The International Space Analogue Rock Collection (ISAR)

Nicolas Bost[1,2],
Frédéric Foucher[1] Frances Westall[1], *et al.**

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[1]Centre de Biophysique Moléculaire, CNRS, Orléans
[2] Conditions Extrêmes et Matériaux: Hautes Températures et Irradiation
**C. Ramboz, D. Pullan, J. Bridges, B. Hofmann, I. Fleischer, G. Klingelhöffer, A. Steele, H. Amundsen, S. Petit, A. Meunier, F. Rull, M. Viso and J.L. Vago*

nicolas.bost@cnrs-orleans.fr

In situ space exploration

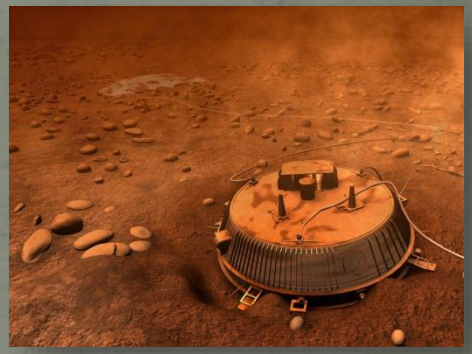
Mars

MSL, 2013

Moon

Apollo 11, 1969

Titan

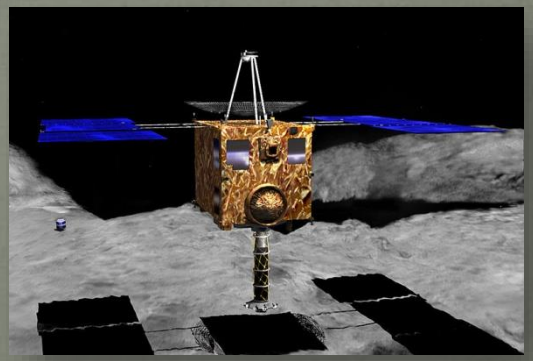


Huygens, 2005

Comets

Philaé (Rosetta), Tchourioumov-Guerassimenko, 2014

Asteroids



Hayabusa et Minerva , astéroïde Itokawa, 2005

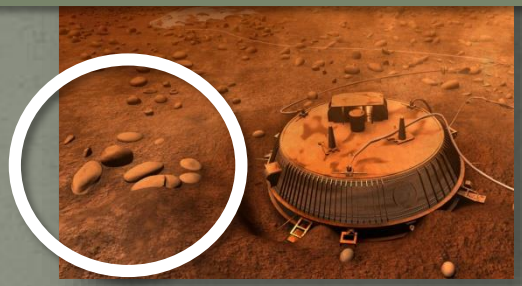
+ Europe, Encelade…

Rocks : one of the main objects of study

Mineralogy, geology, search of organic molecules, search for traces of life…

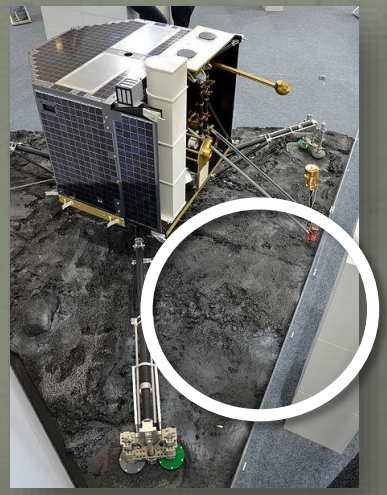
MSL, 2013

Apollo 11, 1969



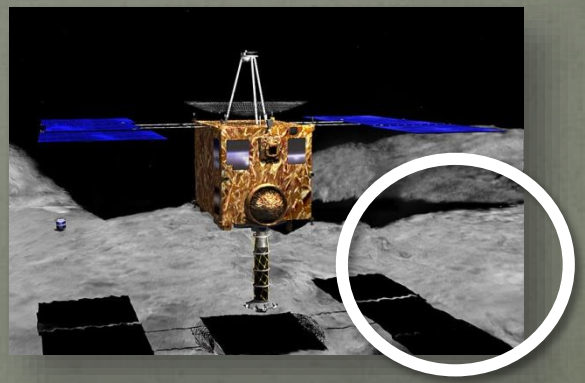
Huygens, 2005

Comets



Philaé (Rosetta), Tchourioumov-Guerassimenko, 2014

Asteroids



Hayabusa et Minerva , astéroïde Itokawa, 2005

Instruments for rock study

Laboratory vs spatial

On Earth

« Regular »

-Camera and note book
-Hammer
-Optical microscopy using thin section

Complementary

-Raman
-IR
-X-ray diffraction
-EPMA
-ICP
-Drilling
-SEM / TEM
-Mass spectrometry
-LIBS
-Mössbauer
-XRF
-PIXE
-Synchrotron radiaton
…

In situ (on Mars)

« Regular »

-**Camera** ~~note book~~
~~-Hammer~~
~~-Optical microscopy using thin section~~

Complementary

-**Raman**
-**IR**
-**X-ray diffraction**
~~-EPMA~~
~~-ICP~~
-(**Drilling**)
~~-SEM / TEM~~
~~-Mass spectrometry~~
-**LIBS**
-**Mössbauer**
-**XRF**
-**PIXE**
~~-Synchrotron radiaton~~
…

