Cliff Reconnaissance Vehicle « Cliffbot » tests during the ÖWF Mars2013 simulation

Vienna 25-26/05/2013

Objectives

- **The CRV or “cliffbot” is intended to send cameras and/or scientific instruments downhill on slopes and cliffs which are not safely accessible by astronauts**

From this picture originated the cliffbot idea in 2001

Objectives for Mars2013

- 1 - Demonstrate the vehicle mobility capabilities on different types of slopes or “terrain trafficability demonstration”. For Mars2013 higher cliffs than previously tested were also the objective.
- 2 - Assess the operating difficulties when operating in a spacesuit
- 3 - Assess and see how to improve the vehicle situation awareness.
- 4 - Evaluate geological interpretation and discoveries capabilities.

A little cliffbot history

- 2001: CRV 1 first tests
- 2002: CRV 1 first tests in simulation at MDRS in Utah
- 2002: CRV 2 tests at MDRS
- 2003: CRV 3-1 first tests
- 2004,5,6: CRV 3-1/3-2 tested by 5 crews in MDRS simulations
- 2009: CRV 3-2 tested at MDRS and in Iceland
- 2012: CRV 3-3 tested in Dachstein ice cave
- 2013: CRV 3-4 tested in Morocco

CRV 1

CRV 2

CRV 3

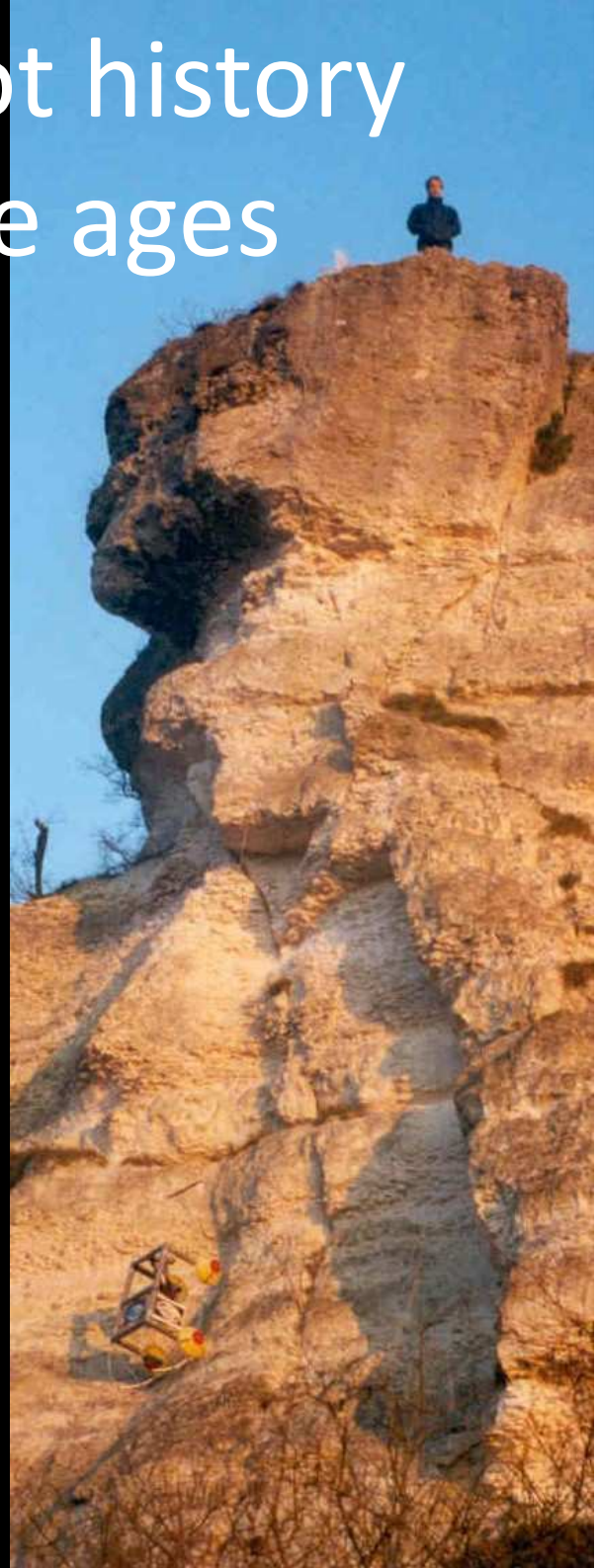
A short cliffbot history through the ages

04-11-2001

CRV1a test 1

02-12-2001

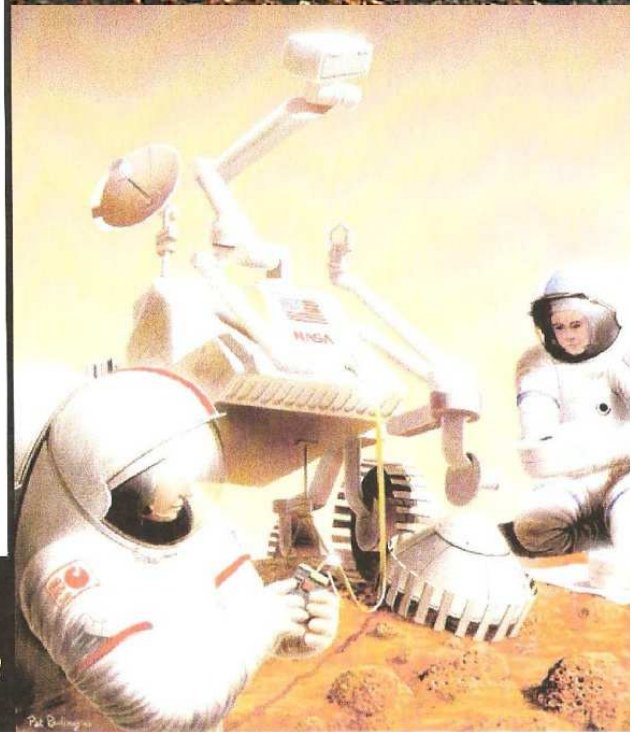
CRV1b test 2



A short cliffbot history through the ages

31 12 2001 CRV1b test 6 - 1st overhang test and 1st fall !

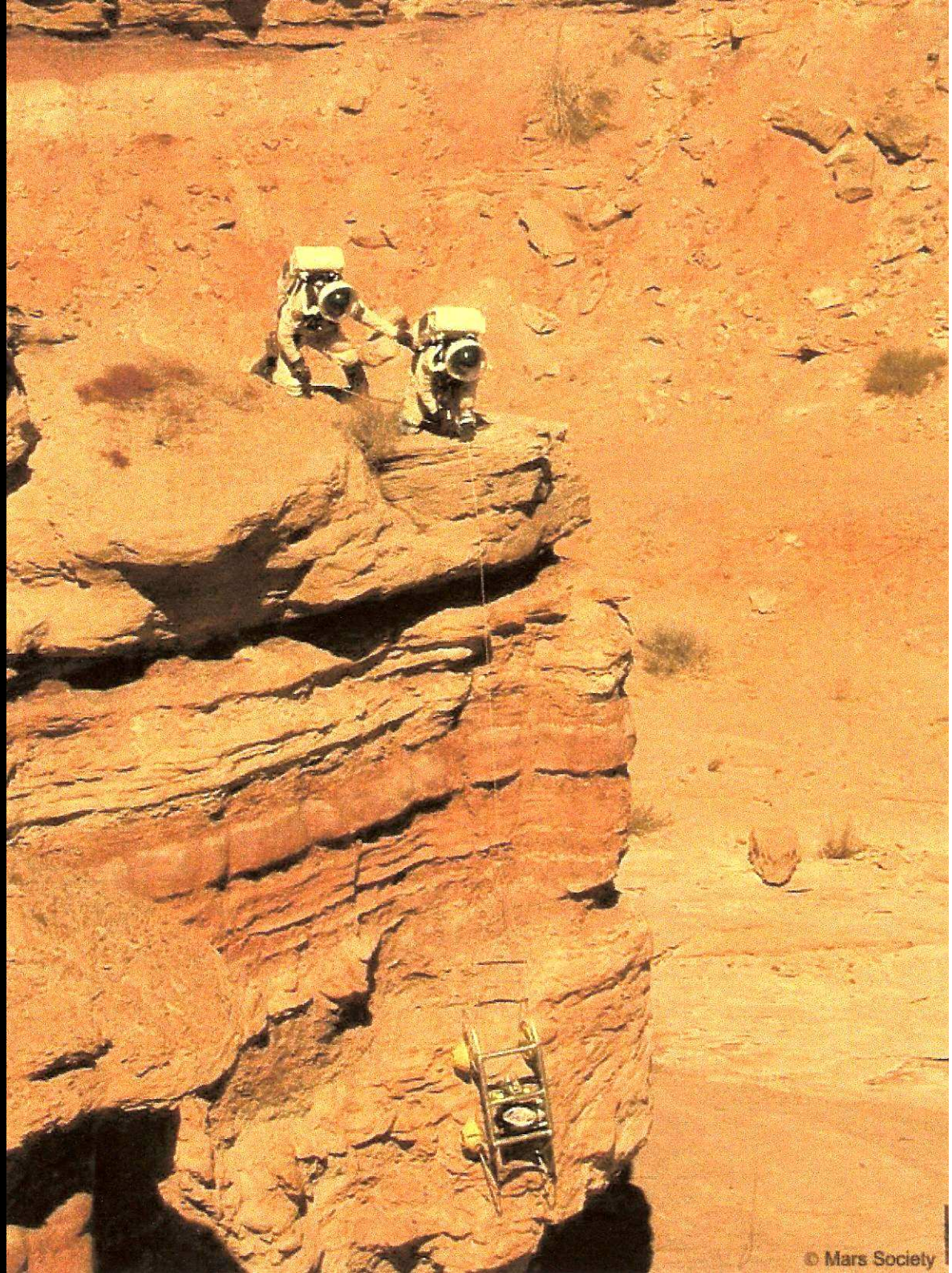
03 01 2002 CRV1b test 7 to 10 - 1st tests on a fossile field (next ones in Erfoud)



