Cliff Reconnaissance Vehicule tests in the Dachstein ice cave

EMC12

München

Planète Mars

Mars cave exploration simulation

- The Österreich Weltraum Forum organized, from the 27 th of April to the 1st of May 2012, a Mars cave exploration simulation South of Salzburg in the ice cave of the Dachstein area
- The ice cave is located at a 1400 m altitude and hold permanent structures of ice all year long.
- Is an ice cave a possibility on Mars ?

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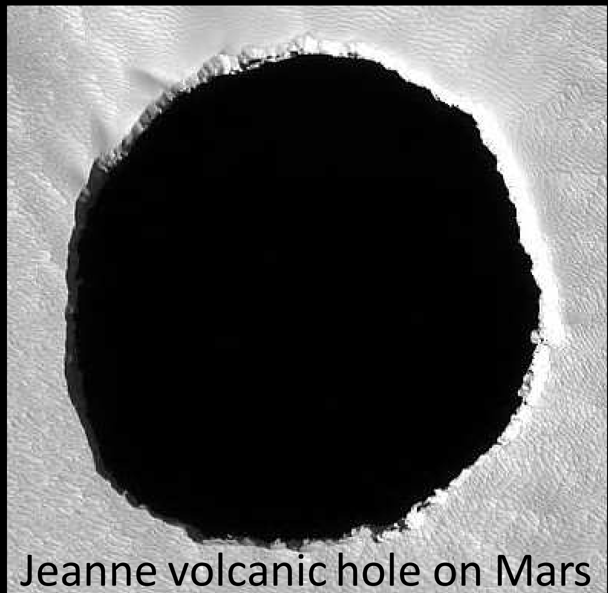
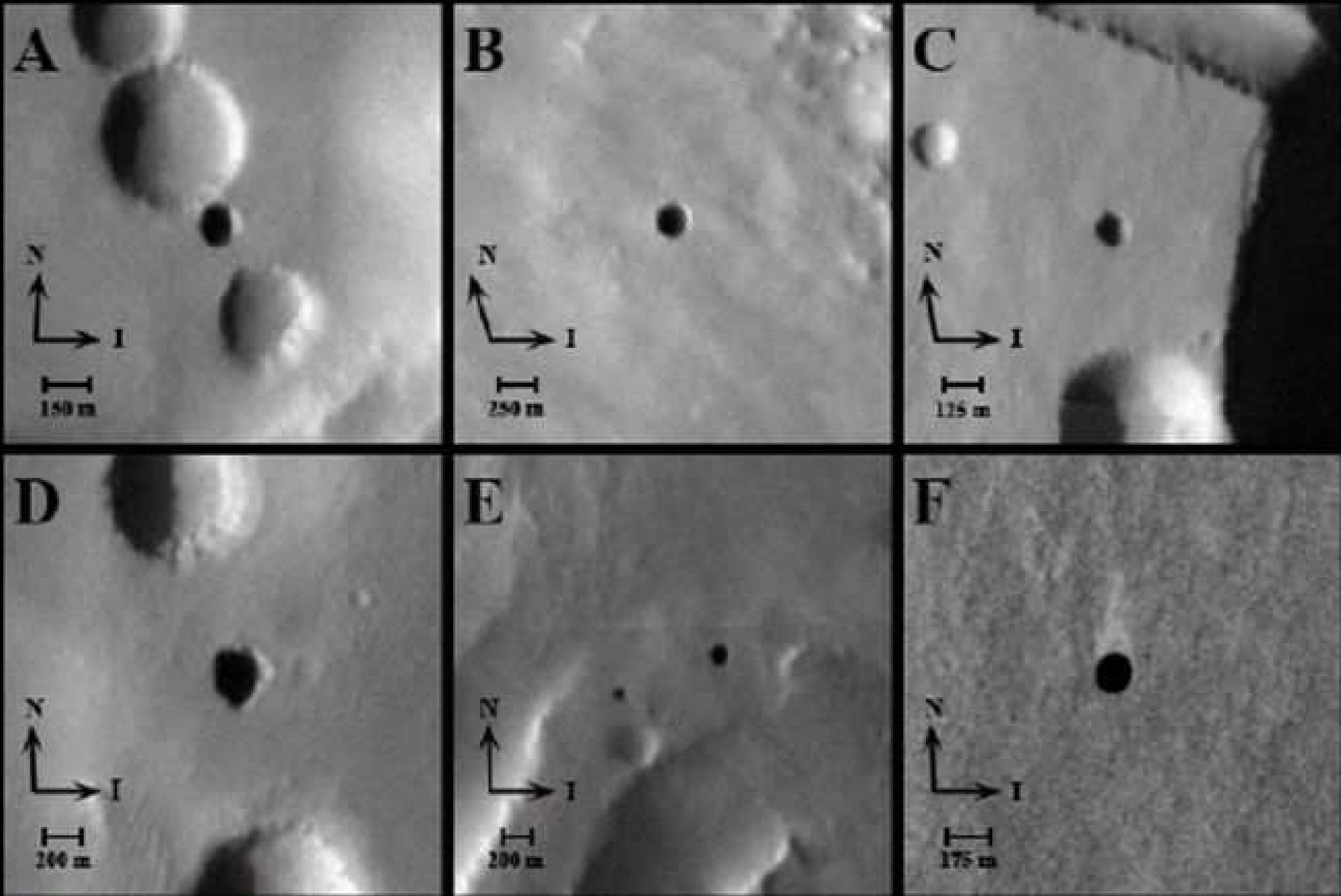
Dachstein ice cave

Doc. NASA/JPL-Caltech/University of Arizona



Jeanne volcanic hole on Mars

Holes observed on Mars



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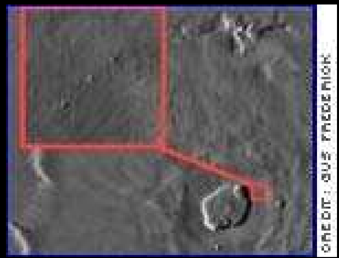
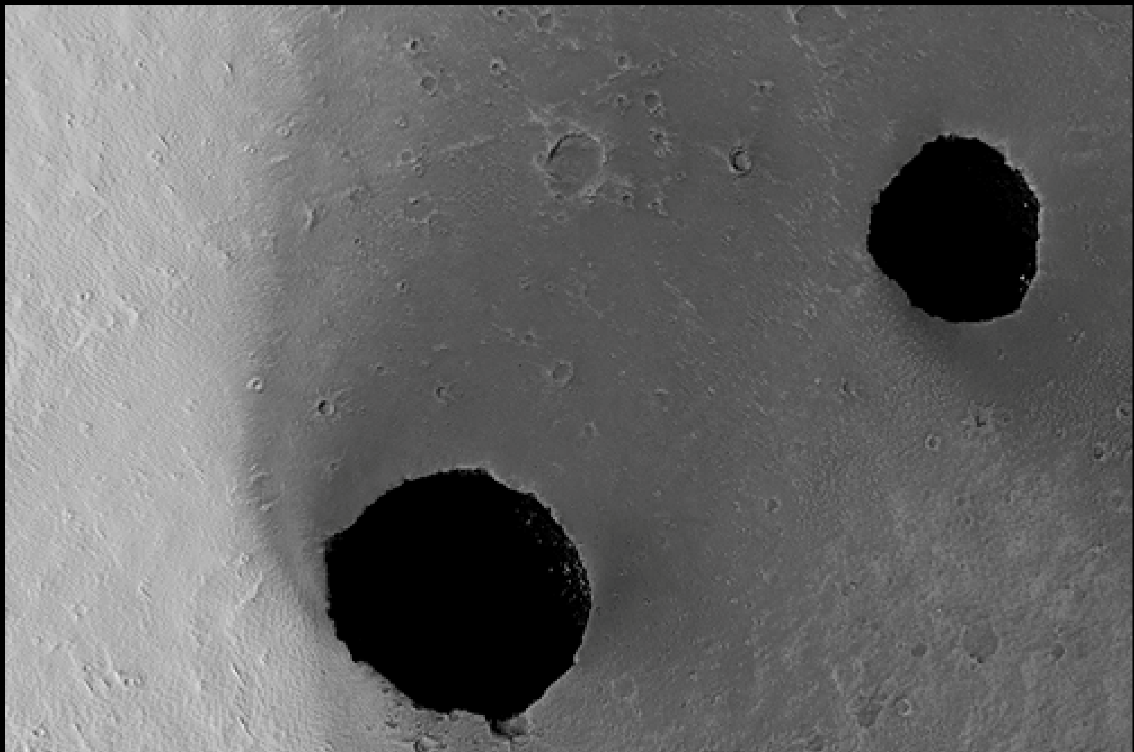
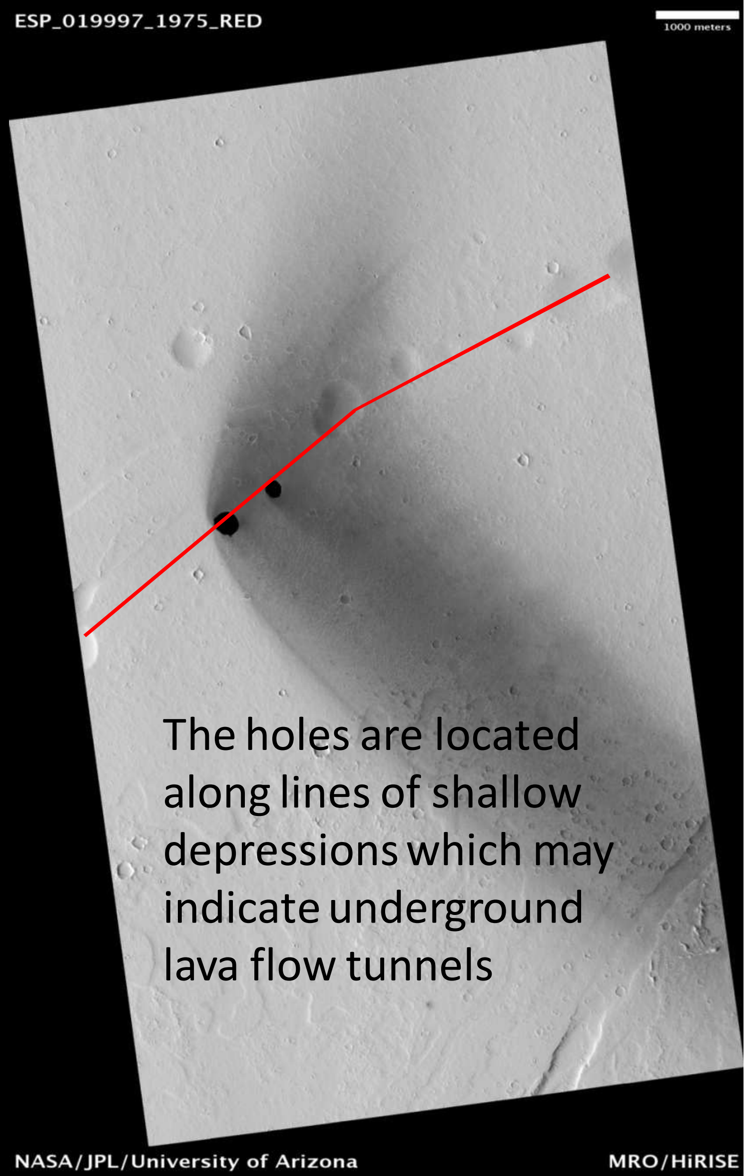
Holes observed on Mars