Limitations

Instrumental resolution and power

+

Automatisation of devices

Instrumental development

Calibration

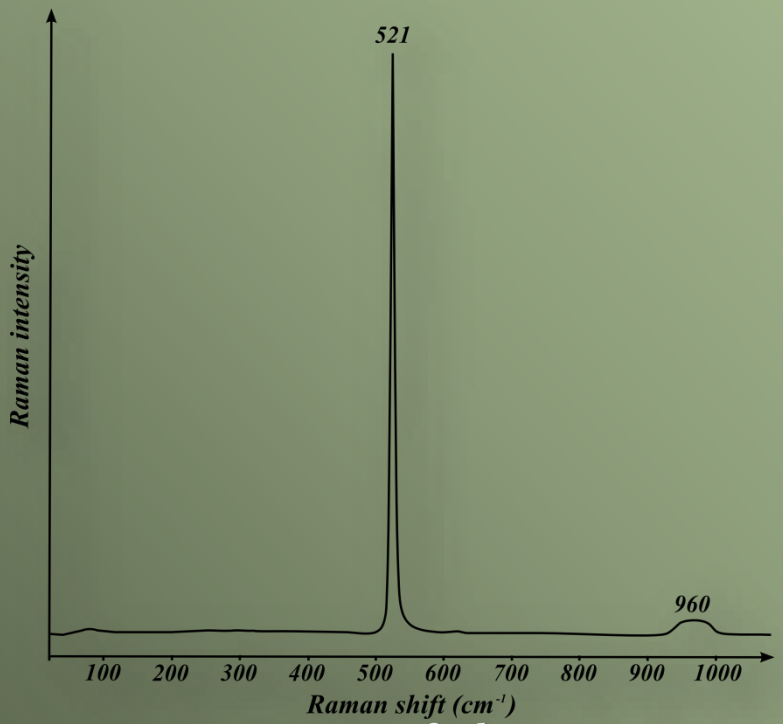
1-Instrumental calibration

« standards »

Camera

ColorChecker

Raman spectrometer



Raman spectrum of Silicium

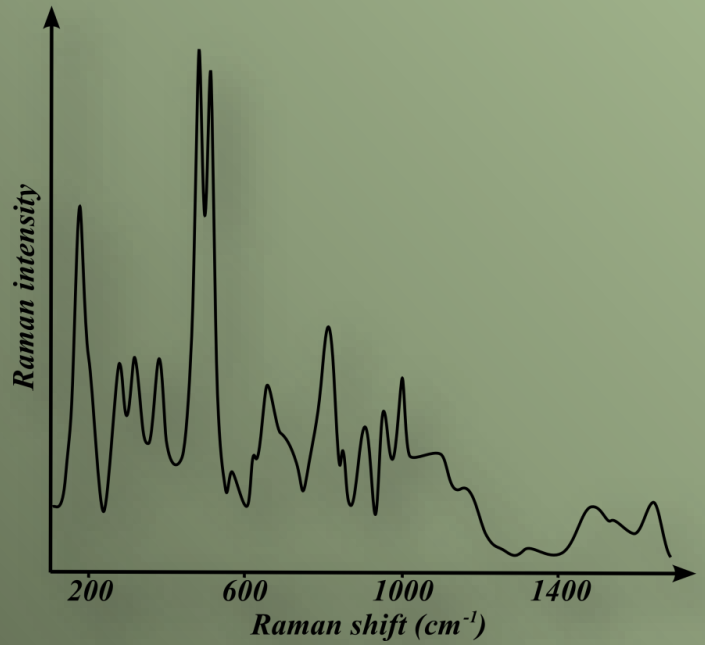
2- « scientifique » calibration

Using of analogue samples

Camera

CLUPI image (ExoMars) of a chert from Kitty's Gap, South Africa, 3.5Ga.

Raman spectrometer



Raman spectrum of a basalt from Perrier, France

difficult to interpret!

Blind test of the ExoMars Payload

Interpretation exercice using analogue samples

Principle

Two martian analogue samples

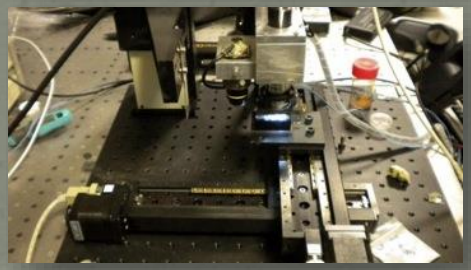
Rock slabs or powder depending of the instruments

And that's all !!!

Which level of interpretation can be achieved ?

