Biomorphic Explorers for Closeup Imaging and Acid-Scratch Tests

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Biomorphic explorers could be used on Mars to acquire close-up images and to perform acid tests for carbonates, supplementing the science from a larger rover or lander. The imaging and acid tests would help constrain the mineralogy and the processes of formation and alteration of the martian soil and rocks. Explorers could provide imaging of features not accessible from the cameras on a larger rover or lander. At the Pathfinder site, most rock surfaces within 12 m of the lander were viewable by the rover and lander cameras, but hand lens magnification was unavailable. A magnified view might have helped us resolve mineral grain boundaries, higher-resolution rock textures, and the grain size distribution of the soil. Other landing sites could have areas of limited rover trafficability due to steep slopes, high rock abundance, or particular distributions of rocks. Explorers could be sent out to take a closer look at tantalizing but unreachable materials.

At a minimum, the explorers could be outfitted with a camera to provide imaging similar to a geologist using a 10x hand lens. This would assist mineral identification from features such as crystal size and shape, color or albedo, cleavage, fracture, and parting. The capability to also provide higher (microscope) or lower (hand-sample and outcrop scale) magnification would be an added bonus. Stereo or color imaging would not be required, but highly desirable. Some explorers might also be equipped with a flash lamp or lamp of some kind to allow imaging in cracks, pits, and crevices with low light levels. Some explorers might carry a brush or other cleaning tools to sweep away dust before imaging.

For the acid test, an explorer would have to carry an expendable amount (a few drops) of hydrochloric acid and have the ability to scratch a rock (perhaps one of its legs could have a sharp industrial diamond tip). On Earth, this is a standard test used by field geologists, in which a drop of acid does nothing on most minerals, effervesces on calcite, and only effervesces on dolomite after it has been scratched to generate dolomite powder. Tests would have to be run under Mars conditions to find out whether this type of test works under a range of ambient Mars conditions, whether it requires the acid or sample to be heated, how soon the imaging would have to follow to look for fizzing, whether an acoustic sensor would work better than imaging for detecting the fizz, and what level of acid dilution works best. The scratching might not be necessary if calcite and dolomite fizz at different acid temperatures. Explorers capable of making acid tests might only be sensible for a landing site where carbonates are expected and are an important part of the science goals.

It would be helpful if the explorer could be commanded to take close-up images or perform an acid test of a particular spot or area, selected in wide-angle images. There could be a particular mineral in a rock or portion of a rock that scientists would like to look at more closely or test with acid. At a minimum, whatever the explorer investigates should be put in a larger context so we can discern whether it was investigating a typical rock, unusual rock, boundary between soil types, rock fragment in the soil, particular mineral grain, mixture of minerals, vein minerals filling a crack in a rock, etc. This could be done by imaging the explorer from a camera on a lander or rover, when the explorer is taking its measurements and when the explorer has moved away. Alternatively, the explorer itself could be outfitted with a wide field of view camera and provide its own context. Measurements of the same patch of soil or rock (or same type of material) using different science instruments would significantly improve the science return.

Joy Crisp August 19, 1998

Biomorphic Explorers for Closeup Imaging and Acid-Scratch Tets

Science on extremely small explorers:
Basic field geology

Supplement lander/rover science

Constrain mineralogy and
processes of formation and alteration
of the martian soil and rocks.

Operations

DESIRED MODE OF OPERATION:
Command explorer to take close-up images or perform an acid test of a particular spot or area, chosen by scientists from wide-angle images.

☞ Whatever the explorer investigates should be put in a larger context!
Typical rock, unusual rock, boundary between soil types, rock fragment in the soil, particular mineral grain, mixture of minerals, vein minerals filling a crack in a rock?, etc.

- Image explorer from a lander or rover camera, when the explorer is taking measurements and when explorer is out of the way
- Or put wide field-of-view camera on explorer

Measurements of the same patch of soil or rock (or same type of material) using different science instruments will significantly improve the science return.

The Acid Test

Only sensible for a landing site where carbonates are expected and identification is an important science goal.

Standard Field Geology Test (10% HCl)

acid drop does nothing on most minerals,
effervesces on calcite,
only effervesces on dolomite after scratching.

Explorer Test

Carry a few drops in a dispenser
& capability of scratching rock

Acid test results would depend on temperature
landing site location, time of day, sun/shade

Testing to Define Experiment

Testing under landing-site operation conditions
Scratchingunnecessary?(usetemp.dependence?)
Heat acid or sample? Monitor temperature?
Image afterwards: how soon?
Acoustic sensor better than imaging?
Level of acid dilution?

Added-Science-Bonus Explorer Options:

- Higher magnification (microscope)
- Lower magnification
  (hand-sample and outcrop scale)
- Stereo
- Color
- Light source (flash lamp?)
  for imaging in cracks, pits, and crevices
- Brush or other cleaning tools

Estimates of Mars grain sizes

	Grains (μm)	Clods & Rock Frags. (cm)
Dust, drift	0.1-10	n/a
Soillike material	0.1-1000	0.1-4
Rocks, bedrock	0.1-10,000	0.1-500
Sand dunes	100-250	n/a
Sand sheets	250-1000	n/a

Data from H. Moore, 1991, USGS Open File Report 91-568

Example Camera Capabilities

Field of View	Resolution (μm)	Science
25 cm × 25 cm	250	basalt: large crystals, vesicles
2.5 cm × 2.5 cm	25	improved basalt and sand viewing
0.25 cm × 0.25 cm	2.5	resolve small basalt crystals and sand
250 μm × 250 μm	0.25	resolve some dust/soil grains, basalt microlites
25 μm × 25 μm	0.025	needed to resolve some dust/soil grains

Pathfinder had no hand-lens

0.7 - 1 mm / pixel at best

Magnification might have resolved:

mineral grain boundaries
rock textures
grain size distribution of the soil
mineral features

10x hand lens could help with mineral ID:

crystal size, shape, color, albedo,
cleavage, fracture, parting

Explorers could **take a closer look** at tantalizing but unreachable materials (behind rocks, ridges, etc.)

Most rock surfaces within 12 m of Pathfinder lander were viewable by rover and lander.

Rover mobility did provide some surprises: Squash, behind Bookshelf, Chimp lineations

Other landing sites could have areas of limited rover trafficability due to steep slopes, high rock abundance, or particular distributions of rocks.

Possibly **save time**

- faster route for explorer?
- multi-tasking (rover + explorer)?