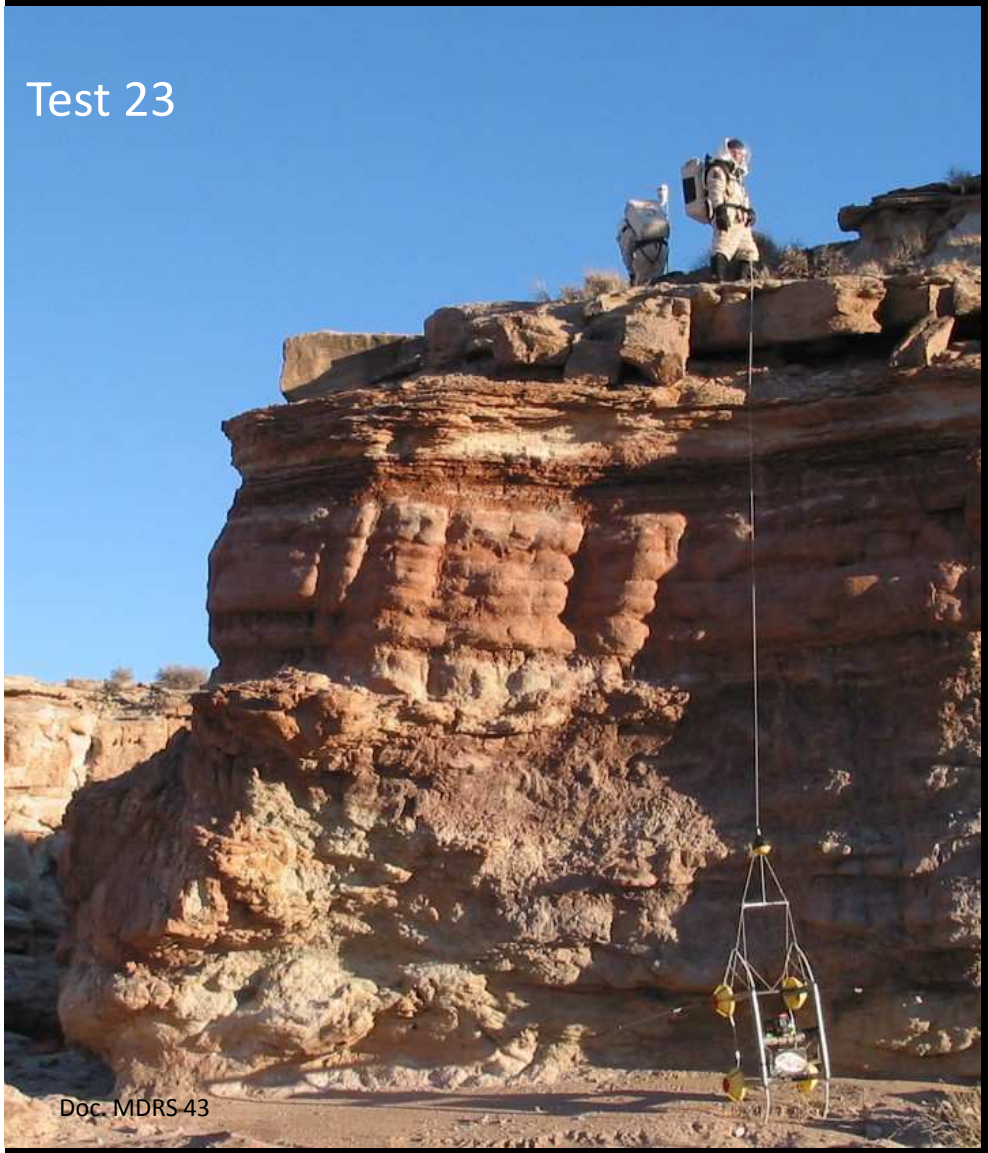
A short cliffbot history through the ages

02-2002 CRV1b tests 11 to 13 during MDRS 2 in Utah

24-02-2002 test 12



A short cliffbot history through the ages



30 06 2002 CRV2 (new structure; hazcam added) 1st tests – tests 14 to 17

11 2002 CRV2 tests 19 to 29 during MDRS 7 in Utah

A short cliffbot history through the ages

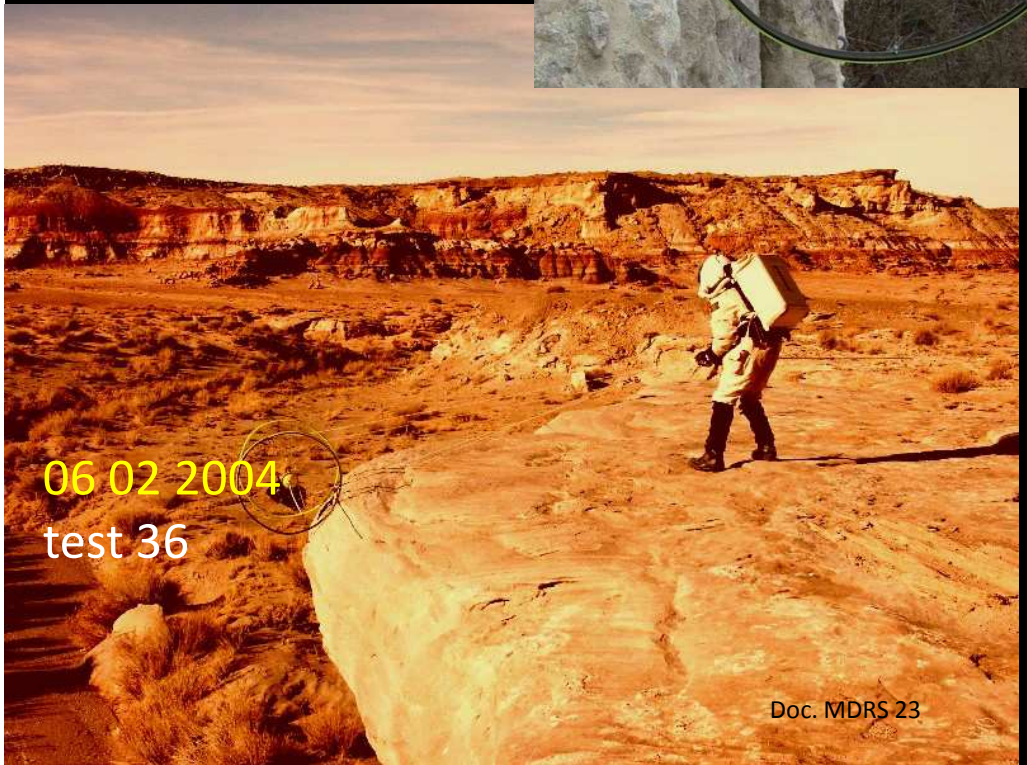
Doc. DR

29 12 2003

Down from 8.5 kg to 4 kg

CRV3 1st tests – test 30

An idea coming from « The Phantom Menace » !