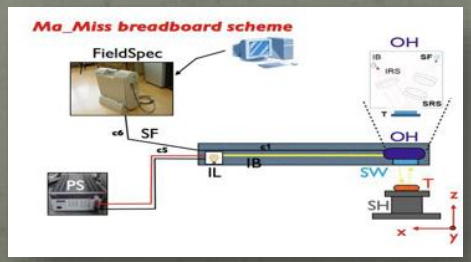
Analyses

MicrOmega
IAS, Orsay, France



RLS
CAB, Valladolid, Spain

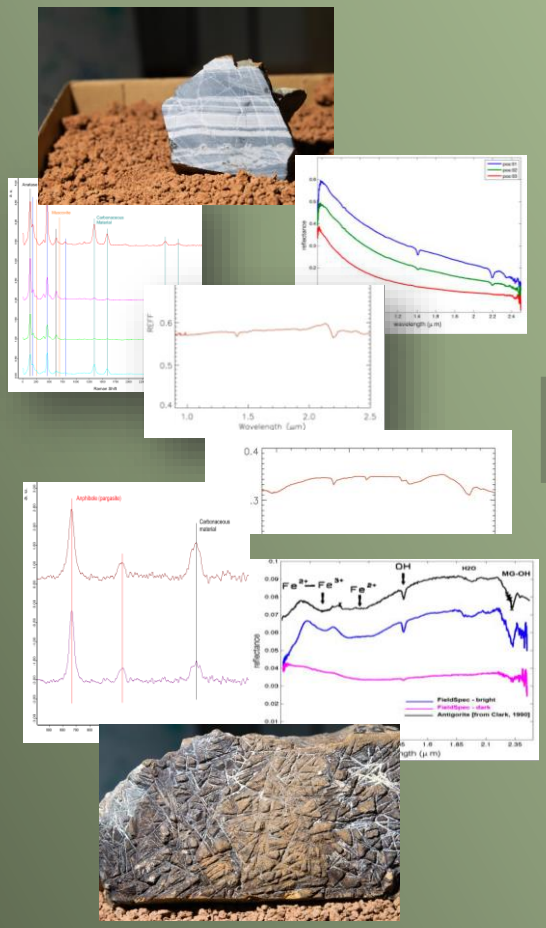
CLUPI
Space X, Neuchatel, Switzerland



Ma_Miss
INAF-IAPS, Roma, Italy

Geological interpretation

Data



Brainstorming

C. Ramboz (geochimist)

N. Le Breton (mineralogist)

Interpretation

Sample 1 = chert

Sample 2 = komatiite

Summary

ExoMars payload could identify and characterise the rock relatively accurately (more info in Bost et al., 2015, PSS).

The payload of an *in situ* mission must be considered as a whole to enable interpretation.

For a "scientific" calibration, instruments need to be tested using the same samples.

ISAR

A rock and mineral collection of analogue samples

The International Space Analogue Rockstore

A collection of fully characterised analogue rocks dedicated to test the payloads of *in situ* missions.

A online database identifying :
-The available samples,
-a loan application system,
-the available data obtained from laboratory instruments and space instruments.

The ISAR: a collaborative project

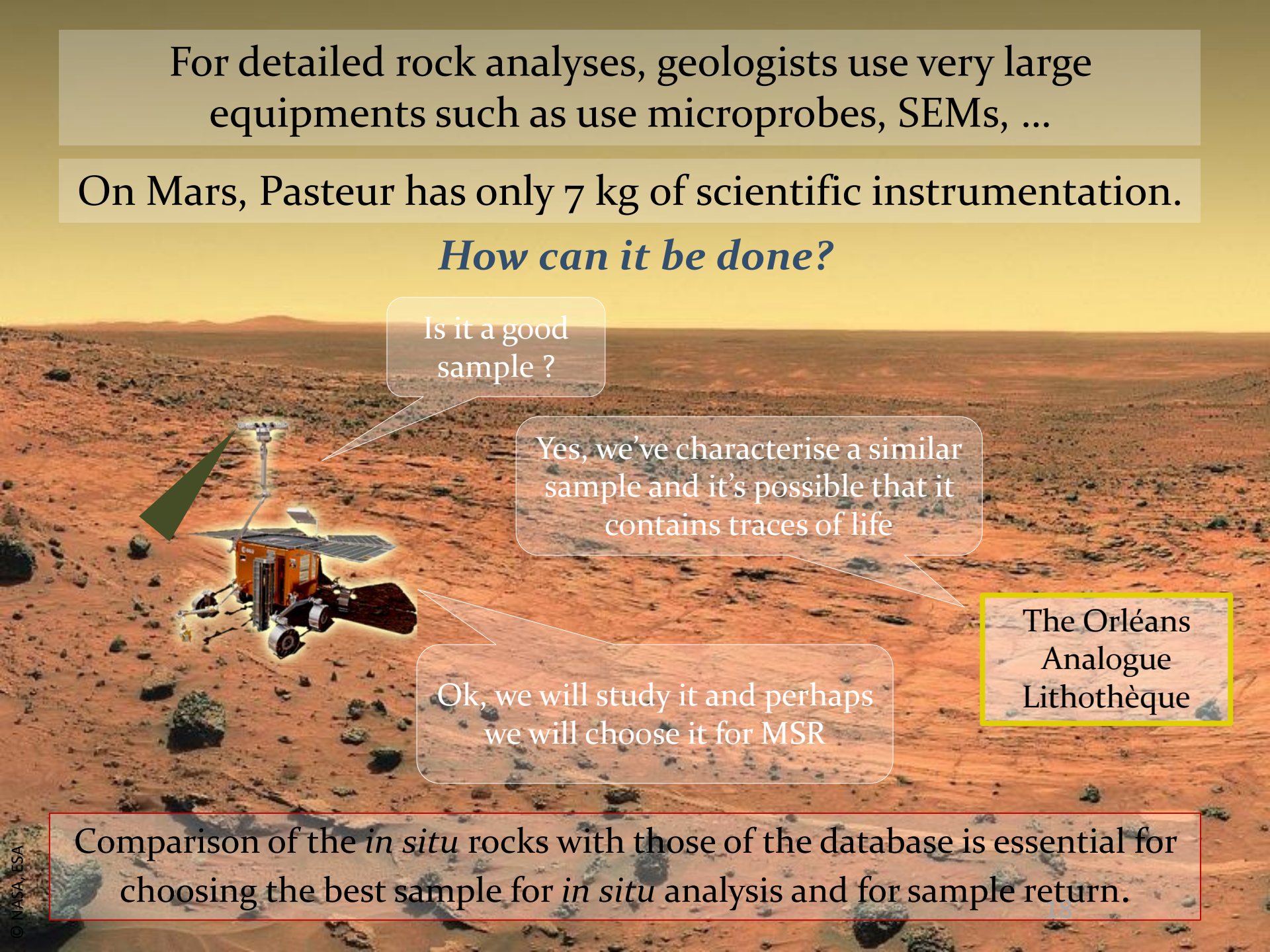
Mars analogues

Principal target of in situ missions

For detailed rock analyses, geologists use very large equipments such as use microprobes, SEMs, …

On Mars, Pasteur has only 7 kg of scientific instrumentation.

