Petri-Dishing the Dirt:

An overview of Astrobiology Projects at Boulby

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What is Astrobiology?

Origin, Evolution, Distribution and Future of life in the Universe

What is Astrobiology?

- What are the limits of life?
- Are these limits universal?
- How does life survive extreme conditions?
- What does this tell us about life elsewhere?

Astrobiology at Boulby

-Intense Pressure

-Extreme Temperatures

-Lack of Light

-High Salt Concentration

-Anaerobic

-Low Radiation

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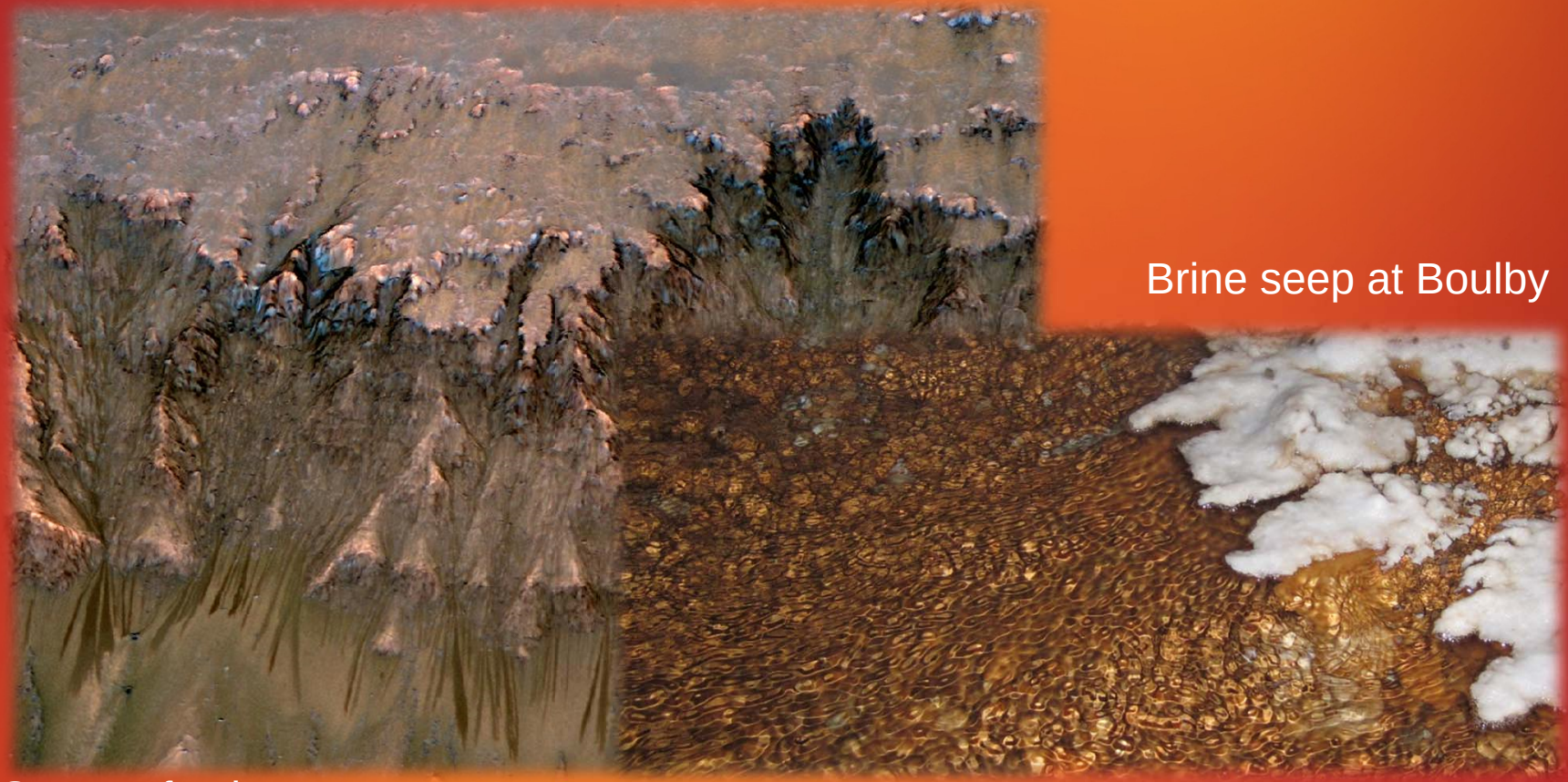
NASA!!