These holes are located on volcanic mountains sides



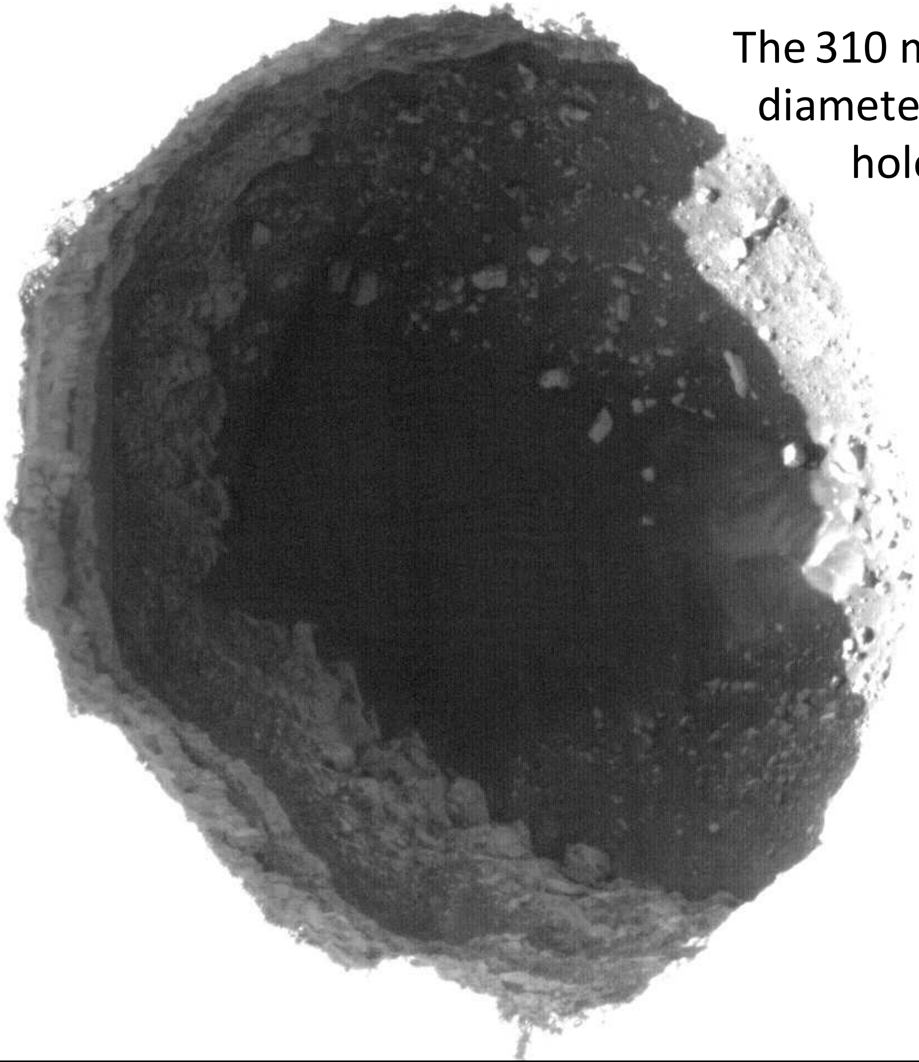


The holes are located along lines of shallow depressions which may indicate underground lava flow tunnels