06 02 2004
test 36

Doc. MDRS 23

02 2004
tests 33 to 44 during MDRS 23

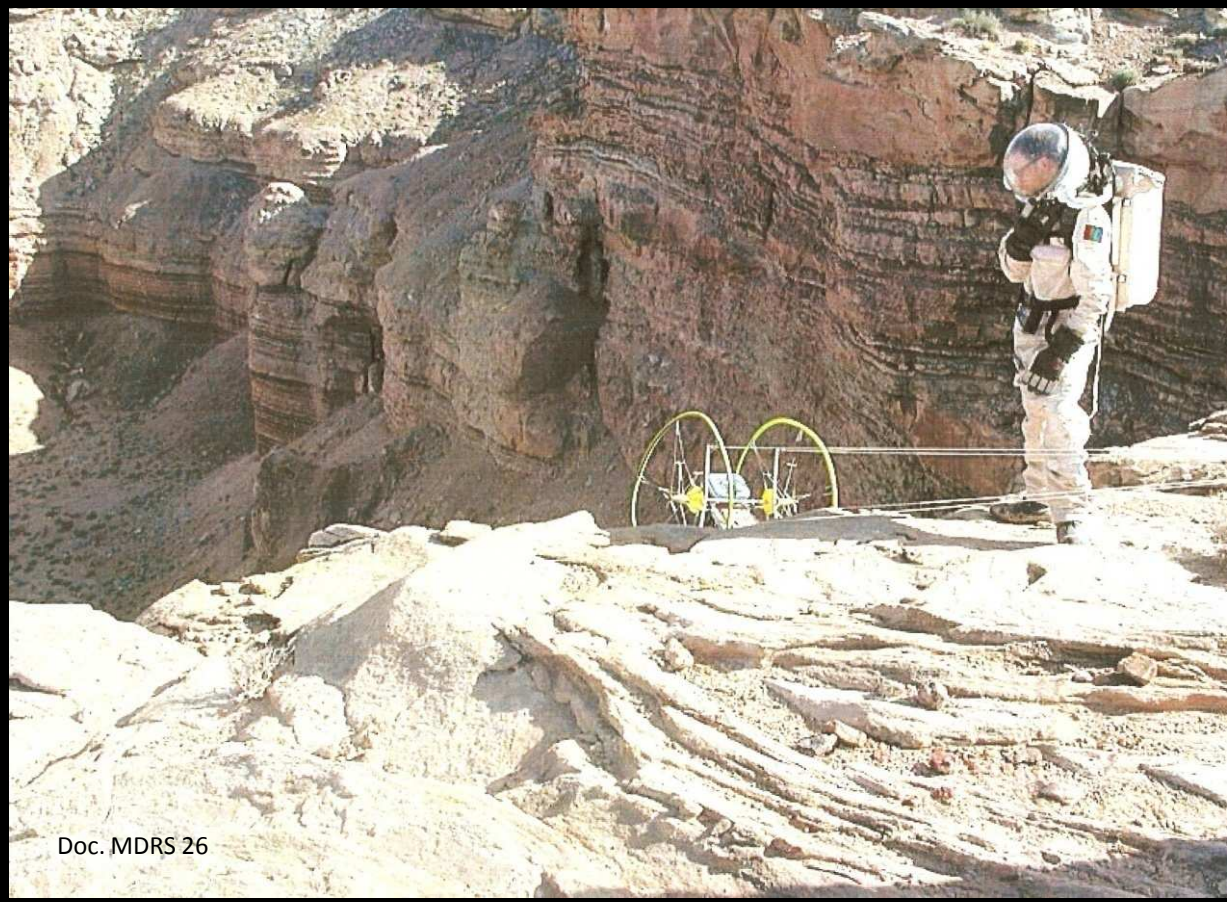
Doc. MDRS 23

09 02 2004 test 38

A short cliffbot history through the ages

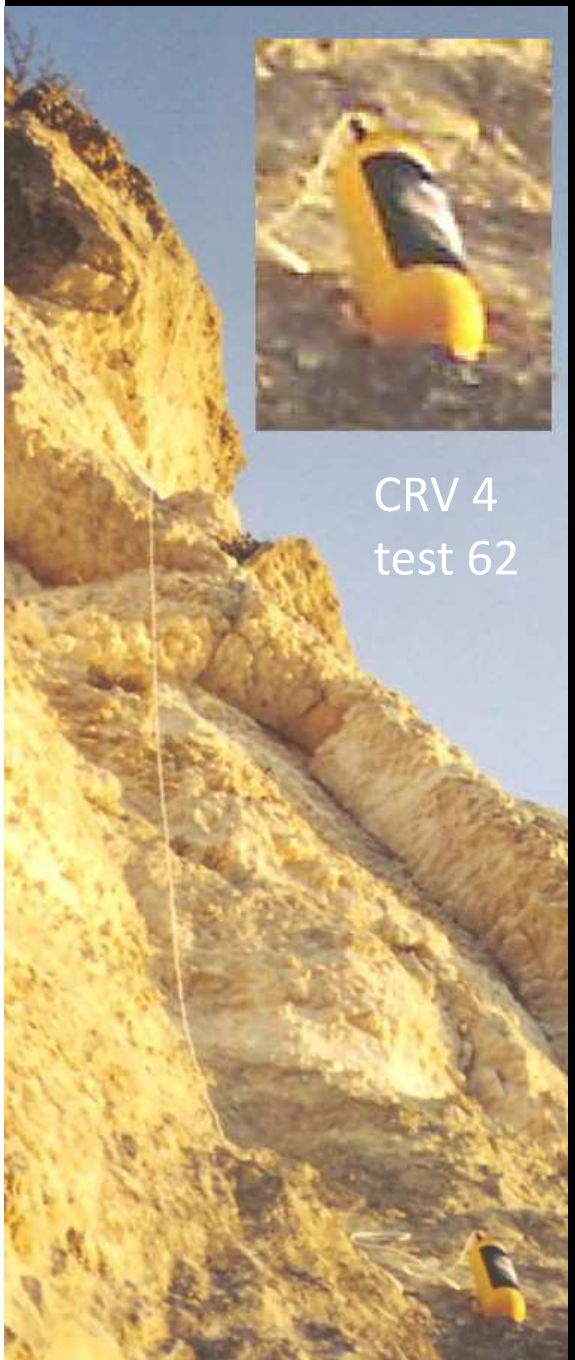
03-2004 tests 45 to 47 during MDRS 26

04/05-2005 CRV 3-2 (hazcam added) tests 48 to 61 during MDRS 39/40



A short cliffbot history through the ages

18 12 2005 CRV4 prototype tests 62 to 64



26 12 2005 CRV3-2 test 66 with carbon axis: 15m fall !

02 2006 CRV3-2 tests 68 to 72 during MDRS 43

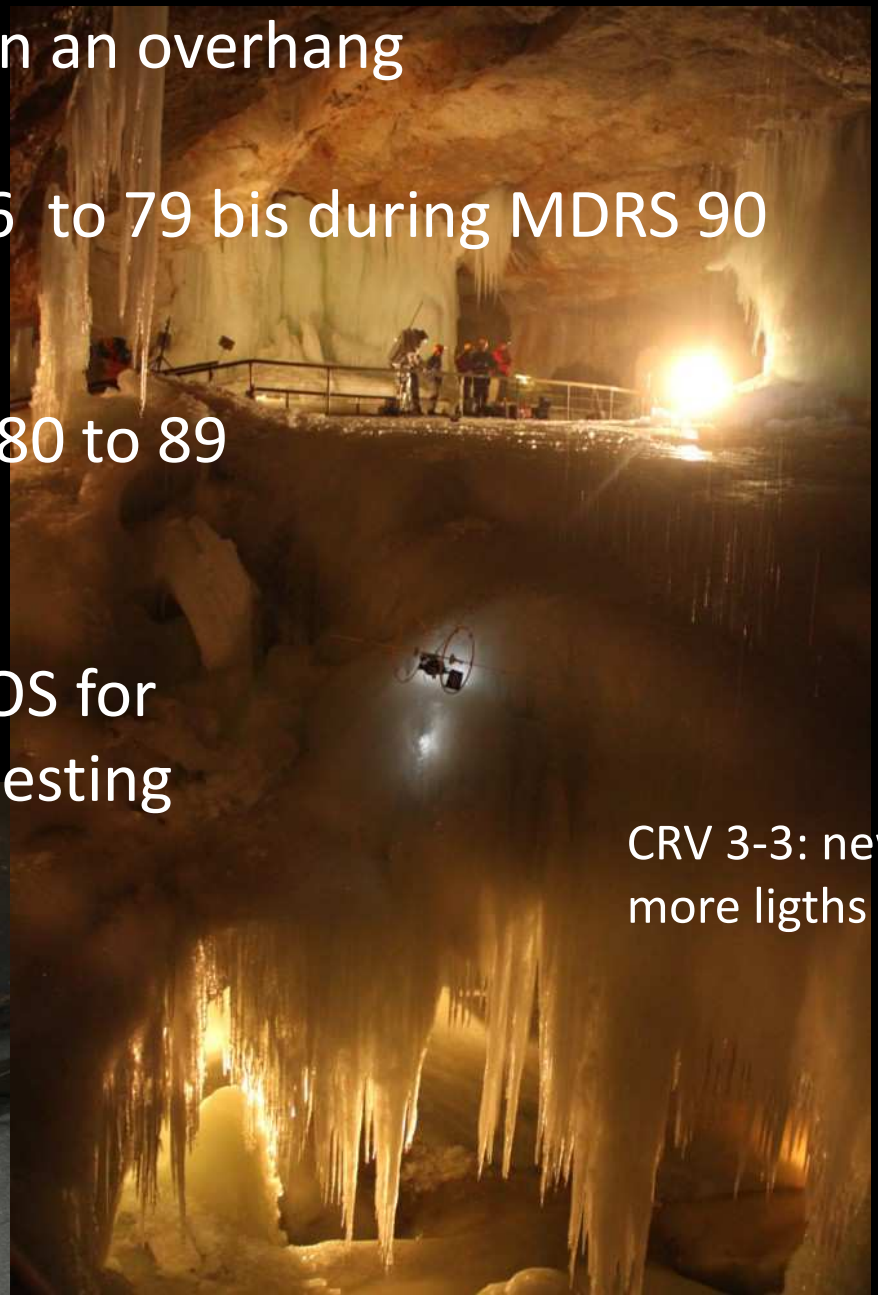
10 02 2006 CRV4 tests 73-74 during MDRS 43