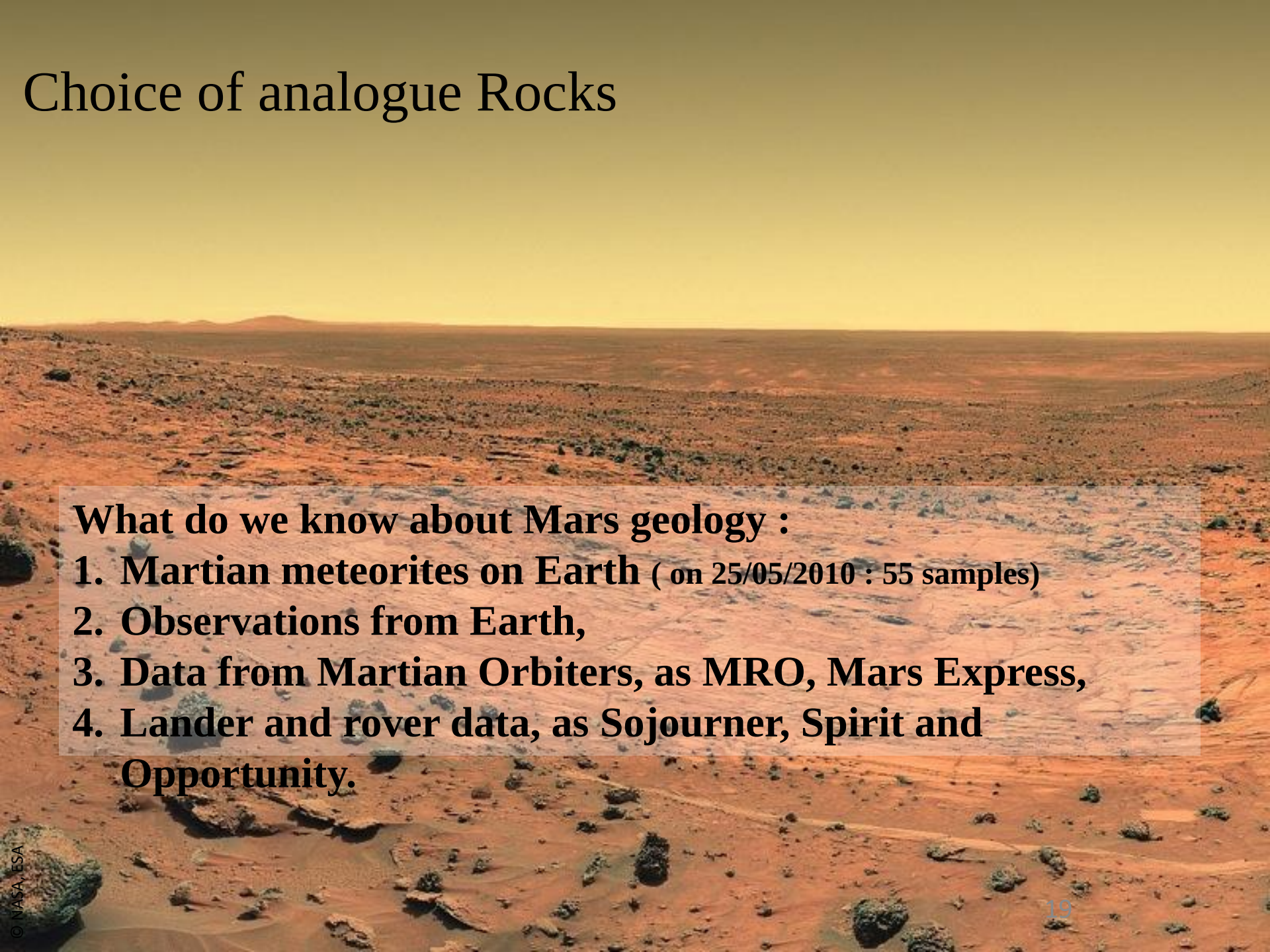
How can it be done?



The Orléans Analogue Lithothèque

Comparison of the *in situ* rocks with those of the database is essential for choosing the best sample for *in situ* analysis and for sample return.