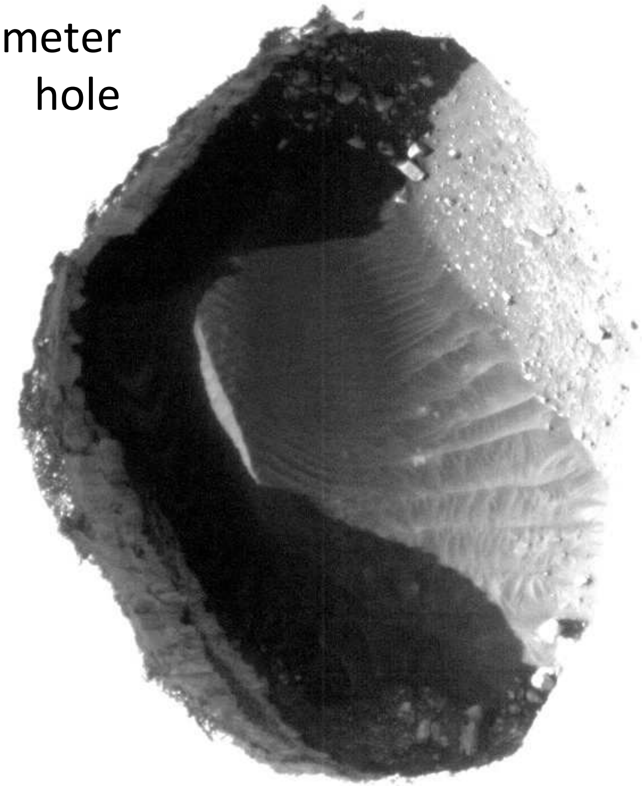
Holes observed on Mars

Looking down the holes

The 310 m diameter hole

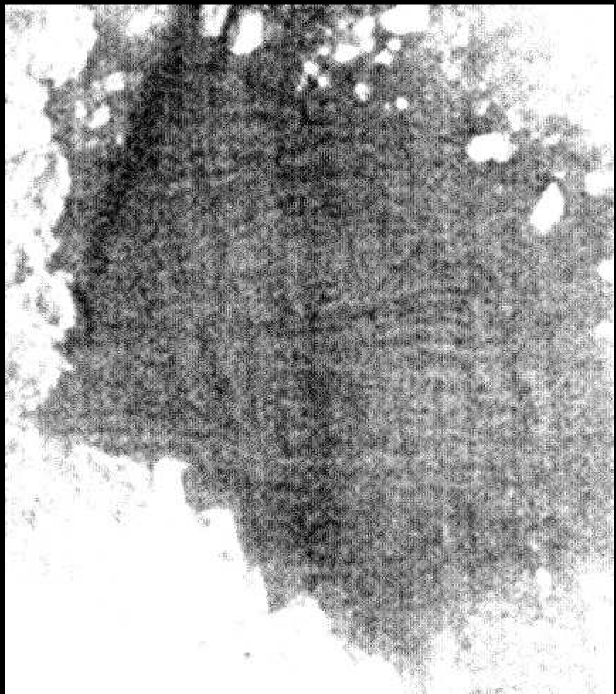


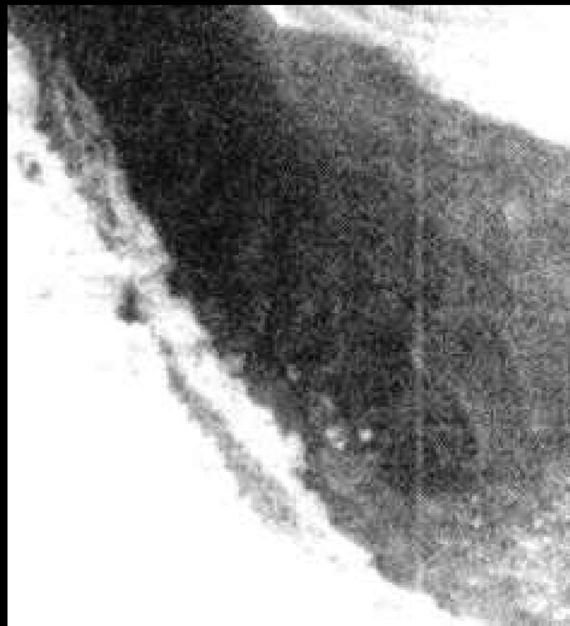
The 180 m diameter hole

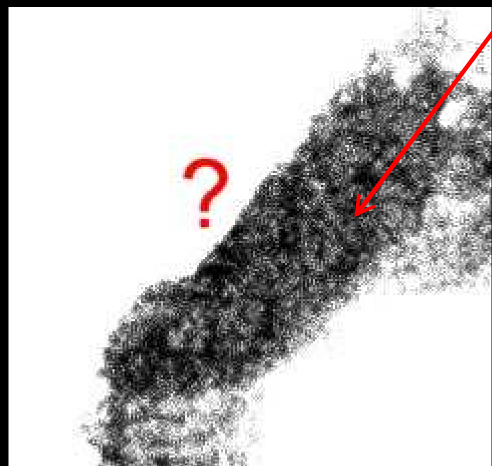


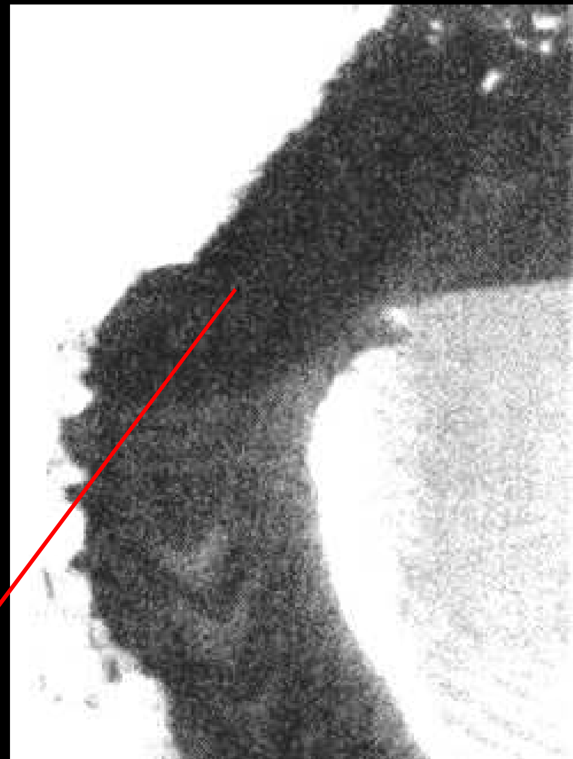
Doc. NASA/JPL-Caltech/University of Arizona – APM picture enhancement

Is there an entrance?