A short cliffbot history through the ages

11 11 2008 CRV 3-2b test 75: 4/2/1 ropes configuration replaced by a rod - test on an overhang

02 2010 CRV 3-2b tests 76 to 79 bis during MDRS 90 (one fall)

28 04 2012 CRV 3-3 tests 80 to 89 in the Dachstein ice cave

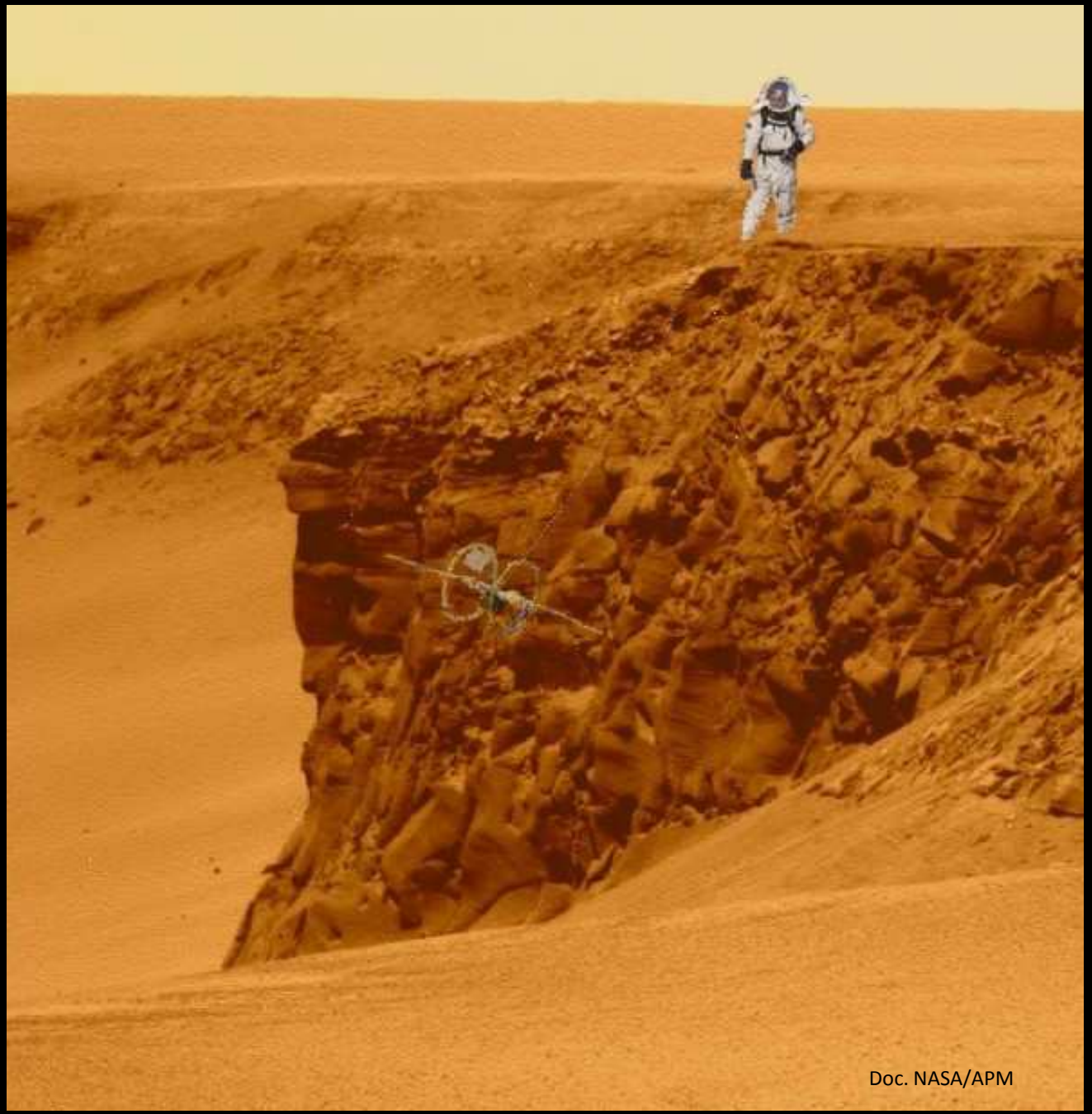


And CRV 5 used by LATMOS for ExoMars sounding radar testing
(tests not numbered)

Heavier structure w.r. to radar weight

CRV 3-3: new wheels and hazcam; more ligths

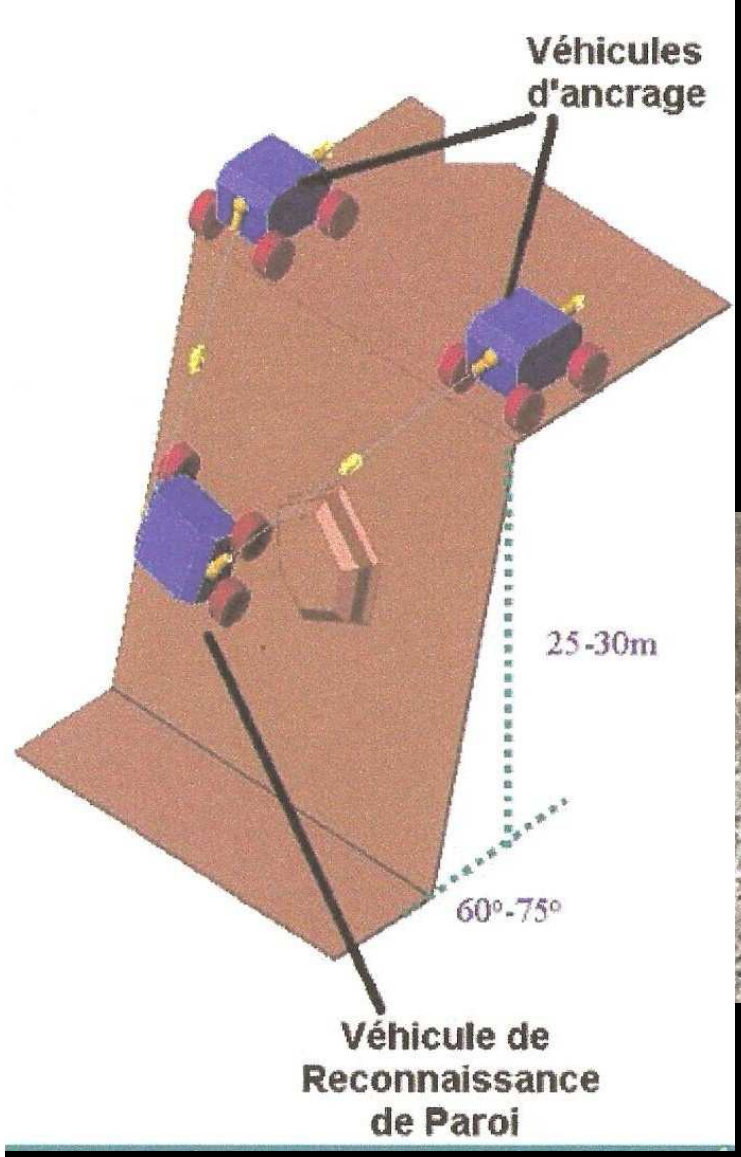
A short cliffbot history through the ages