Astrobiology at Boulby
Mars on Earth!



Brine seep at Boulby

Seeps of salty water on Mars
McEwan et al. (2011) *Science* **333**, 740

Projects

- BISAL Boulby International Subsurface Astrobiology Lab
- MINAR (I-IV) Mine Analogue Research
- (MASE Mars Analogues for Space Exploration)

BISAL

- Est. 2011

-1.1 km underground

- First permanent underground Astrobiology lab

- One of deepest Microbiology labs

BISAL

Samuel Payler

- Active biogeochemical cycling in deep Subsurface evaporites

- Identifying & characterising microbial communities

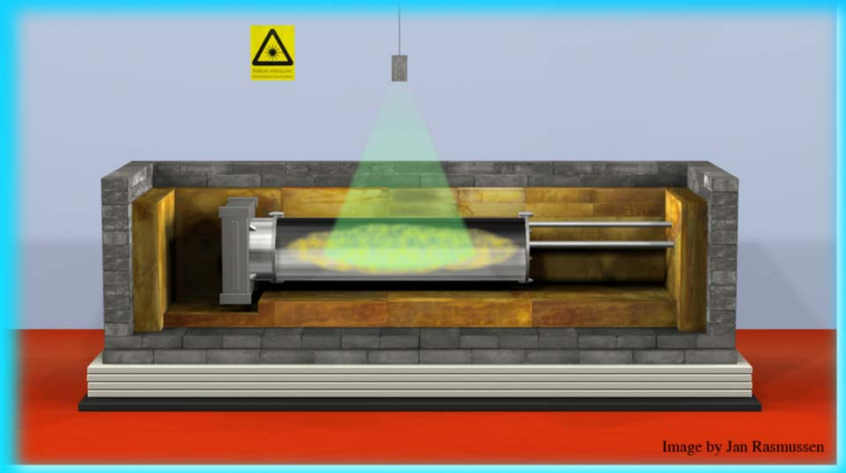
Sampling brine seep at Boulby

BISAL

Jen Wadsworth

- Observing microbes in ultra low radiation environments

- Simulating high radiation environments, comparing viability



Controlled exposure to high ionising radiation doses

MINAR

BISAL
Boulby International Subsurface Astrobiology Lab

Science & Technology Facilities Council

UK Centre for Astrobiology

CLEVELAND POTASH

THE CROWN ESTATE

Exploring space to help mining

MINAR

Overall objectives

- Test space technologies in a coordinated program
- Test technologies that might be used in mining applications
- Use this technology to search for and study life in the deep subsurface

MINAR

Science objectives

- Determine microbial communities inhabiting deep subsurface hypersaline environments, their biogeochemical functions and importance

- Determine biogeographical distributions of different life forms in the deep subsurface

MINAR

Analogue technology objectives

- Test instruments for planetary exploration in the mine

- Test remotely operated and autonomous vehicles in the mine

MINAR

Mining technology objectives

- Develop better instrumentation to asses ore quality

- Develop better autonomous mine environment mapping
→ Prevent collapses, assess economic viability of old/unused environments

MINAR I (April 2013)

-Participation from:
NASA, ESA, DLR, UKSA,
Various Universities

-Excursion into mine to examine conditions

-Planning future of MINAR

-Workshop ‘From outer space to mining’

MINAR II (April 2014)

Integrated test of instrumentation (emulators)

- Panoramic Camera (PanCam)
- Raman spectrometer
- CLUPI (Close-Up Imager)
- SPLIT (Small Planetary Linear Impulse Tool)
- XRF (X-Ray Fluorescence)

MINAR III (2014)

Integrated test of ExoMars instrumentation
(CLUPI, Ramen, SPLIT, XRD, ATP analysis, Ultrasonic drill)

- Defined set of samples with replication

- Further tests of instruments to enhance data set

- Beginning of life detection (ATP)