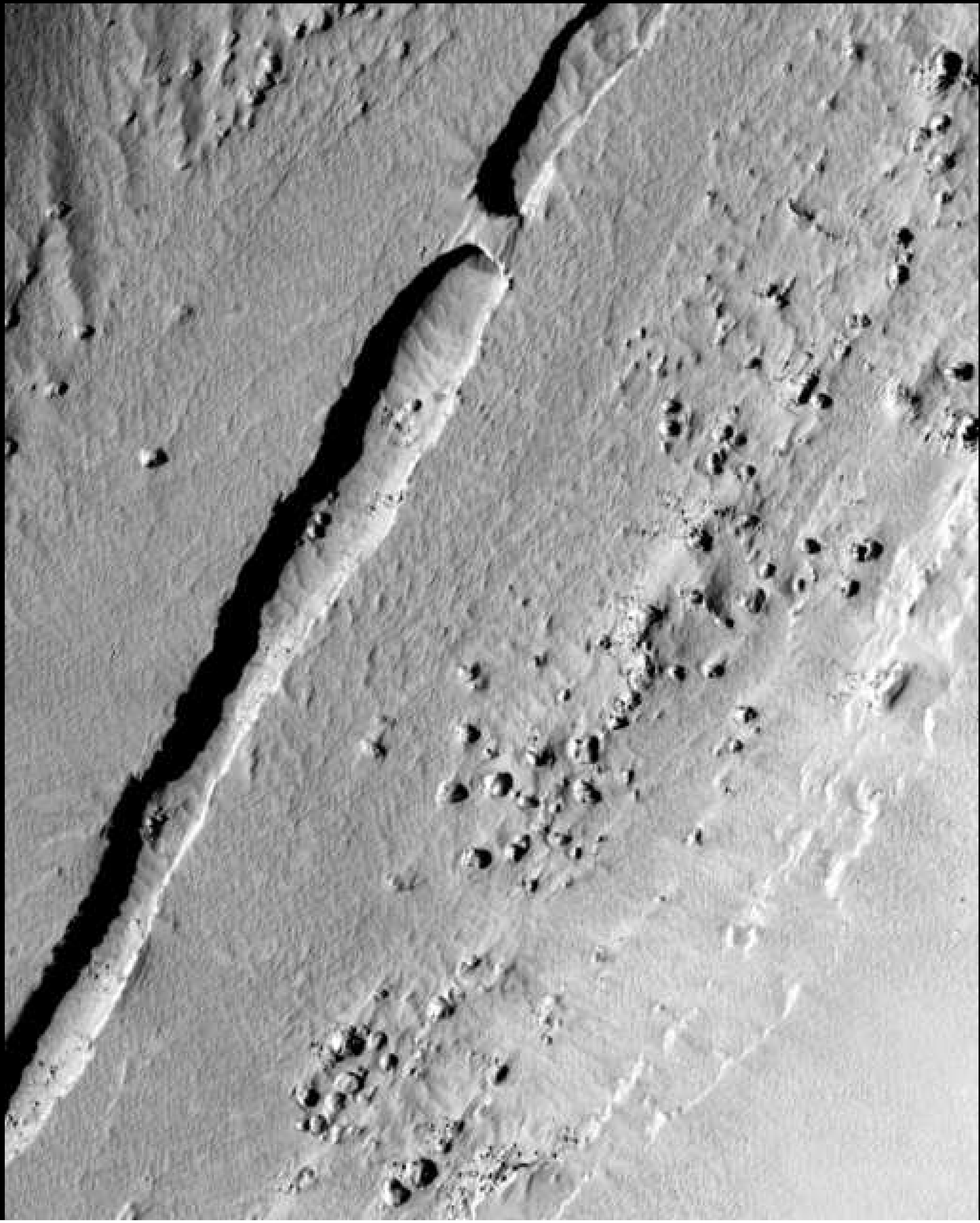


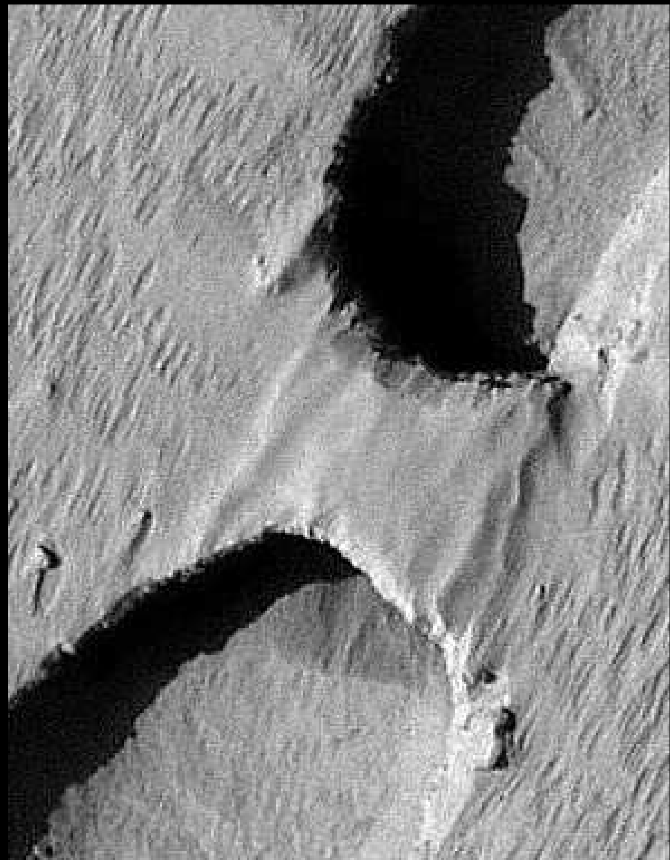




Doc. NASA/JPL-Caltech/University of Arizona
– APM picture enhancement

Lava tubes on Mars





Example of a bridge remaining on an old lava tube

Doc. NASA/JPL-Caltech/University of Arizona

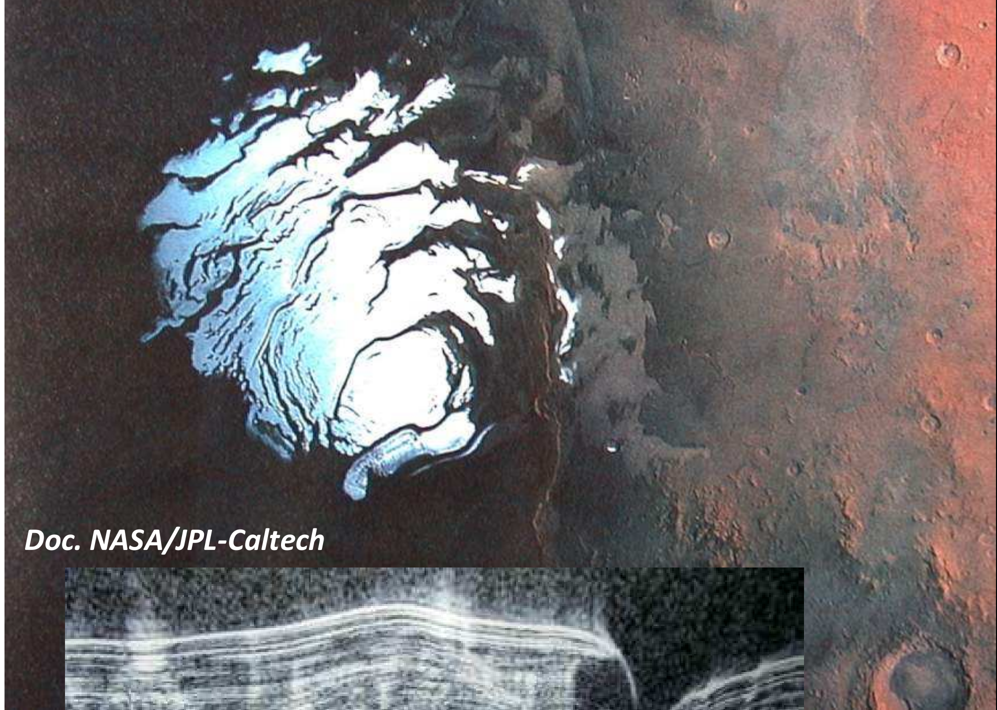
Lava tubes on Earth

Canary islands
(Doc. J. Souchier)

Ice on Mars

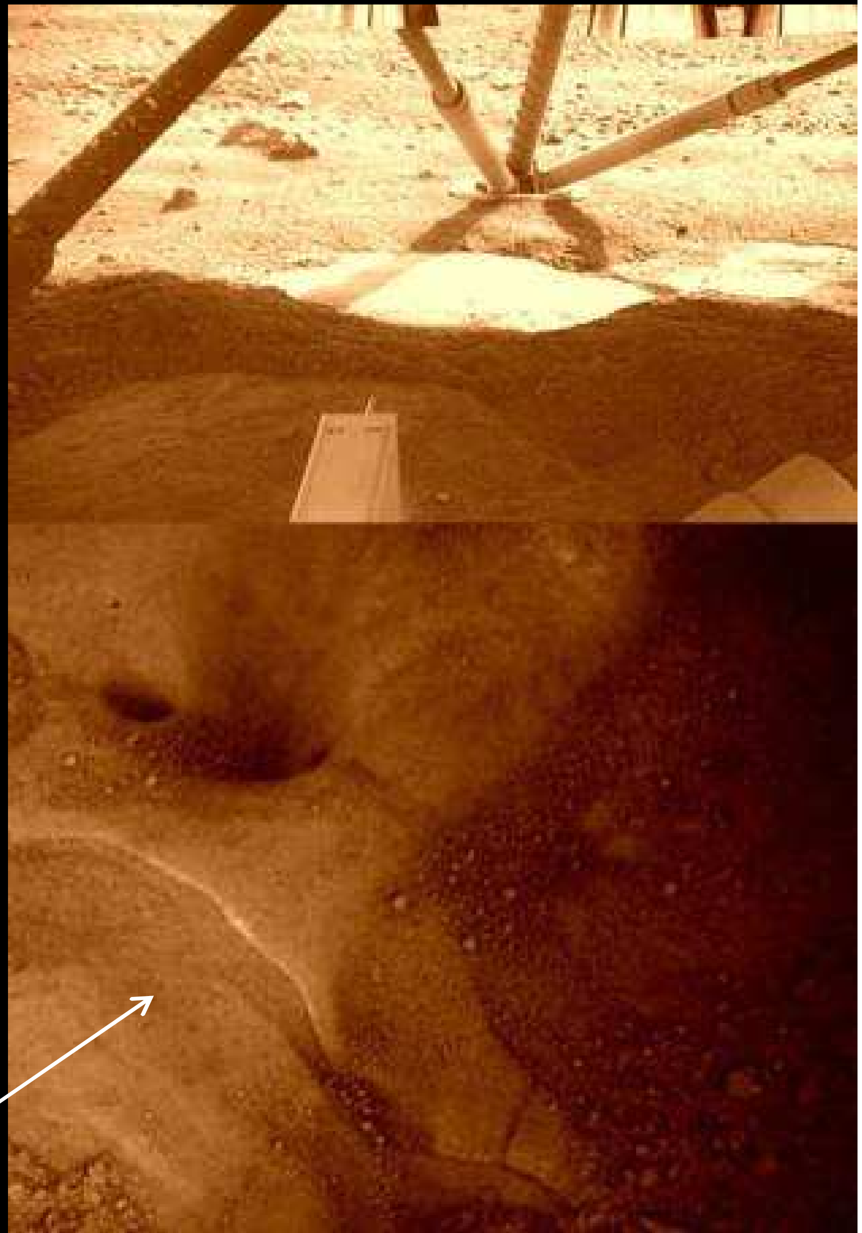
Doc. NASA/JPL-Caltech/University of Arizona/Max Planck Institute