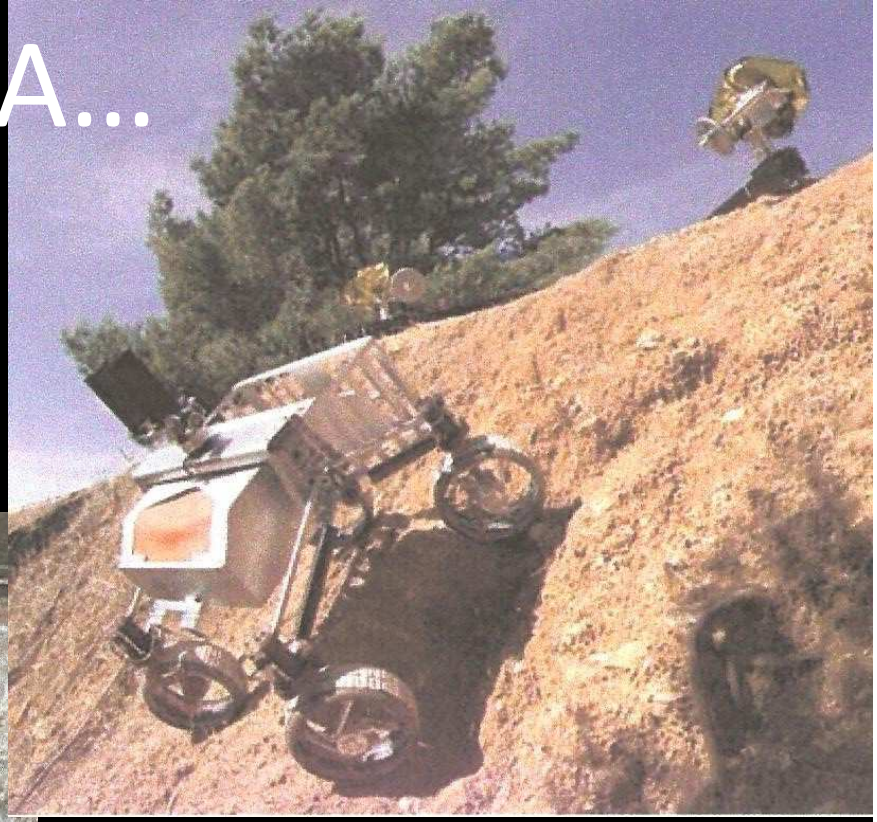


And in some years…

And NASA…

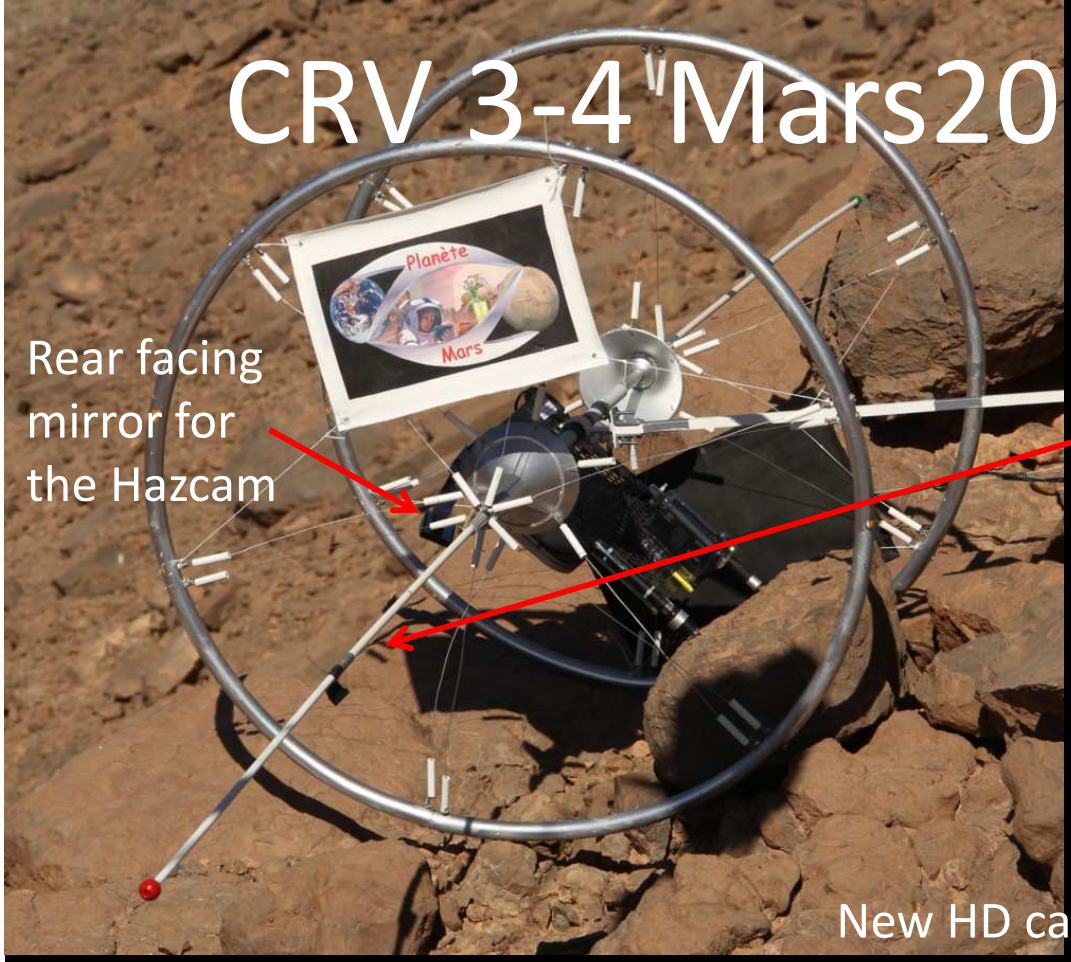
At JPL beginning of the 2000s





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

CRV 3-4 Mars2013 configuration

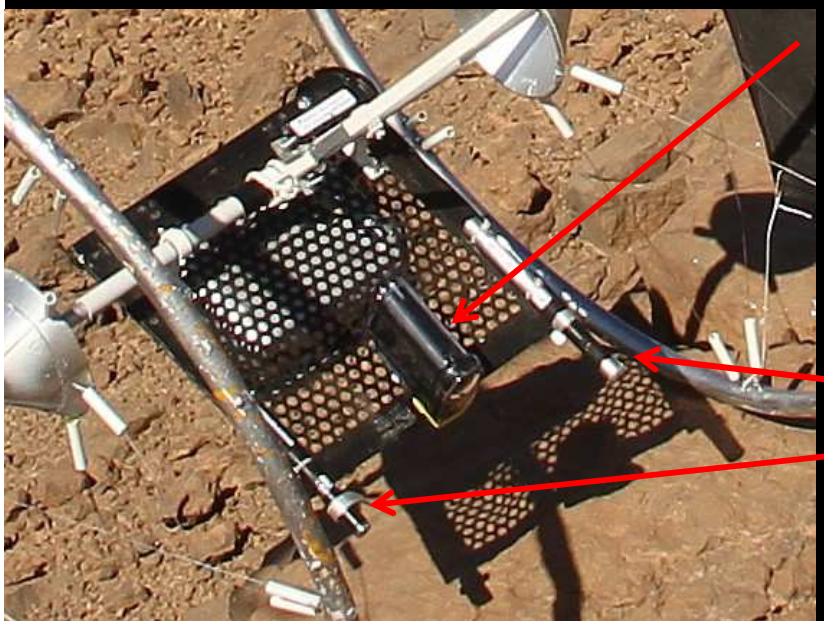


Rear facing mirror for the Hazcam

Three flashligths which were on the 3-3 Dachstein configuration deleted: - 0,46 kg

Anti roll rods: rigid 50 cm fiber glass inner rod; flexible 50 cm plastic outer rod

Emitter video box located under the plate



New HD camera located above the plate: - 1,61 kg

- 2,07 kg /Dachstein

Green laser

Red laser

Distance 22,5 cm

Tests conducted during Mars 2013

Test n°	Date	Localisation (+ indication on a map separately)	Vertical Heigth m	Rope length m	Comments (spacesuit ops or not, difficulties, duration)	Data acquired (sciencecam, hazcam visual/photos/recording, outside photos or videos)
90	9/12/12	Outside wall Innsbruck Red Cross building	1,5	1,5	Operations in Aouda spacesuit	Sciencecam recorded (6 mn), hazcam on
91	9/12/12	Outside wall Innsbruck Red Cross building	1,5	1,5	Operations in Aouda spacesuit, vehicle in inverted position, 2 runs	Sciencecam recorded (5mn and 2 mn), hazcam on
92	3/2/13	North Camp Erfoud; close to WP1; west from WP1	5	6	Ops by D. Schildhammer in Aouda S; vehicle prepared by A. Souchier (anti roll rods and equipments on); 3 runs; 4m vertical then 35° slope	Hazcam and sciencecam operational; hazcam picture on the monitor; monitor photos; tests 92 to 95 filmed by Austrian TV Servus
93	"	"	8	16	Ops by A. Souchier; blockage at the lowest point: a rock protrudes between the right wheel spokes (see photos); manual deblockage; return up by a different way (length 21 m)	Hazcam and sciencecam operational; hazcam picture on the monitor
94	"	"	6	7	Ops by D. Schildhammer in Aouda S; vehicle prepared by A. Souchier (anti roll rods and equipments on); 4 runs on more than 4 m; 2 runs on 2 m; 1 run on 6 m; 1 run on 4 m; 1 run on 6 m; tests conducted between 15h35 and 16h00	Hazcam and sciencecam operational; hazcam picture on the monitor