Choice of analogue Rocks

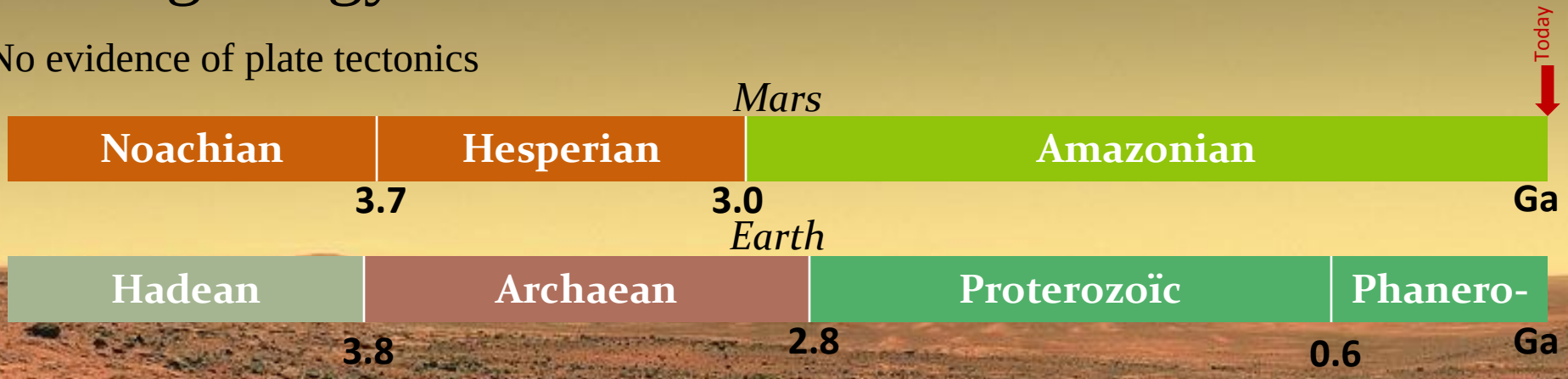


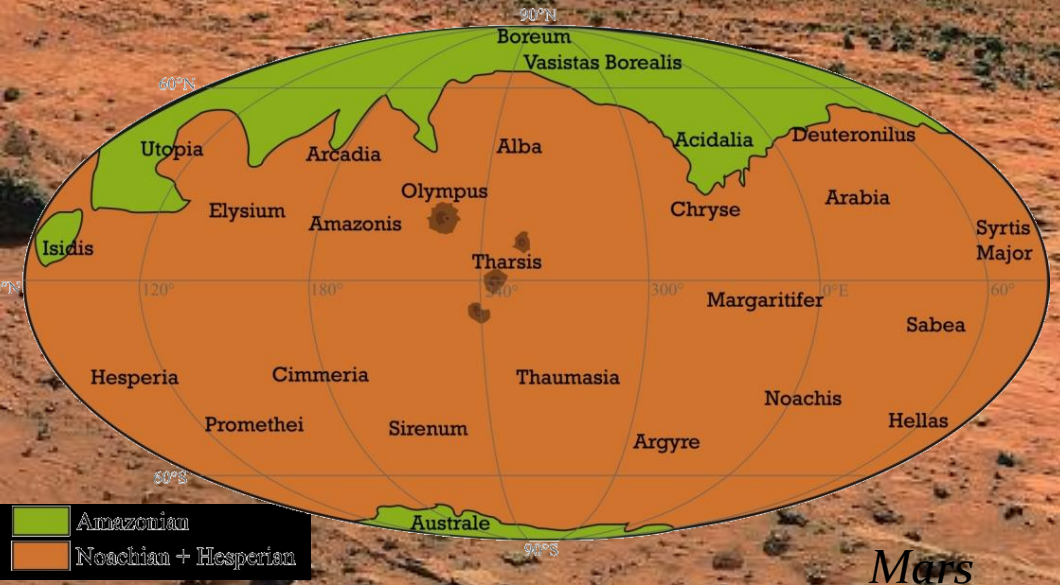
What do we know about Mars geology :

1. **Martian meteorites on Earth (on 25/05/2010 : 55 samples)**
2. **Observations from Earth,**
3. **Data from Martian Orbiters, as MRO, Mars Express,**
4. **Lander and rover data, as Sojourner, Spirit and Opportunity.**