In the polar caps naturally but also ice underground in the high lattitudes



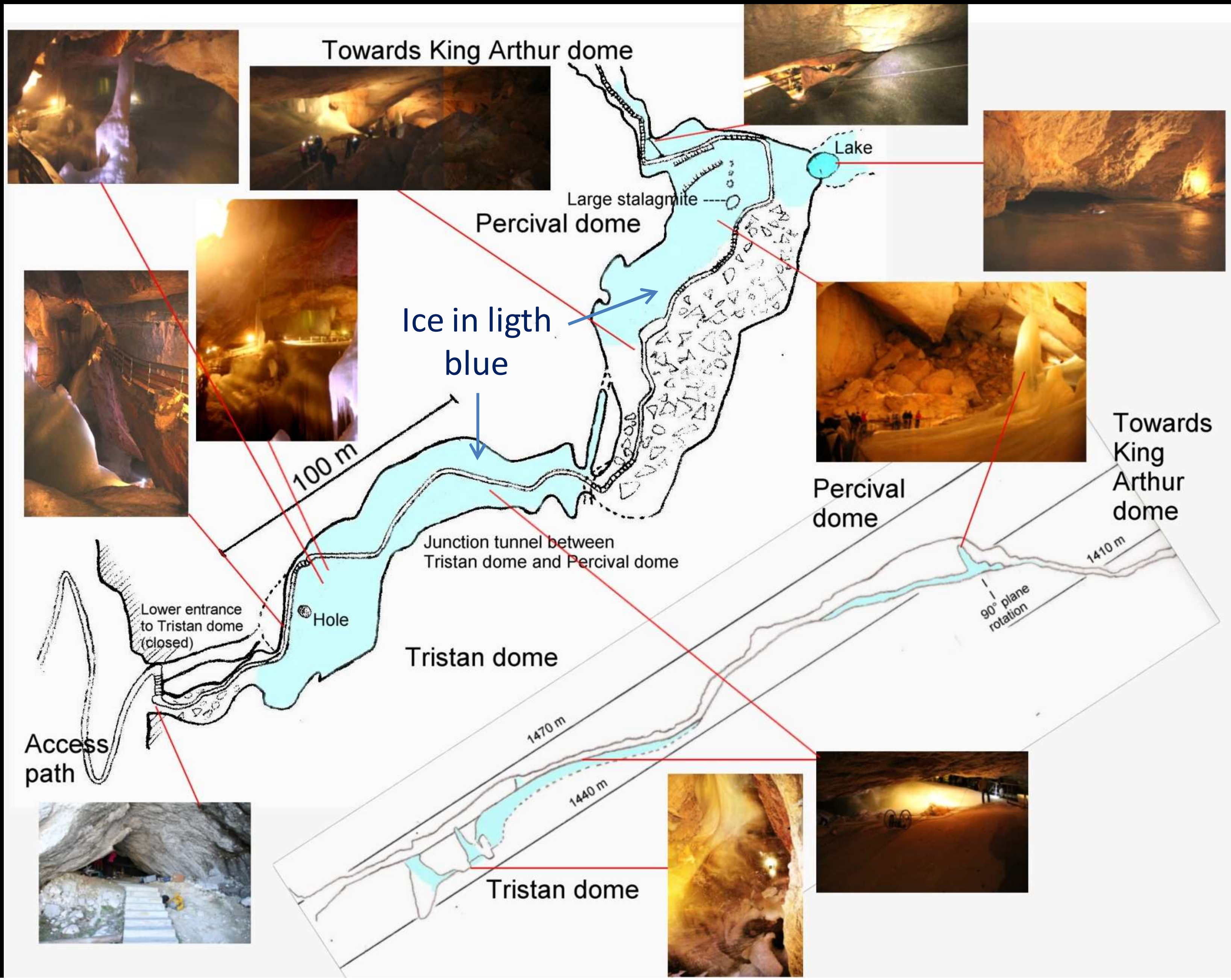
Doc. NASA/JPL-Caltech

Doc. NASA/JPL-Caltech /ASI-UT



Ice in the ground under the Phoenix lander. The covering dust has been blown off by the retrorockets.

Dachstein ice cave configuration



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Dachstein cave and ÖWF operations room

ÖWF operations room

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The Planète Mars association Cliff Reconnaissance Vehicle (CRV or « Cliffbot »)

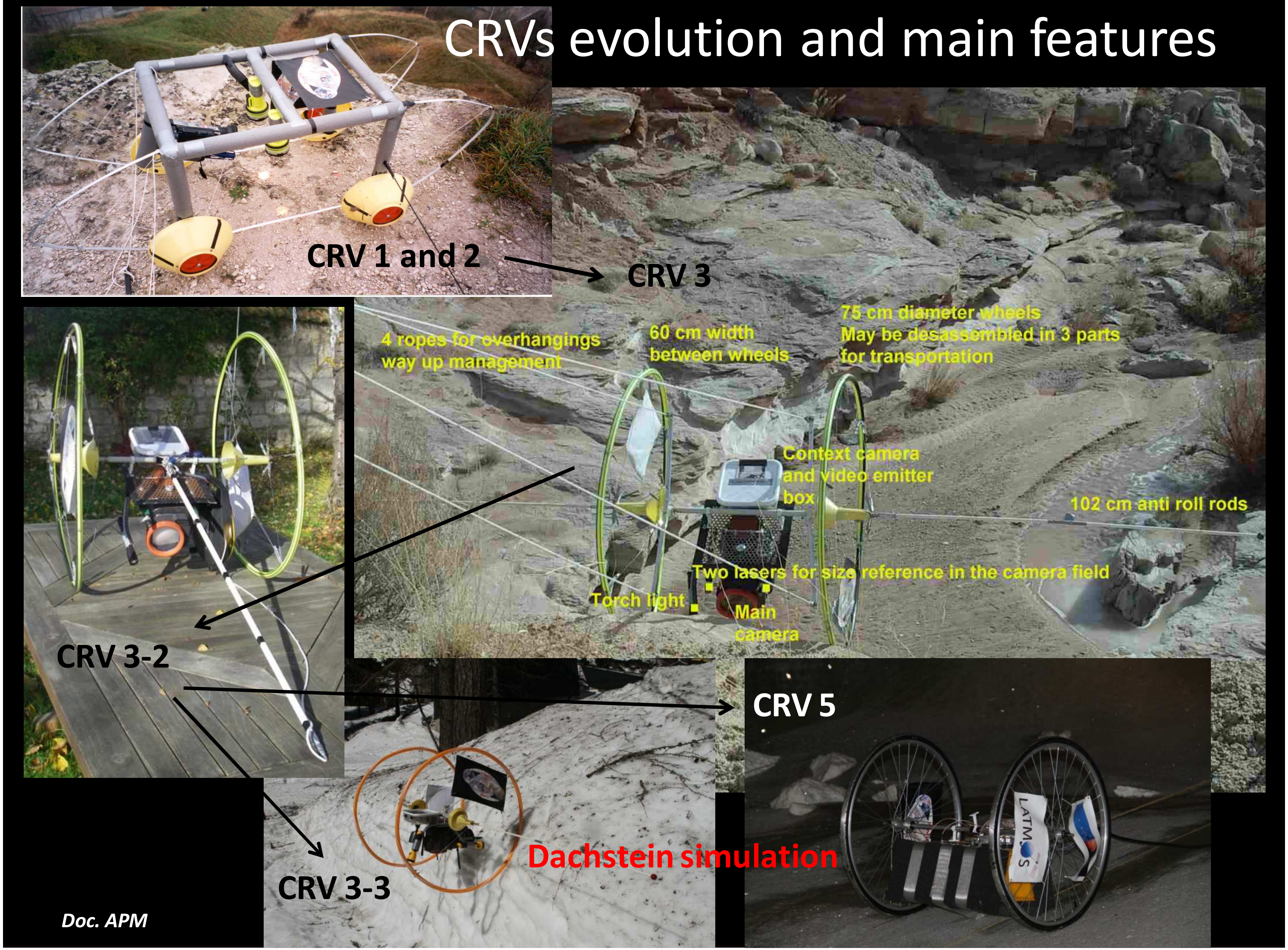
- Objectives: Cliffs and steep slopes tell a planet history on hundreds of million years. Exploring a cliff is a substitute to drilling. Sending a vehicle is safer than sending a man (or prepares a manned exploration).

- The CRV aims at defining best configuration for all terrain mobility on cliffs ans slopes. It is manually operated.

- Payload has been mainly a camera but the Dachstein simulation demonstrated for the first time a ground sounding radar operation (by LATMOS laboratory)

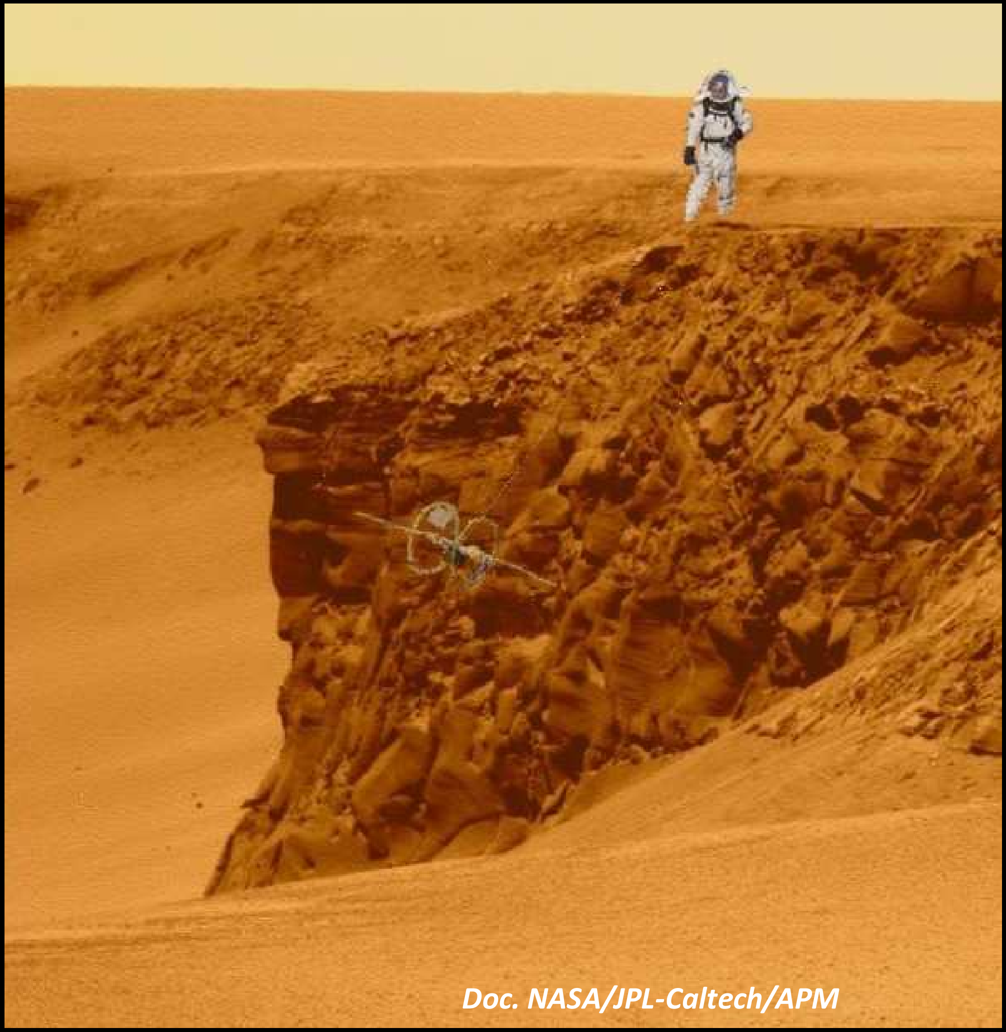
Doc. NASA – Pat Rawlings

CRVs evolution and main features



A picture of a future Cliffbot exploring a steep slope was presented in the 25th of september 2012 Mars Program Planning Group Report

Doc. NASA



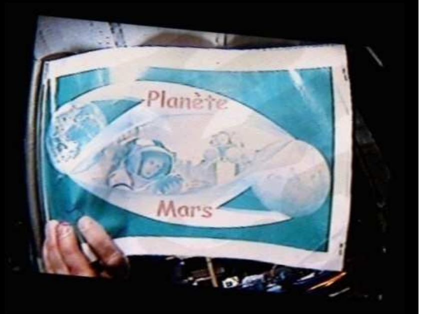
Doc. NASA/JPL-Caltech/APM

But we have already been there !