Tests conducted during Mars 2013

Test n°	Date	Localisation (+ indication on a map separately)	Vertical Heigth m	Rope length m	Comments (spacesuit ops or not, difficulties, duration)	Data acquired (sciencecam, hazcam visual/photos/recording, outside photos or videos)
95	"	"	7	10	Ops by A. Souchier	Sciencecam off; hazcam operational; objective was video by the TV crew of the hazcam monitor
96	5/2/13	¼ th of the big cliff North of Black Hill	19	19	Blockage on the way up 2 m under the starting point: the anti yaw main rod is stuck and slightly bent between two rocks (photos available); deblockage from under by a 3 m pole from a rocky (photos available); strong help from the polish TV team which was following the test	Sciencecam off; hazcam on and picture on the monitor (excepted when the vehicle is at maximum distance)

Tests conducted during Mars 2013

Test n°	Date	Localisation (+ indication on a map separately)	Vertical Heigth m	Rope length m	Comments (spacesuit ops or not, difficulties, duration)	Data acquired (sciencecam, hazcam visual/photos/recording, outside photos or videos)
97	6/2/13	Above WP 1 at the crest top; 31N22.532 and 4W3.348	8	10	Operations by G. Groemer in Aouda S including all preparatory operations (anti roll rods and equipments	Hazcam and sciencecam operational; hazcam picture on the monitor
					on); 8 m vertical; overhang; the vehicle comes back rotated 180°; momentary blockage of the rope in a cliff crack; freed by pulling harder; pole to hold the receiver away from the cliff would be interesting	
98	"	East of preceding point; 31N22.535 and 4W3.330	20	36 (max rope)	Operations by G. Groemer in Aouda S; 5m vertical then 35° debris slope	"
99	"	East of preceding point; 31N22.532 and 4W3.337	20	36	Operations by G. Groemer in Aouda S; same profile	"
100	"	Very close to first point; 31N22.532 and 4W3.348	20	36	Operations by G. Groemer in Aouda S; same profile; the vehicle rotates 180° in the overhang and roll on the debris slope with hazcam looking in front; comes back still rotated 180°	" Sciencecam videos from tests 92 to 100 provided to the TV teams; also loaded in the base camp computers.

Tests conducted during Mars 2013

Test n°	Date	Localisation (+ indication on a map separately)	Vertical Heigth m	Rope length m	Comments (spacesuit ops or not, difficulties, duration)	Data acquired (sciencecam, hazcam visual/photos/recording, outside photos or videos)
101	18/2/13	31N22,551 et 4W03,280		46	Operations without spacesuit from the top of one of the fossil mud volcanoes. Red laser weak	TBC
102	"	Same location	Around 5	5	From the same location, exploration of a cave with a sky opening. The vehicle is used without the anti roll rods.	TBC
103	"	31N22,902, 4W2,986 Northern end of Kess Kess chain	32	32	Operations without spacesuit; quasi vertical cliff	TBC
104	"	Sphynx point	8	8	Operations without spacesuit; quasi vertical cliff; vehicle stopped before reaching the bottom of the cliff on an horizontal area	TBC

Tests conducted during Mars 2013

Test n°	Date	Localisation (+ indication on a map separately)	Vertical Heigth m	Rope length m	Comments (spacesuit ops or not, difficulties, duration)	Data acquired (sciencecam, hazcam visual/photos/recording, outside photos or videos)
105	19/2/13	31N22,880, 4W 04,442	23	23	Operations without spacesuit; quasi vertical cliff	TBC
106	"	250 m west of previous test	15	15	Operations without spacesuit; quasi vertical cliff	TBC
107	"	31N22,880, 4W04,442; Western tip of the Kess Kess cliffs	35	35	Operations without spacesuit; quasi vertical cliff	TBC
108	"	31N22,864, 4W4,236	17	20	Operations without spacesuit; 60° slope cliff	TBC
109	"	31°N22,822, 4W4,070	18	18	Operations without spacesuit; vertical cliff	TBC

Traficability

Two main difficulties were encountered during Mars2013

03 02 2013 test 93

The vehicle cannot be brought back because a rock protrudes between the spikes of the right wheel. This could be avoided by plain wheels or a spike fairing. Plain wheels were not selected to keep the capacity to desassemble the vehicle and store it in a suit case. The shallow rocky slope on which the problem appeared is not the primary objective for the vehicle operations

05 02 2013 test 96

Blockage on the way up with the yaw main rod stuck between two rocks

Others:

06 02 2013 test 97

Momentary blockage by the rope in a cliff crack

Difficulties when operating in a spacesuit

No special operating difficulties reported

CRV 97 0mn 0s

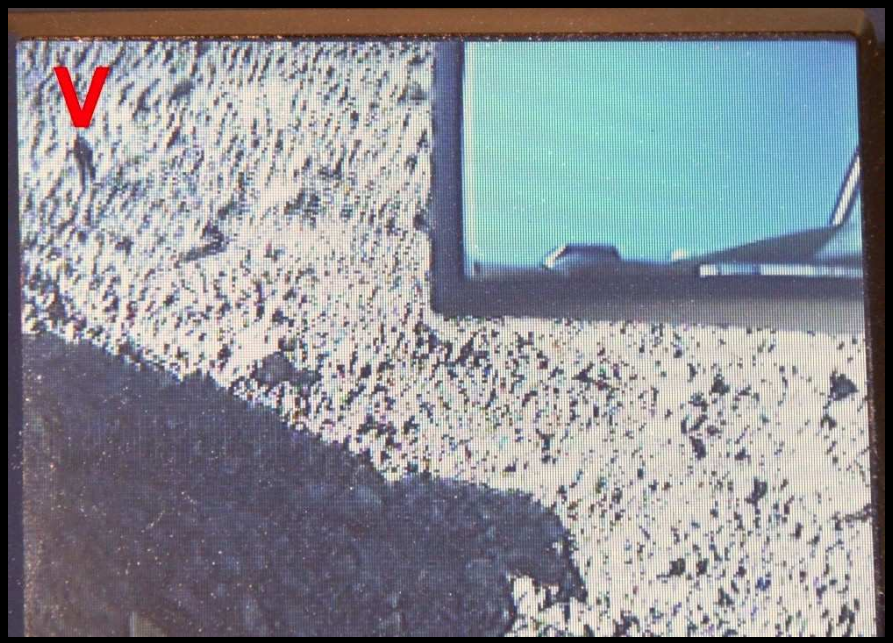
CRV 92

Vehicle situation awareness

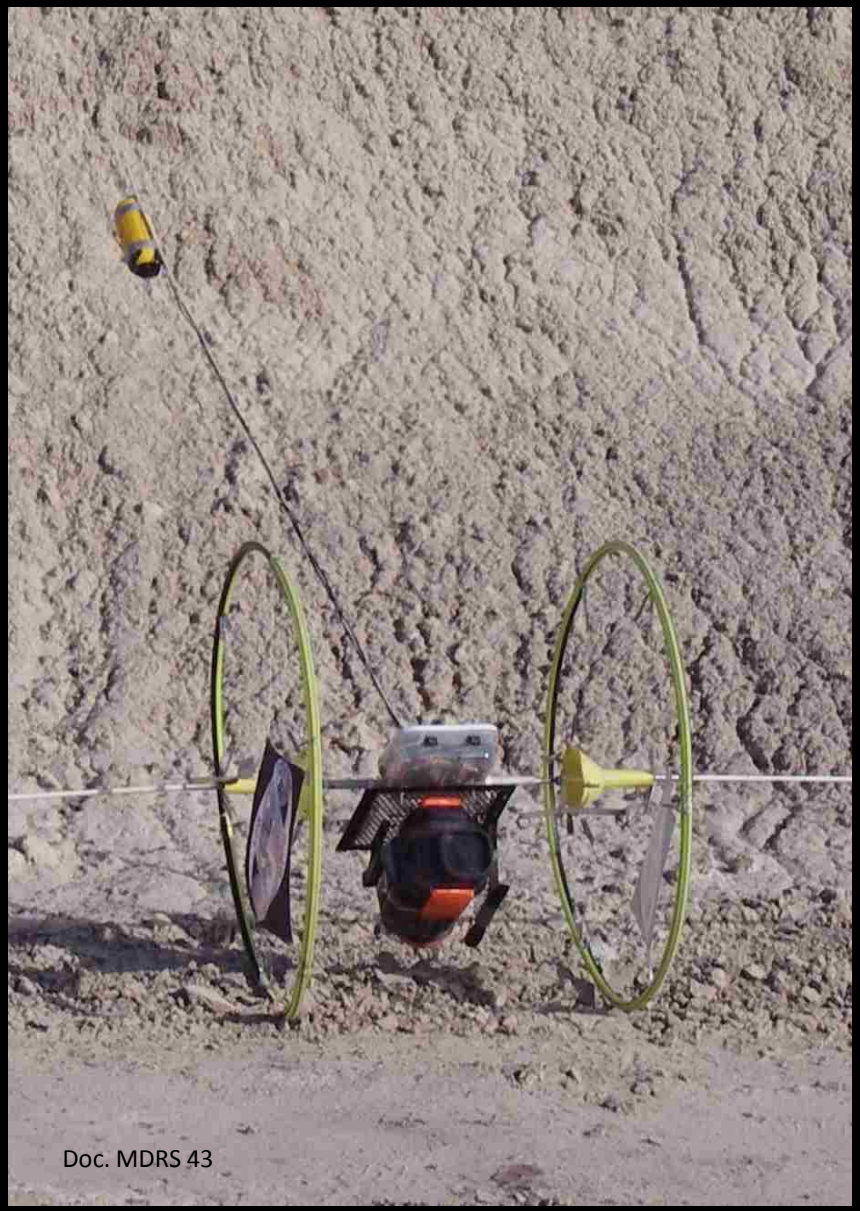
The single hazcam is not enough for a good vehicle situation awareness: the 2 blockages were understood from direct observation

However the hazcam picture was used by G. Grömer to see the vehicle rotation and stabilization under an overhang during test 97

The rear facing mirror usefulness was not demonstrated; the mirror was lost during tests 97 to 100



A solution for vehicle situation awareness tested in 2006 during MDRS 43



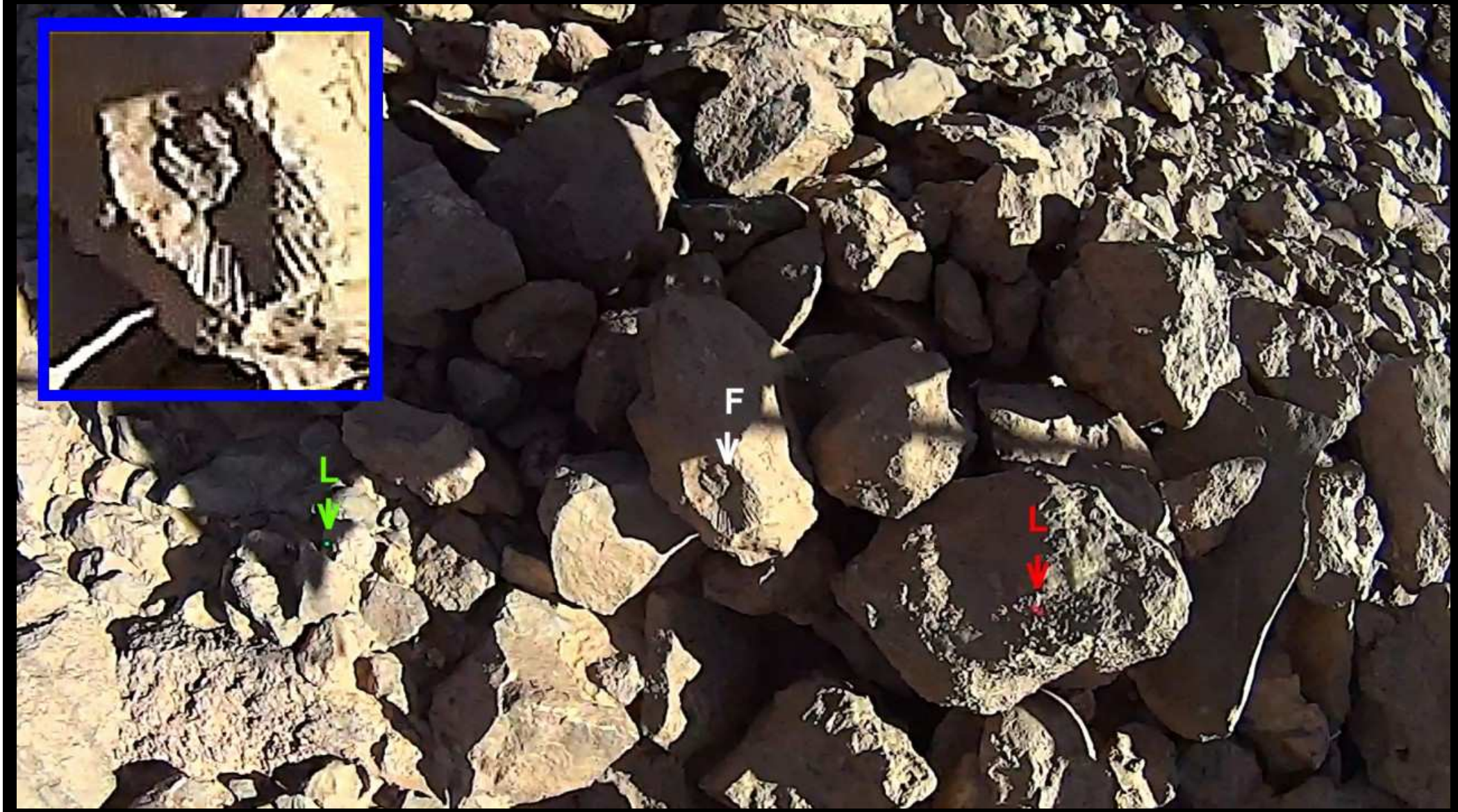
Hazcam in a container above the CRV on the rope – but could be also a blocking point

Exploration and geological capabilities

Very probing results were obtained:

1 Fossiles detection

CRV 93 6mn 41s



But very large field of view (120°) compared to old CRV1b tests in 2002 on a fossile field