Mars geology

No evidence of plate tectonics





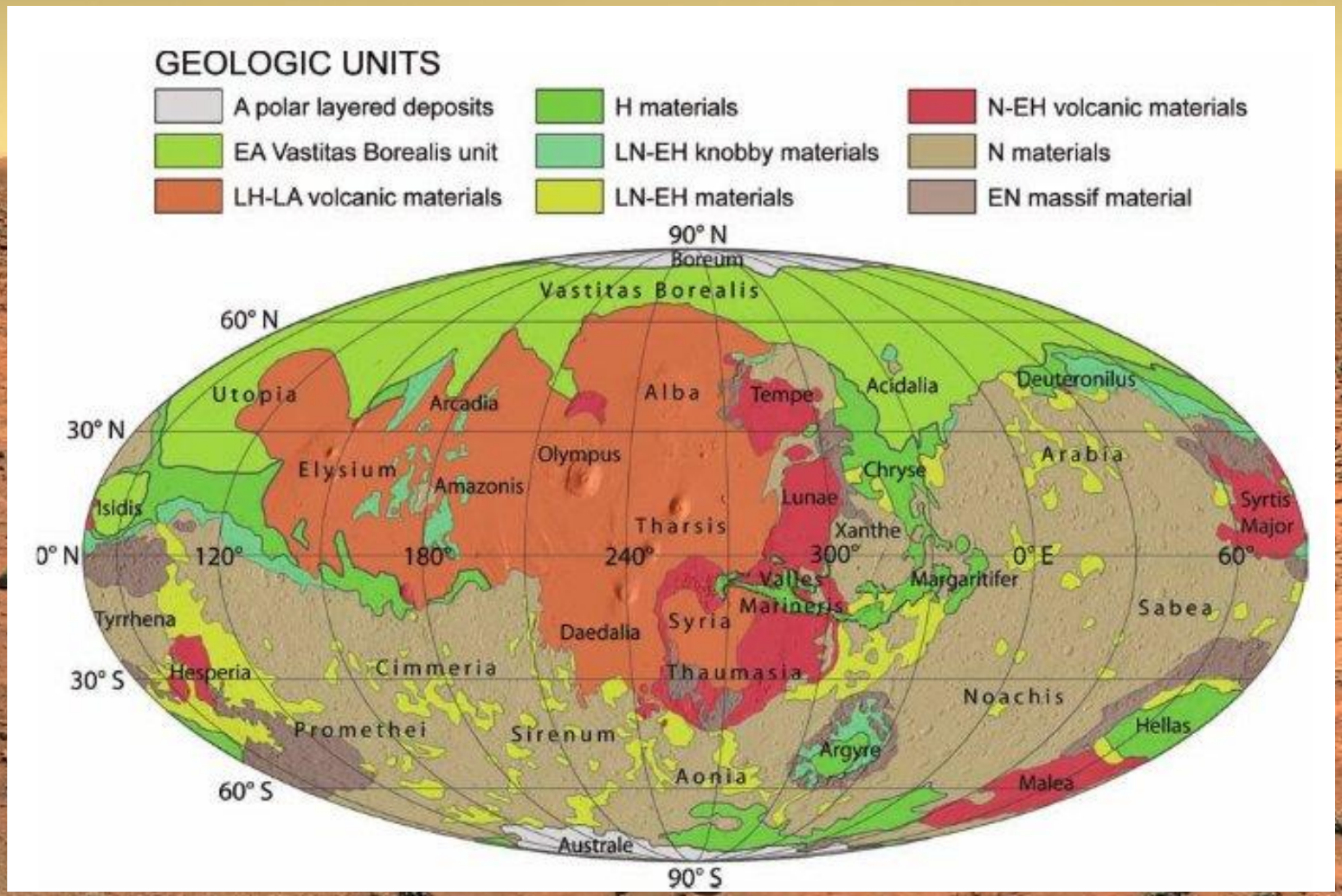
Mars

Earth

After, Soderblom et Bell, 2008,Cambridge

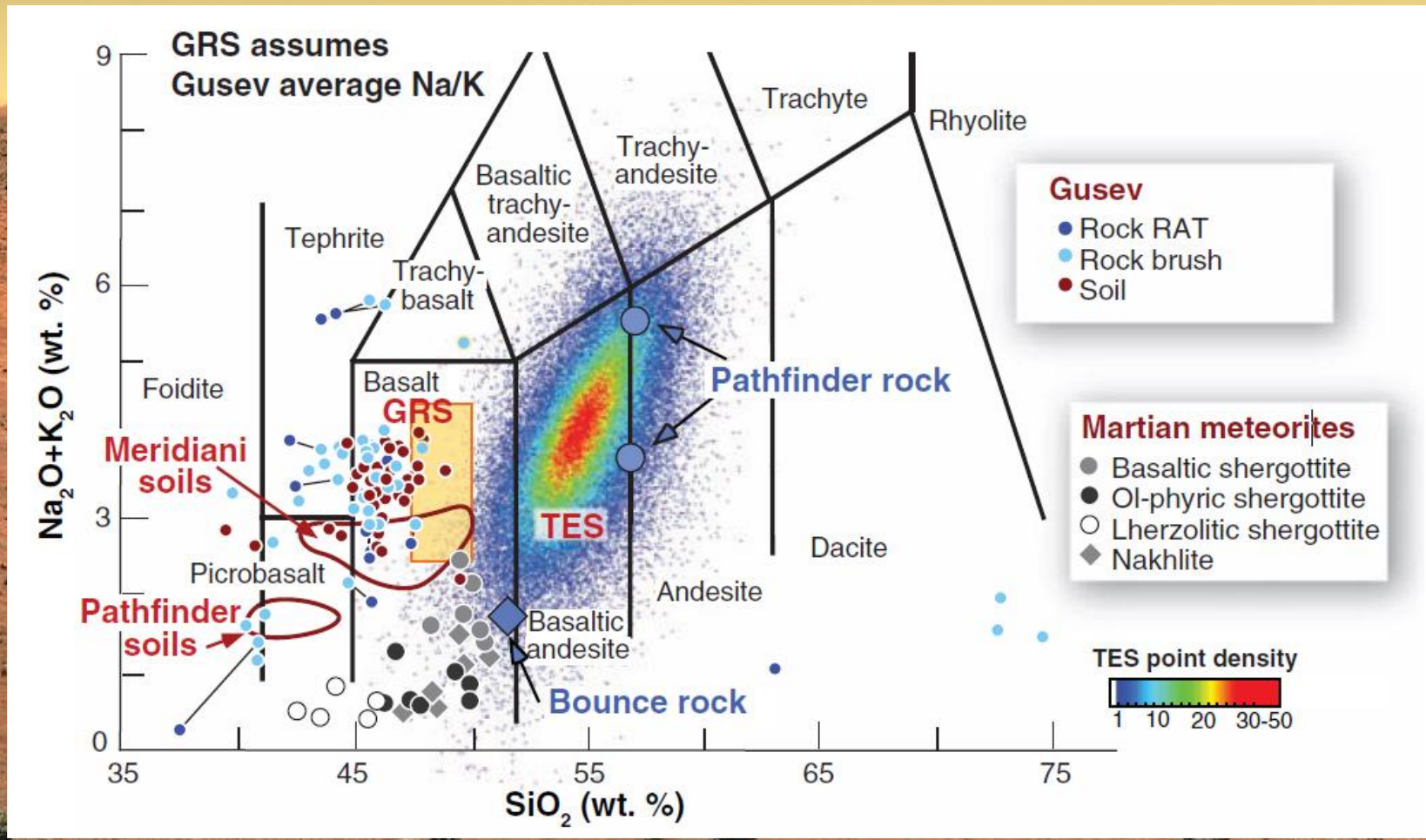
Mars geology

Mostly very primitive volcanic rocks : Basalts



Soderblom et Bell, 2008 after Nimmo et Tanaka, 2005,Cambridge Press