No, this is a picture taken during MDRS 43 simulation at the Mars Society MDRS in Utah pasted on a Mars Opportunity image

Details of CRV 3-3 configuration

Reception box



New color monitor

Vehicule rear with main camera container window, two lasers and two flashligths

Vehicule front with main camera container cover, new color orientable hazcam (on the left) and flashligth (on the right) for the hazcam field of view

And new wheels, new batteries

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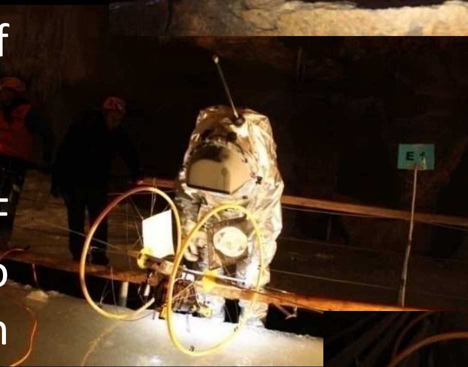
Dachstein CRV tests objectives

First objective:

Assess the usefulness of the CRV to explore non reachable areas by a man in space suit in a cave (typically a vertical hole or steep to medium ice slopes). It appeared during the campaign that Tristan dome was a good representation of vertical non accessible hole.



Second objective:

Operate the vehicle with the Aouda spacesuit (by an ÖWF operator) and find what are the difficulties linked to operations in a spacesuit. Aouda is more representative of an actual spacesuit than the ones used in Utah during previous CRV tests.

Third objective:

Operate the vehicle with the Aouda spacesuit gloves.

Fourth objective:

Document the difficulties encountered on various all terrain configuration by the vehicle on the way down or up.

Fifth objective:

Use the pictures sent by cliffboat on board hazcam to control the vehicle operations.

Sixth objective:

Acquire nice pictures of the vehicle in the spectacular ice cave environment.

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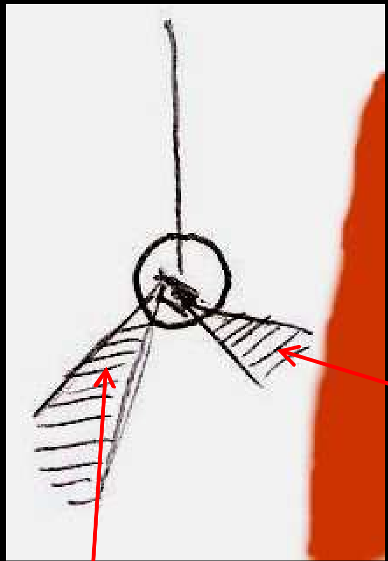
Tests conducted in Dachstein

Test	Date	Location	Duration	Length	Height	Objectives	Results
80	28/4	Snow slope close cable car station	10 mn	4 m	2 m	Experimental test on snow	1 spoke unscrewing; parts displaced on main axis
81	28/4	Percival dome upper part	/ multi test	10 m	2 m	Demonstration to media; 1st on ice	CRV slides laterally easily on ice; video verification OK
82	29/4	Tristan dome	55 mn	15 m	5 m	Operations with Aouda spacesuit	Final preparation conducted in space suit, video interrupted by ice; on board video OK
83	29/4	Tristan dome	10 mn	18 m	15 m	1st test in deep hole	Video transmission quickly out (battery); nice on board video; difficulty upwards, main axis bent
84	30/4	Percival dome lower part	10 mn	7 m	4 m	Test with Aouda gloves	Way down with gloves, knot with gloves
85	30/4	Percival dome upper part	10 mn	10 m	5 m	Long distance test on ice; photos	Sliding laterally rigth precludes long distance, anti roll rod bent
86	30/4	Percival dome	7 mn	4 m	1,5 m	Chaotic rocks	Way down needs initial speed
87	1/5	Tristan dome	30 mn	15 m	15 m	Test in deep hole in suspension. Terrain swapping	Video transmission OK, used for terrain swapping, nice on board video, hole mapping conducted
88	1/5	Between Tristan and Percival	50 mn	31 m	10 m	Use of video to pilot the CRV	Front view not enough for obstacles management; rod bent
89	1/5	Percival lake	10 mn	15 m	1 m	Photos; 1st test wheels in water	Nice photos

Main results

Ability to map a hole or bring informations on the hole features



The CRV has been designed to map a cliff or steep slope vertical slice with its main or « scientific » camera

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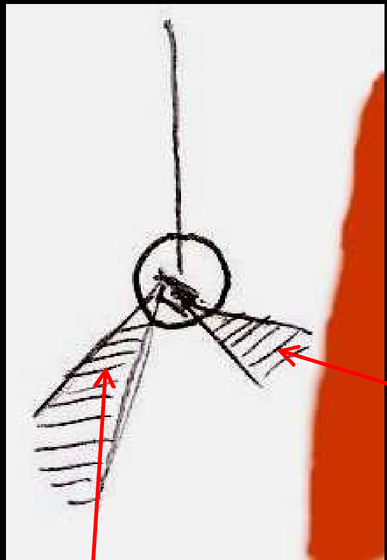

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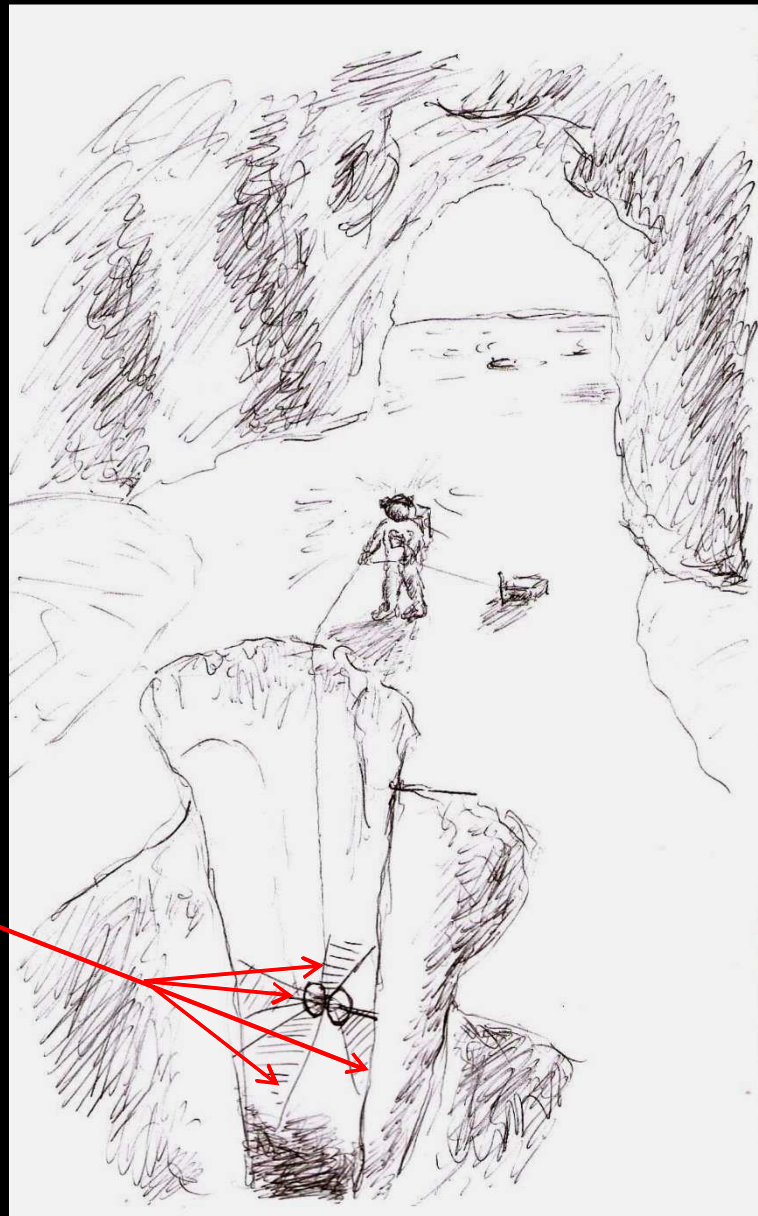
Scientific camera