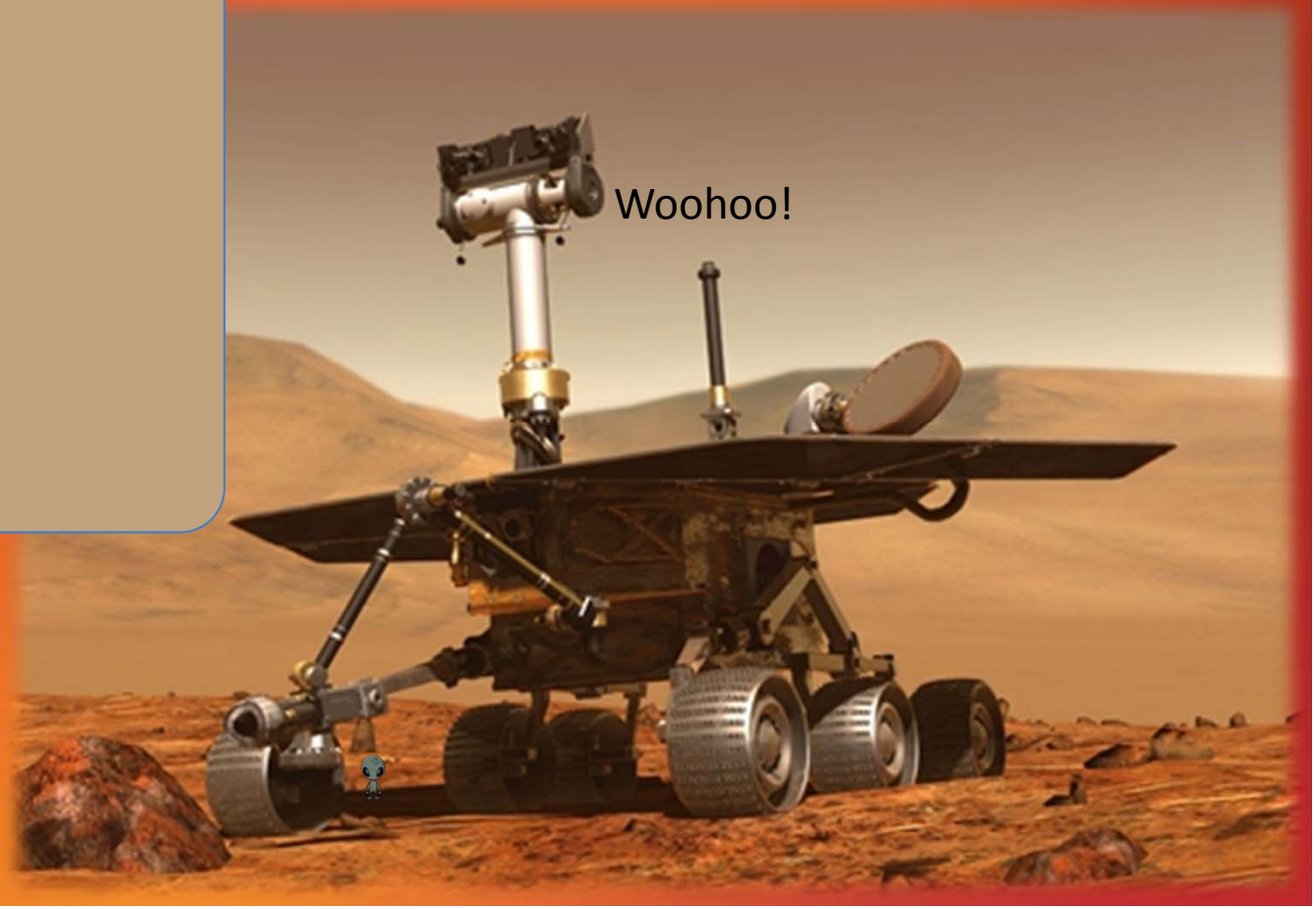
-Tests of new instruments (drill, XRD)