CRV 94 24mn 42s

Fossiles detection

CRV 98
7mn 56s

Fossiles detection

CRV 98 5mn 01s

Fossiles detection

CRV 97 9mn 33s

Fossiles detection

2 Geology/mineralogy: blue rocks

CRV 98 2mn 47s

CRV 98 2mn 48s

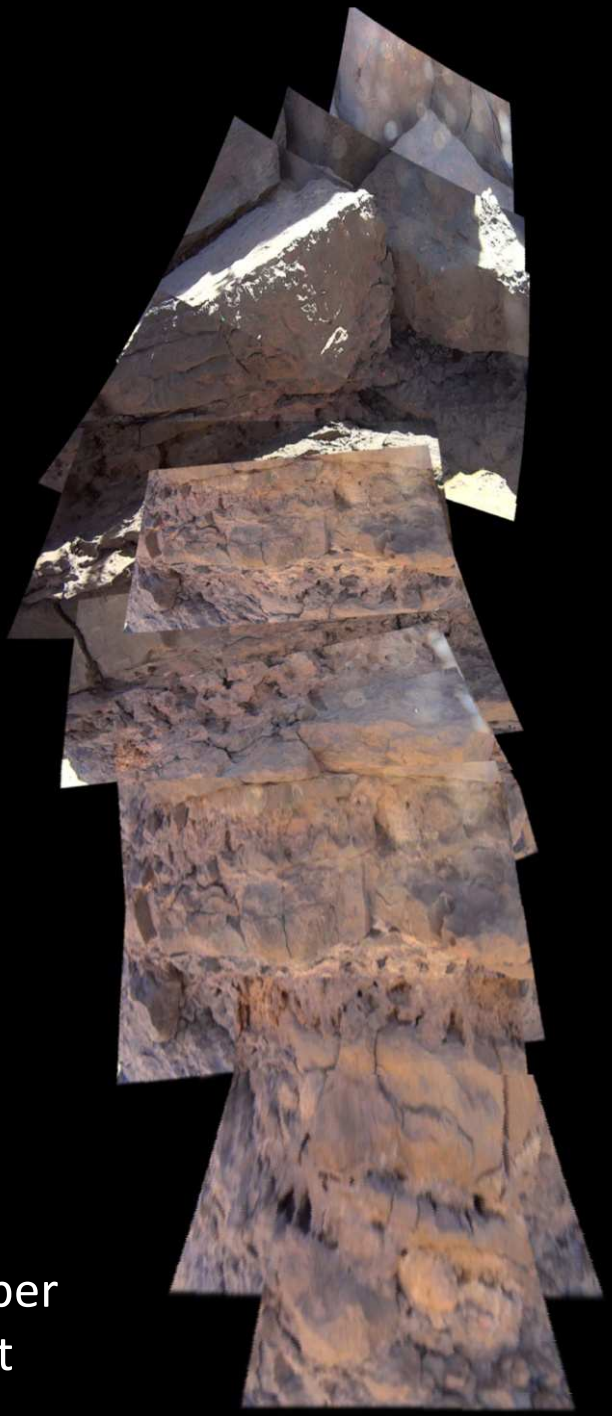
Blue rocks

The blue rocks area under an overhang

CRV 98 5mn 11s

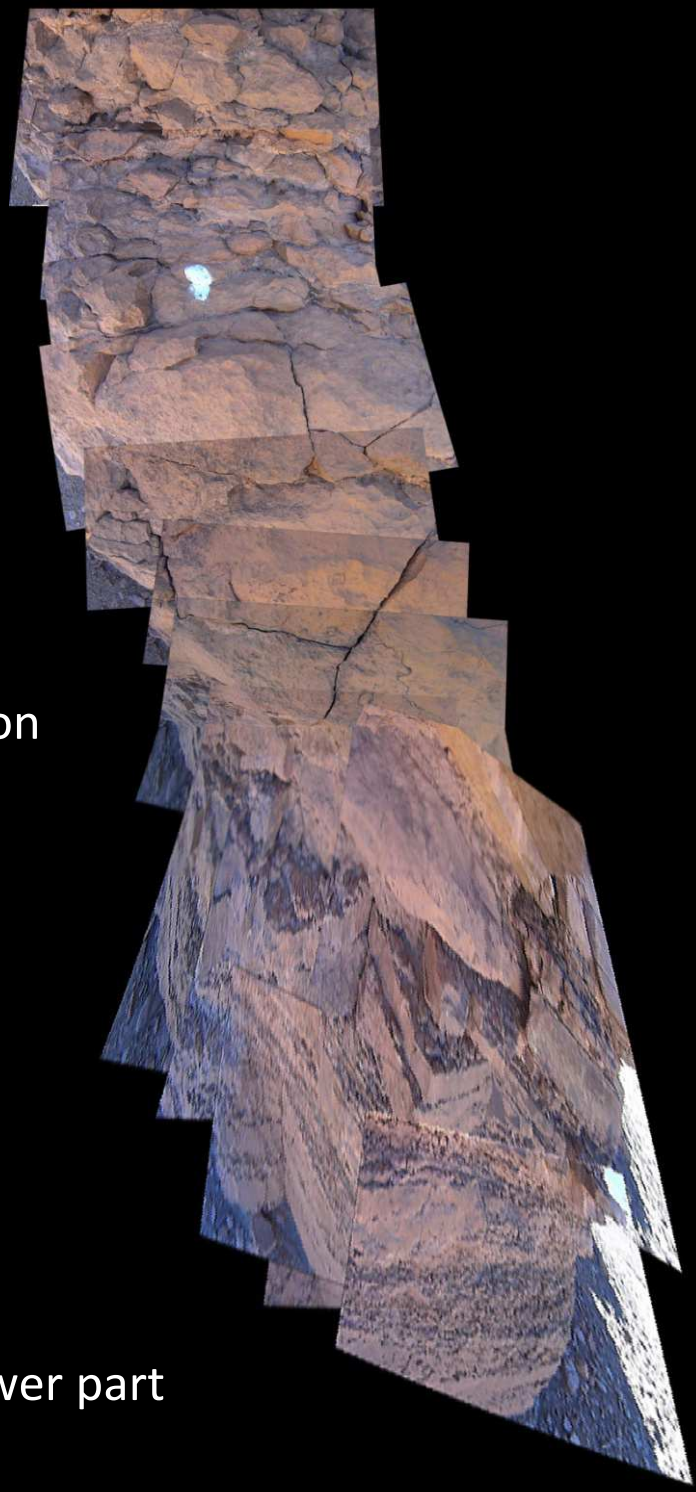
Striated rocks

3 Cliff/slope mapping



Upper part

Exemple of mapping on the 8 m cliff explored during CRV test 97

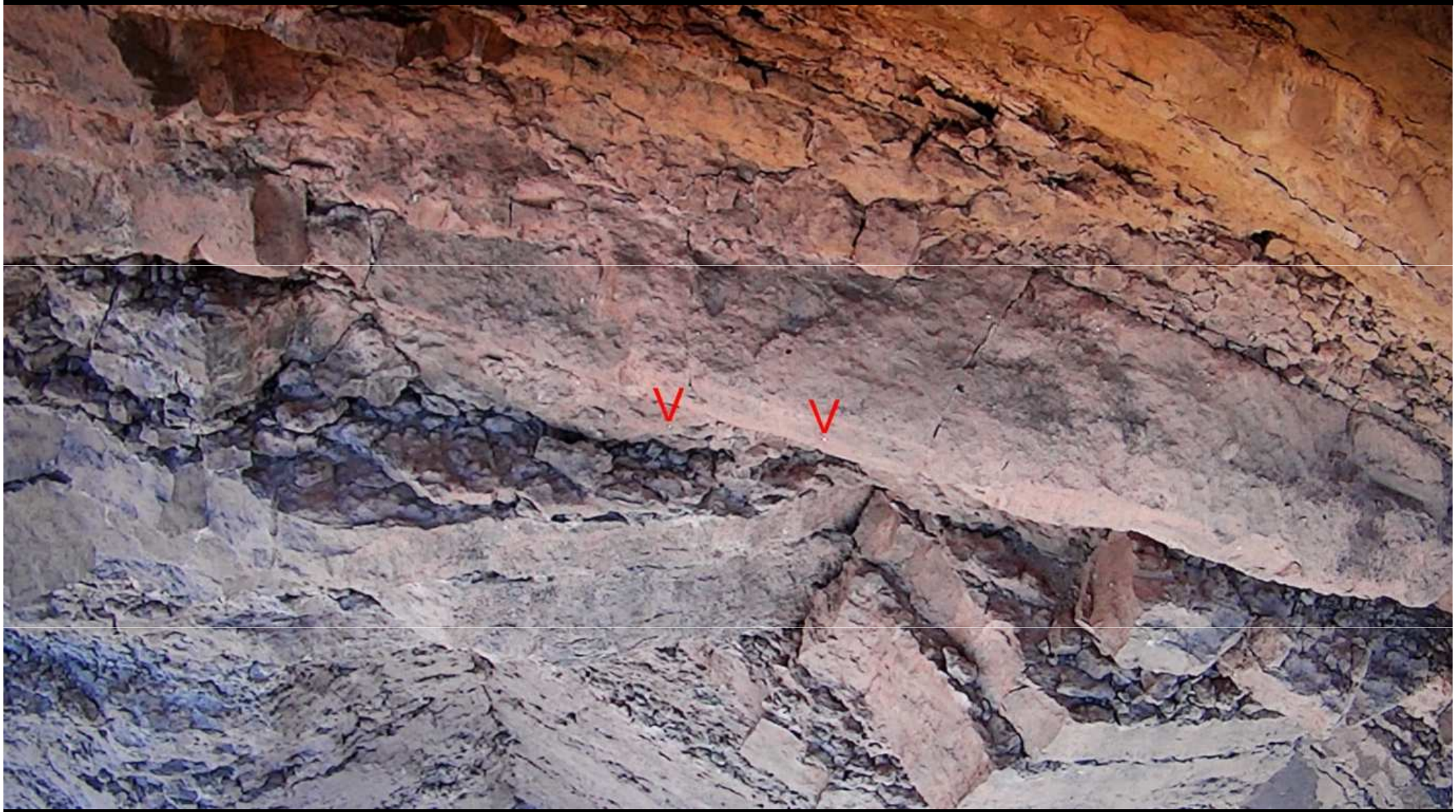


Lower part

4 General exploration

CRV 94 12mn 50s

CRV 97 3mn 23s



70 cm overhang measured from the 2 lasers 22,5 cm distance

CRV 97 3mn 29s

Cliff lateral view

CRV 94 3mn 20s

Small cave (and fossile)

CRV 92 13mn 09s

Same small cave

CRV 100 0mn 36s

Blue gray area in the cliff

Large cave exploration

Doc. ÖWF

Doc. ÖWF

And cliffs/slopes till 46 m

Thank you

Docs A. Souchier/APM excepted other indications