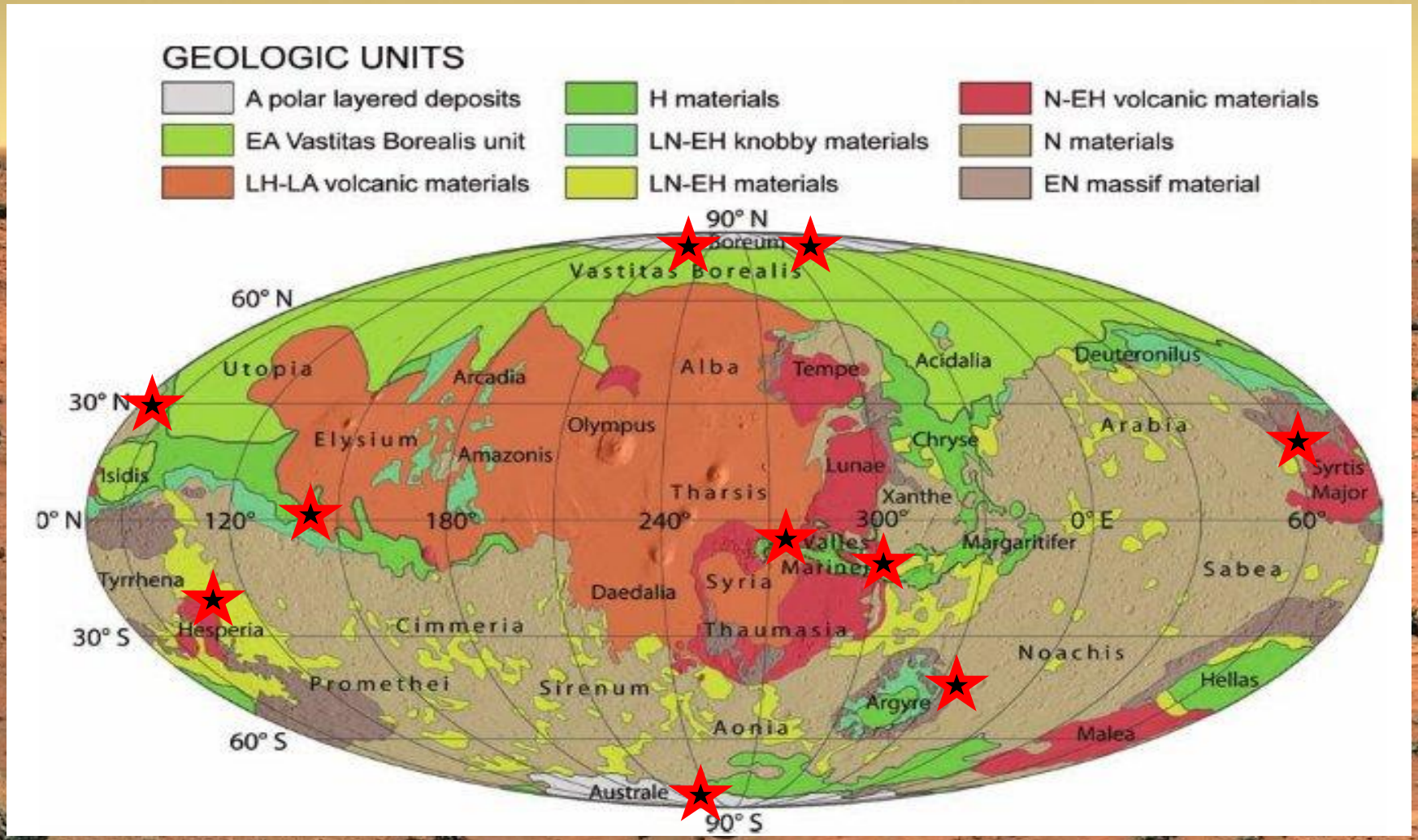
Mars geology



McSween *et al.*, 2009,

Mars geology

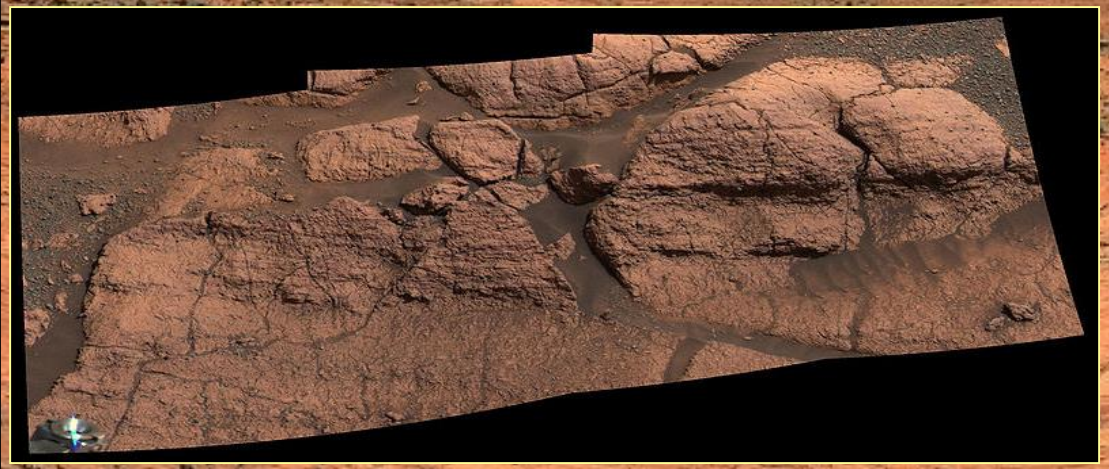
- Sediments (Lacustrines, hydrothermals, evaporite,…)



Soderblom et Bell, 2008 after Nimmo et Tanaka, 2005, Cambridge Press

Mars geology

Mars has bedded sediments.
Formed under the action of liquid water, wind?