ExoMars Rover Instruments

PanCam

CLUPI

Ramen



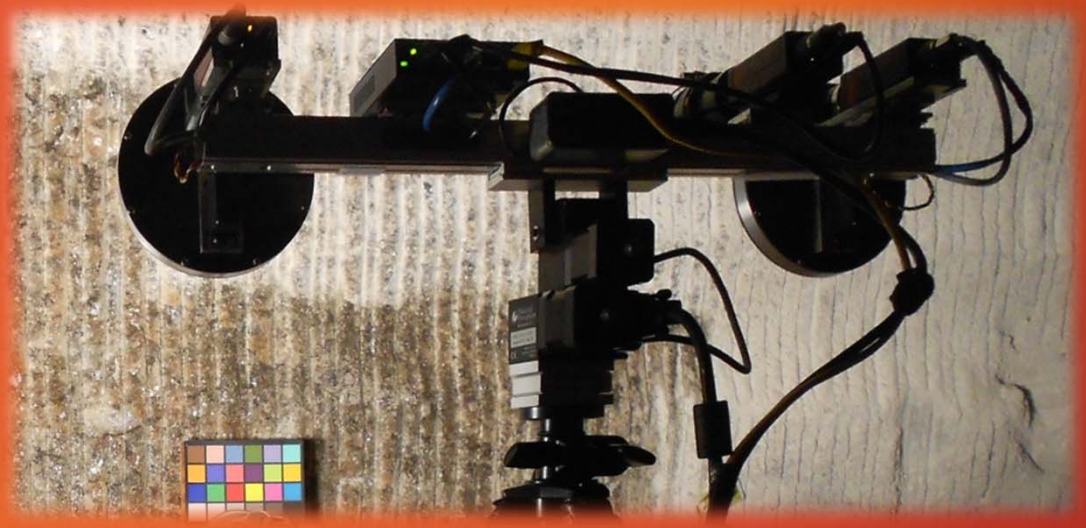
MINAR III (2014)

PanCam ‘Eyes’

- Contextual information

- High res colour images

- Three cameras mounted within an optical bench and two wide angle multispectral cameras



MINAR III (2014)

- Close up contextual images (sharp images of any target from 10 cm)

- Search for signatures of biology, provides information on the geological context

- Observe the drilled core samples prior to being sent to other instruments

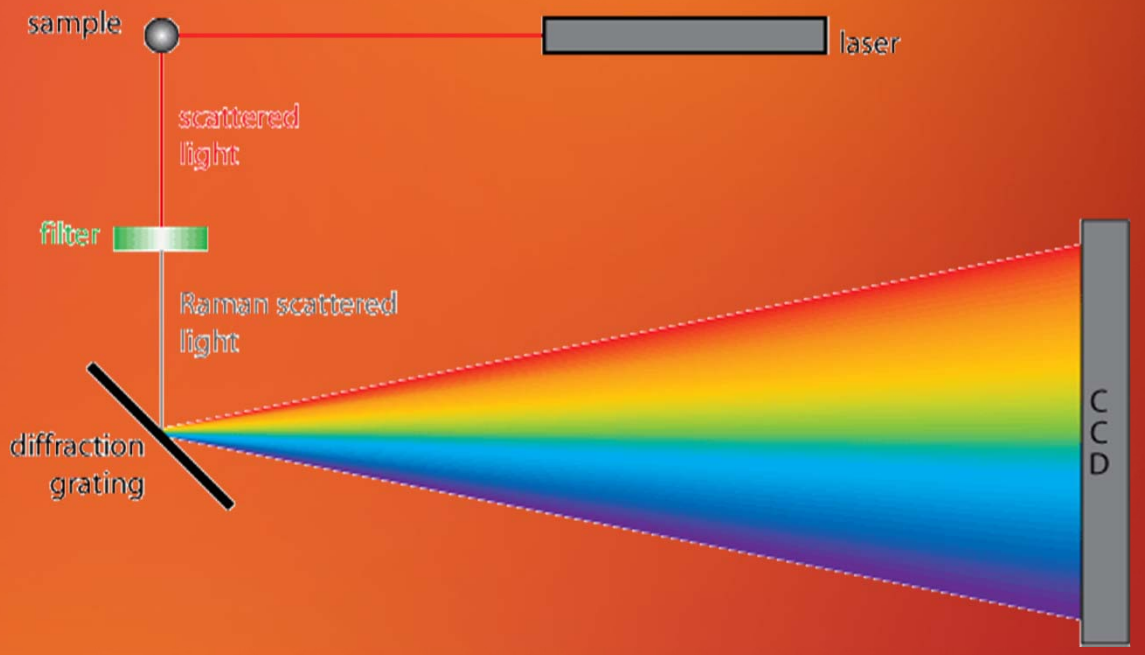
CLUPI ‘geologist’s hand’

