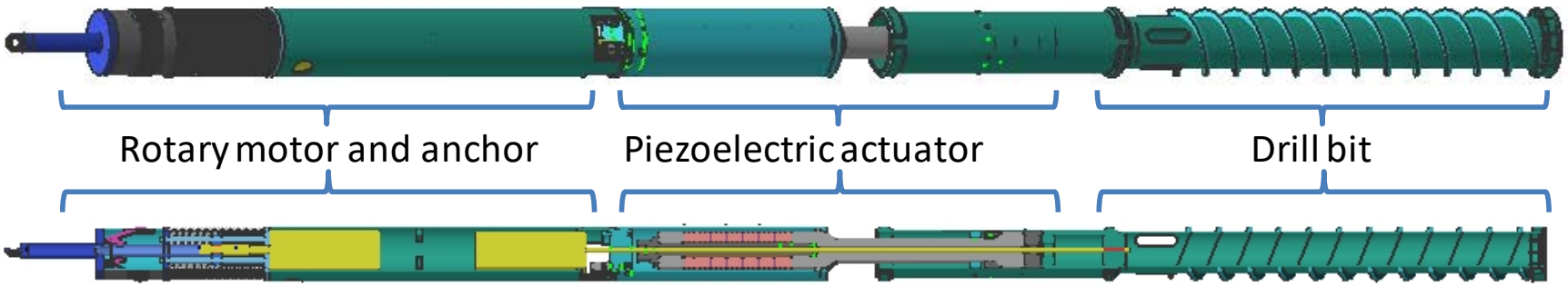
Video

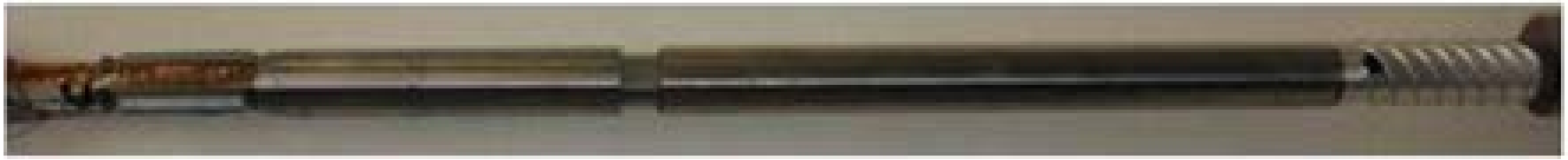


The Auto-Gopher components

The mechanism has been scaled to about 2-meter long tube with 3 main components:

- Drill bit
- Piezoelectric actuator
- Rotary motor and anchor

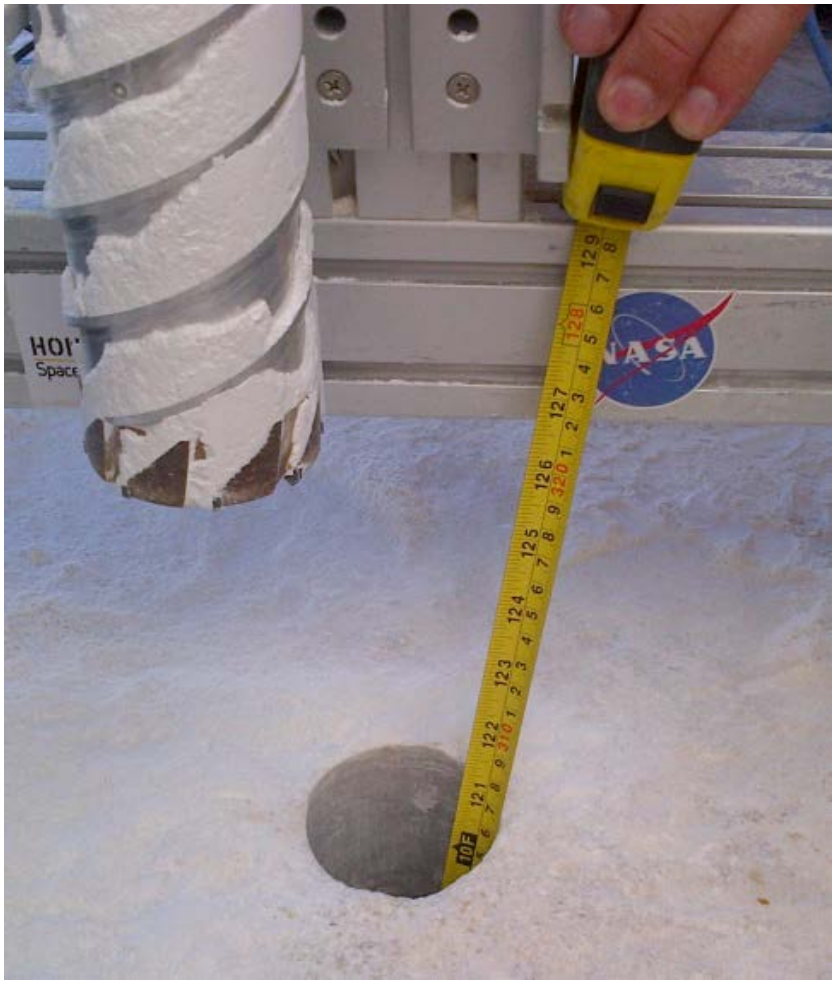




Field test

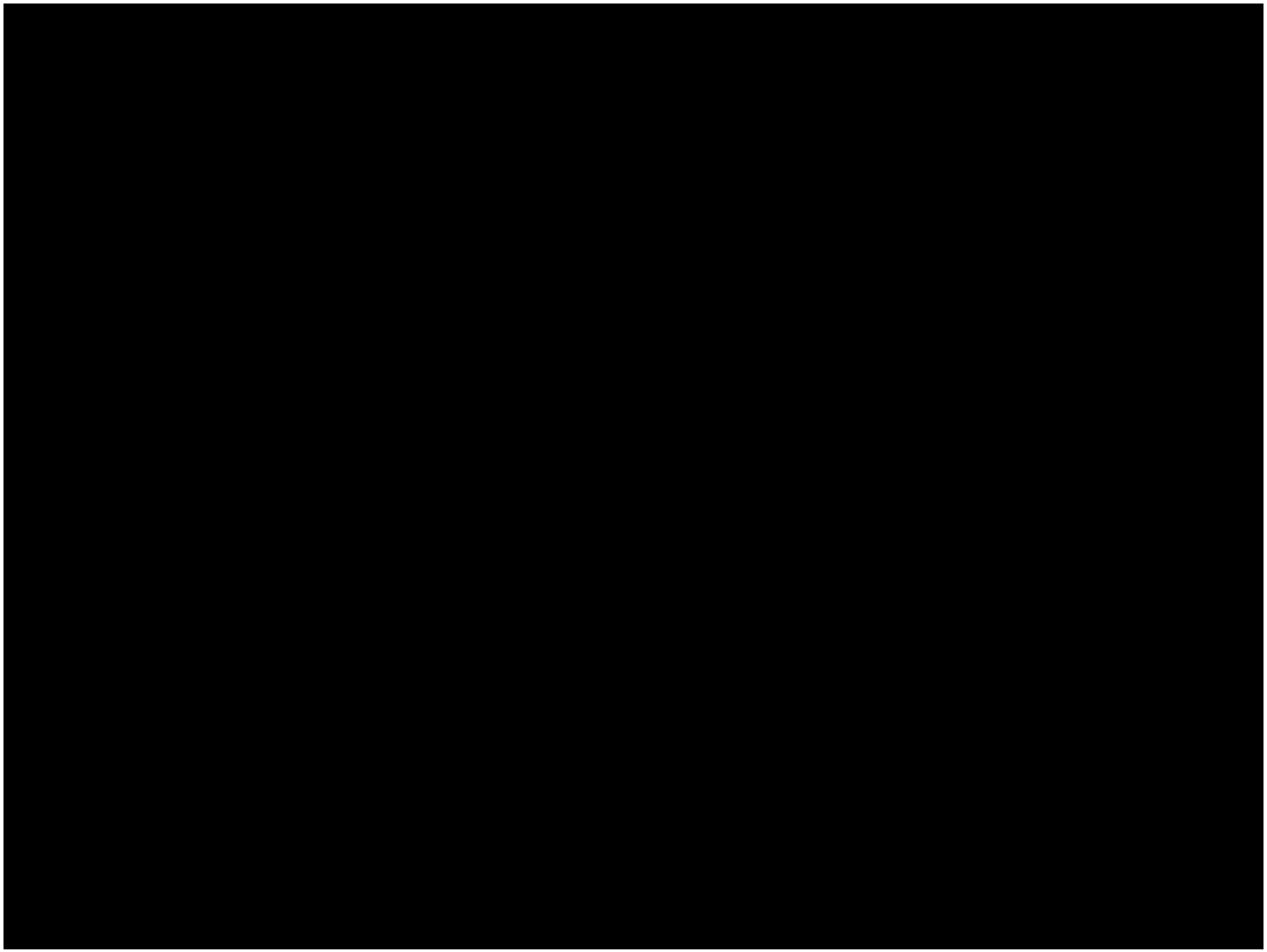
- Location – a gypsum quarry of the US Gypsum Company outside Borrego Springs, California
- Field test team included engineers and scientists from Jet Propulsion Laboratory, Honeybee Robotics, and University of Southern California