Operation camera or « hazcam » - may be oriented any direction before test

Not to give the all around views needed to explore a hole



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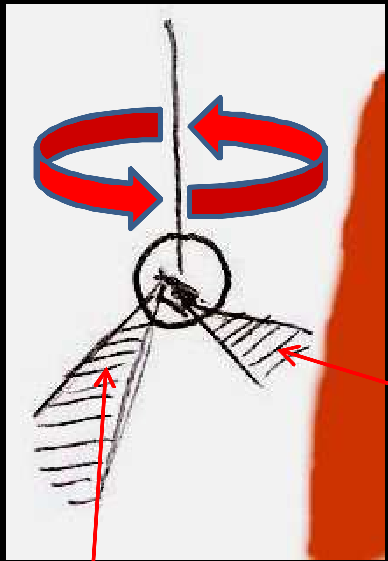

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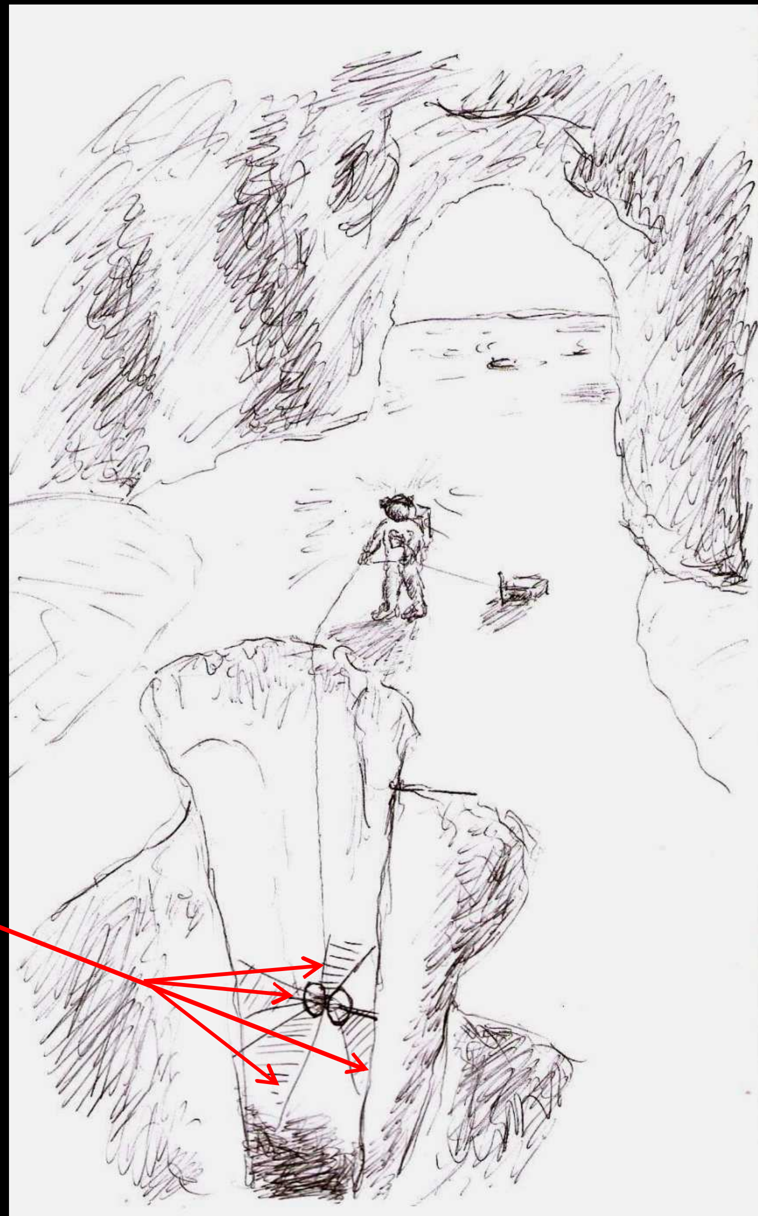
But beeing able to rotate the vehicle when in vertical suspension in Tristan dome hole allowed a swapping mapping of the hole



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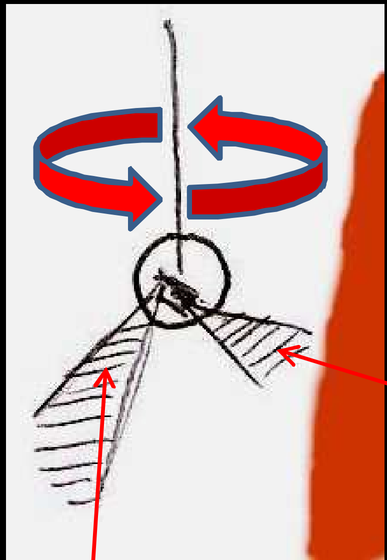

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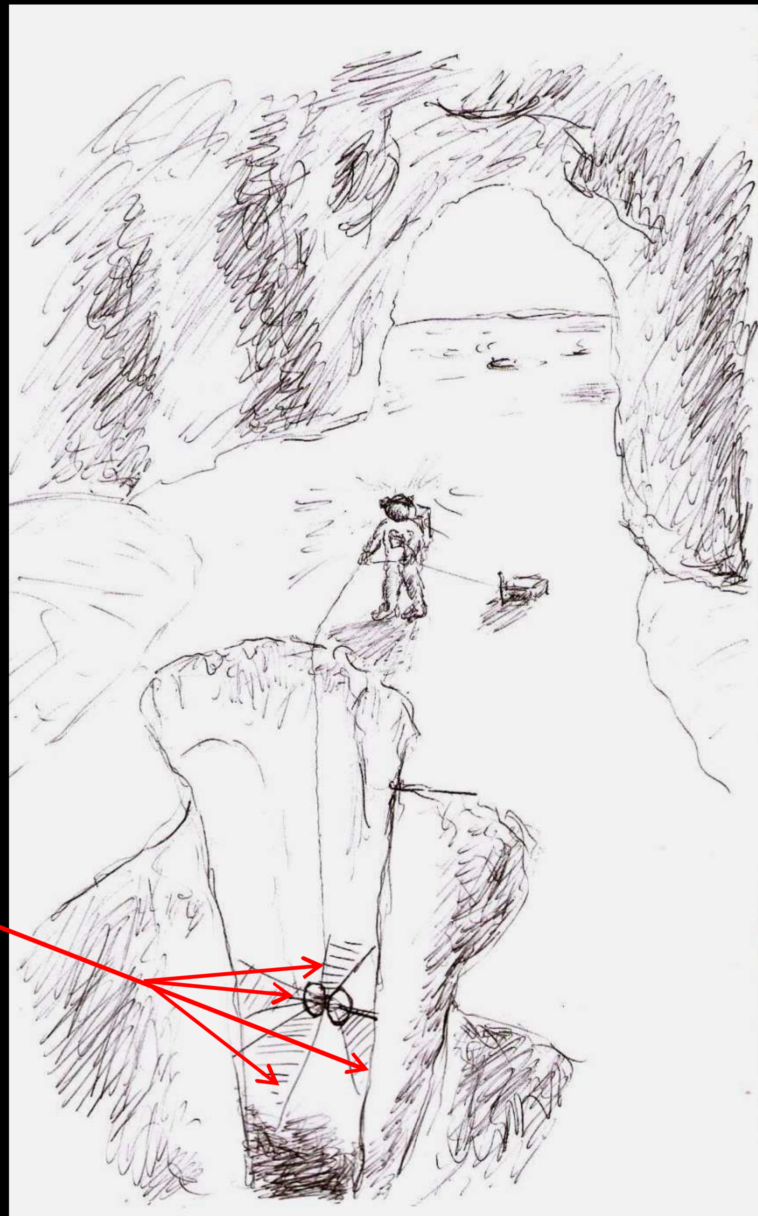