MINAR III (2014)

- Fast, non-destructive chemical and structural identification of materials (s/l/g)

- Utilises a continuous wave, 532 nm laser and will achieve a spectral range of 400 cm^{-1} to 4000 cm^{-1}

Raman 'analytical chemist'



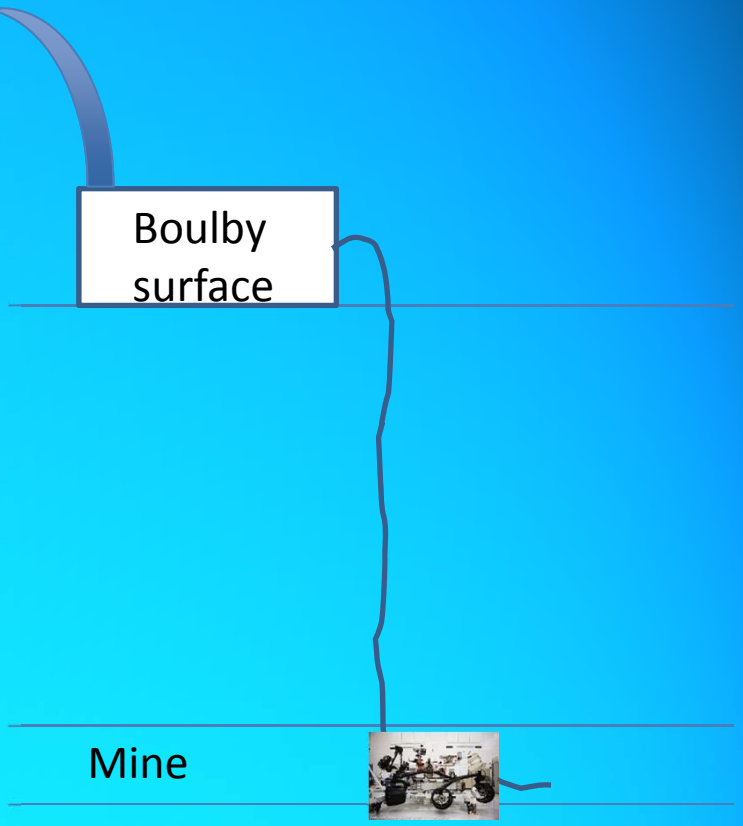
MINAR

Outcome of MINAR II and III:

A paper by Samual Payler to be submitted in the next few weeks for *Journal of Geophysical Research*!!

MINAR IV (2016)

The mine will be used to remotely test rovers for the subsurface exploration of the Moon and Mars



MINAR

Mining and Analogue Research (MINAR)

MINAR phase	MINAR 1	MINAR II	MINAR III	MINAR IV	MINAR V	MINAR VI
Year	2013	2014	2014	2015	2015	2016
Technology						
Discussion on space to mine technology transfer						
Planning for MINAR						
Analogue instrument testing in Boulby						
Autonomous vehicle operation testing						
Remote operation of space technology from surface						
Remote operation of space technology from another continent						
Campaign in multiple locations across mine						
Technology transfer from space to mining testing						
Modification of space instruments for mining applications						
Science						
Study of microbial communities in one to two sites						
Use of instrumentation to gather contextual science information						
Study of biogeography in different sites						
Science and Technology Challenges addressed						
Science Challenge 1						
Science Challenge 2						
Analogue Technology Challenge 1						
Analogue Technology Challenge 2						
Mining Technology Challenge 1						
Mining Technology Challenge 2						
Workshop - "Outer Space to Mining"						
Status/proposed date	*Completed*	*Completed*	*Nov-14*	*Apr-15*	*Aug-15*	*Apr-16*

MASE

Mars Analogues for Space Exploration

Thanks for your attention!