Field test



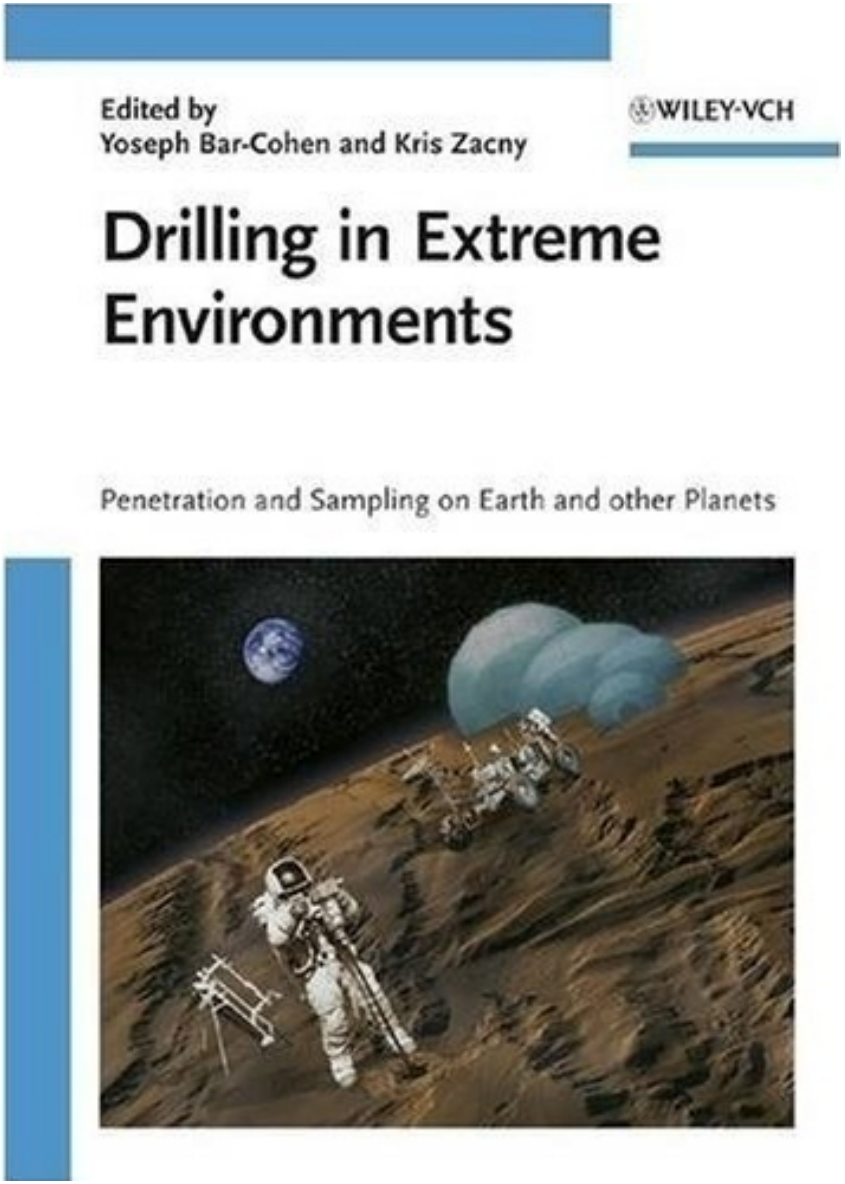
32 cores were extracted from a depth of 3.07 meter

Video



Summary

- Inspired by the gopher, a wireline drill called Auto-Gopher was developed and demonstrated in the field.
- The main feature of the Auto-Gopher is its wireline operation where the drill is suspended on a tether and the motors and mechanisms are built into a tube that ends with a coring bit.
  - The tether provides the mechanical connection to a rover/lander on the surface as well as power and data communication.
  - Upon penetrating a target depth, the drill is retracted from the borehole, the core is removed, and the drill is lowered back into the hole.
- The heart of these drills is a vibratory mechanism driven at ultrasonic frequency and its main attribute includes low axial preload required to drill various materials.
- The results of the studies indicate that the Auto-Gopher can operate as an effective sampling tool for reaching great depths (many hundreds of meters).
- The developed drill has significant potential to future NASA in-situ exploration missions that are addressing the important questions of whether life once existed or exists elsewhere in the solar system.



http://ndeaa.jpl.nasa.gov/nasa-nde/yosi/yosi-books.htm

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