An operationnal vehicule needs more cameras

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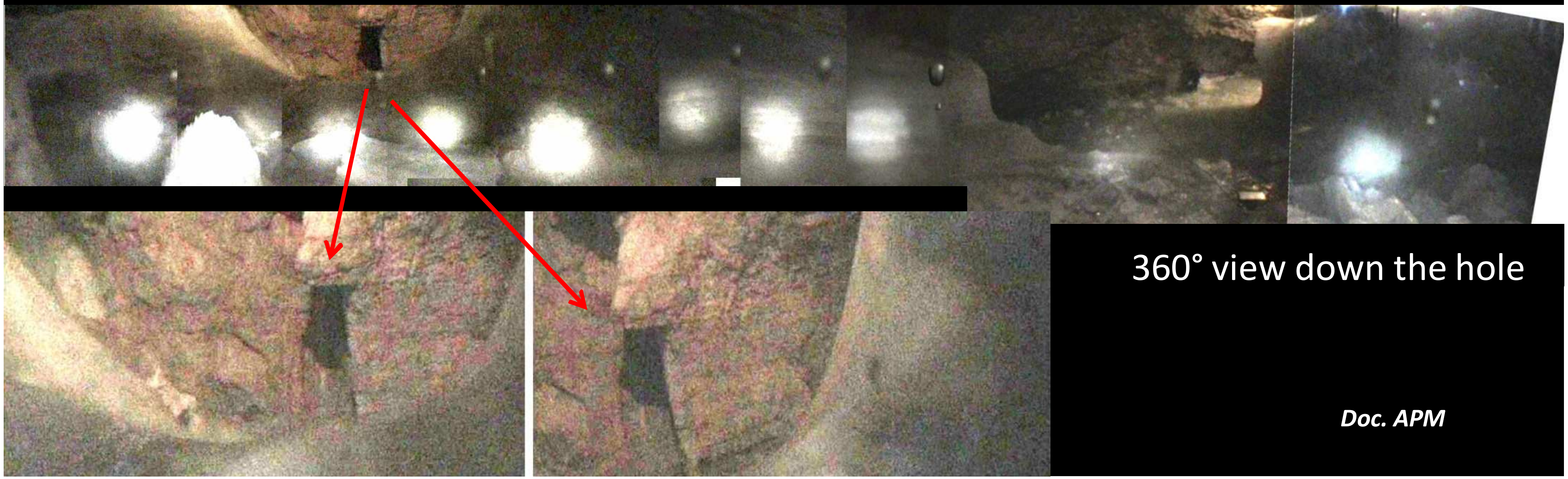
Main results

- Tristan hole mapping



360° view down the hole

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Main results

Some close up views in Tristan Dome

On board main camera

Main results

Operations with Aouda space suit and Aouda gloves

The vehicle, although not totally representative of an operationnal vehicule, could be operated by the operator in the Aouda Space suit

The rather simple push buttons for the flashligths were surprinsingly hard to operate

It stresses the usefulness of dexterity improvement devices as the rods tested in Utah during MDRS 43

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Main results

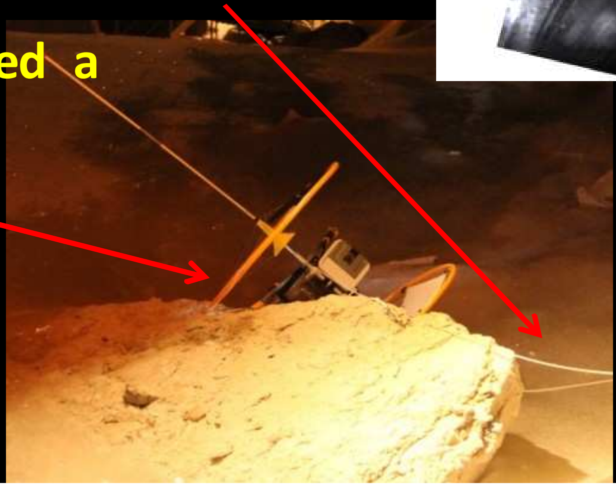
Documenting the difficulties encountered on various all terrain configuration by the vehicle on the way down or up.

The vehicle was able to go down and up providing that a reasonable amount of difficulty was foreseen on the track. Tracks with stalactites were avoided , being considered as too difficult (and breaking stalactites was prohibited !).
In one run (test 83) the CRV had difficulties to go back up because it sled laterally in a field of stalactites against a rocky wall. It came back with the main axis bent. This rises a question: **is it better to have a very stiff vehicle or a deformable one ?**

Stalactites trap in test 83 as seen by the vehicle

In test 88 the rigth **anti roll rod clearly avoided a vehicle tip over** (but was bent)

Some difficulties were linked to too shallow slopes (vehicule stopped by small obstacles)



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Main results

Using the pictures sent by the cliffboat on board hazcam to control the vehicle operations.

This was easily done in test 87 where the vehicle operated suspended. The rotation for terrain swapping was easily controlled from the piscture sent by the on board camera, as well as lateral dispacement

The motion control through the on board camera was test 88 main objectives. However signal was lost quickly (absorption by ice or vehicle batteries too low)

Initial view of the test 88 slope

One of the last views showing the rock behind which the vehicle will be blocked steeply inclined and on an horizontal surface. But understanding the situation would have needed a rear view.

More cameras are needed to assess the vehicle situation by the operator and at minimum a front and rear view

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Main results

- ***Acquiring nice exploration pictures***

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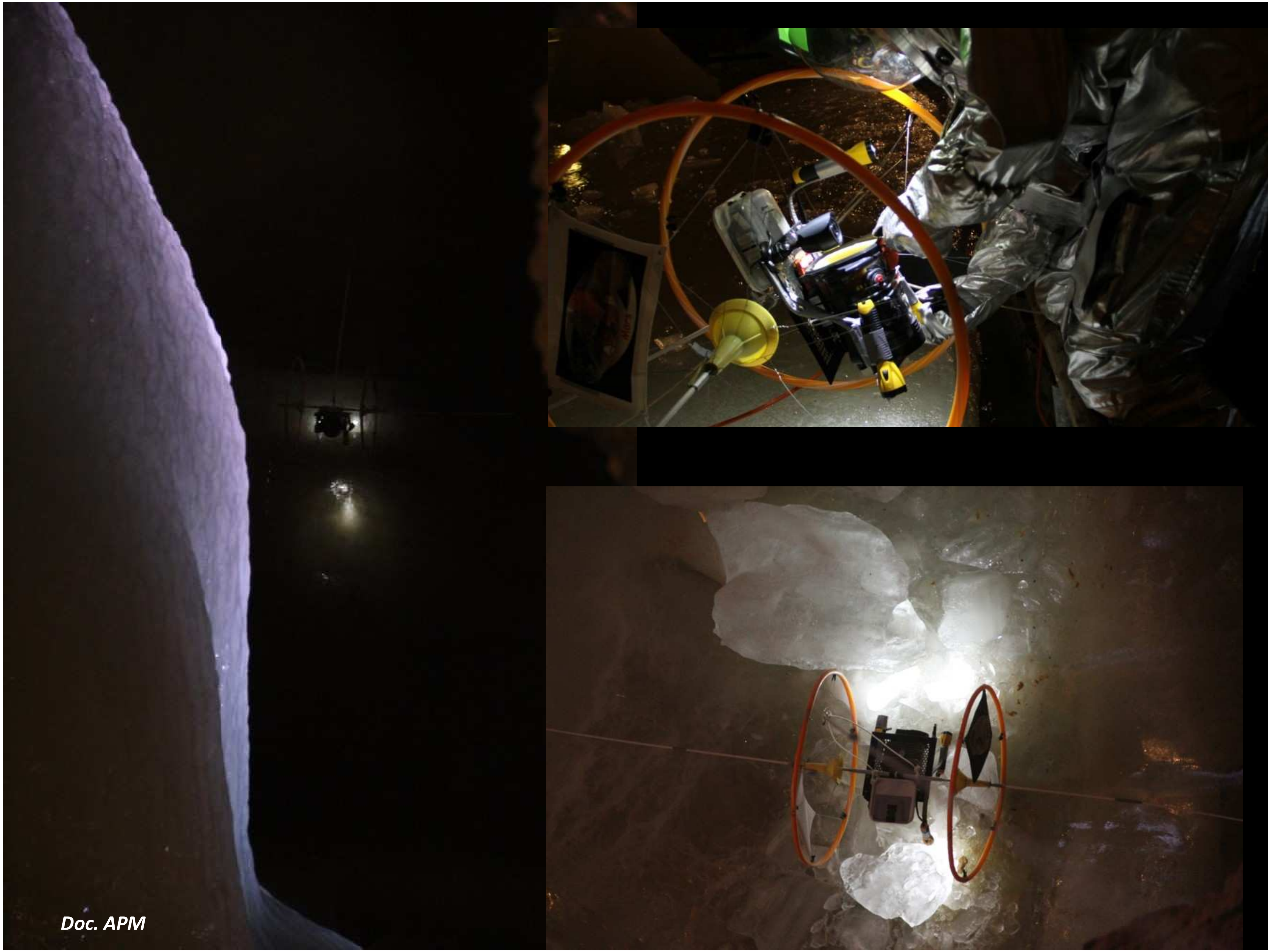
Doc. ÖWF/APM/J. Neuner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The full report on CRV tests in Dachstein ice caves is available on:

http://www.planete-mars.com/rapport-sur-l%E2%80%99experimentation-du-vehicule-de-reconnaissance-de-paroi-lors-de-la-campagne-de-simulation-de-dachstein/

Or on:

http://www.marssociety-europa.eu/dachstein-simulation/

Many thanks to ÖWF

Doc. ÖWF/APM/J. Neuner