Erebus crater, Meridiani Planum,
Pancan on the MER Opportunity 2 March 2006
Squyres et al.,2006
Science cover of number 313, 8 September 2006

Preliminary rock analogue list

Sample	Type	Relevance	*Origin*
Basalts	Ultramafic	Soils and Rock analysis on Mars	*Svalbard (Norway)*
	Primitive	Soils and Rock analysis on Mars	*Etna (Italia)*
	Altered	Possibly contains life	*El Teide, (Tennerife)*
	Silicified	Hydrothermal events on Mars and primitive life	*Barberton (south Africa)*
	Columnal	Geomorphological evidence on Mars	*French Massif Central*
Clays	Natural Nontronite	Typical of aqueous basalt alteration and possible life support	*Nontron (France)*
	Artificial Nontronite	Typical of aqueous basalts alteration without life	*Laboratory*
Sediments	BIF	Hydothermal deposit and opal on Mars, possible association with primitive life	*Pilbara (Australia)*
	Volcanic	Volcanic sediments deposited in coastal environments, contain fossil life	*Kitty's Gap, Pilbara (Australia)*
Carbonates	Biominerals, good comparison with ALH84001		*Svalbard (Norway)*

Laboratory analysis…..

Preparations :	*Tools :*	*Type :*
None	*Hand sample description*	Mineralogy Texture / Structure
Powder	*ICP OES /MS*	Chemistry
	XRD	Mineralogy
	IR , Raman spectrometry	Composition
Thin Section	*Optical view (Microscopic)*	Mineralogy Texture /Structure
	Cathodoluminescence Microscopic	Chemistry / Mineralogy
	Raman spectrometry	Composition
	Electronic microprobe	Chemistry
	Electron Microscope (SEM)	Mineralogy Texture/ Structure

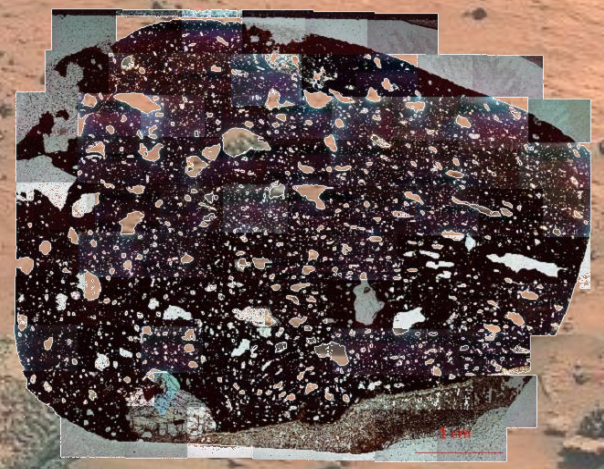
Example : Ultramafic basalt from Svalbard

We made very detailed analysis of the rocks to be used for calibrating the instruments :

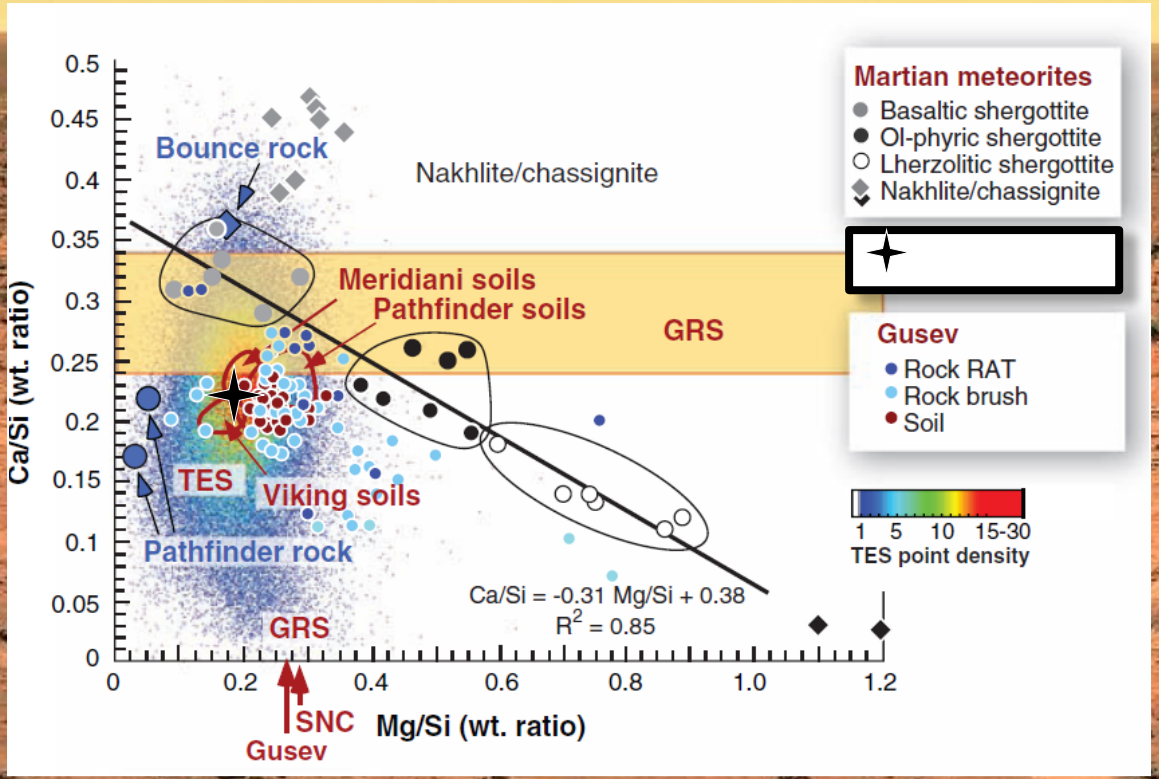
- thin section
- abraded sample surface
- rough sample surface
- powder
- final objective – testing the rover instruments

Example : Ultramafic basalt from Svalbard

good chemical analogues

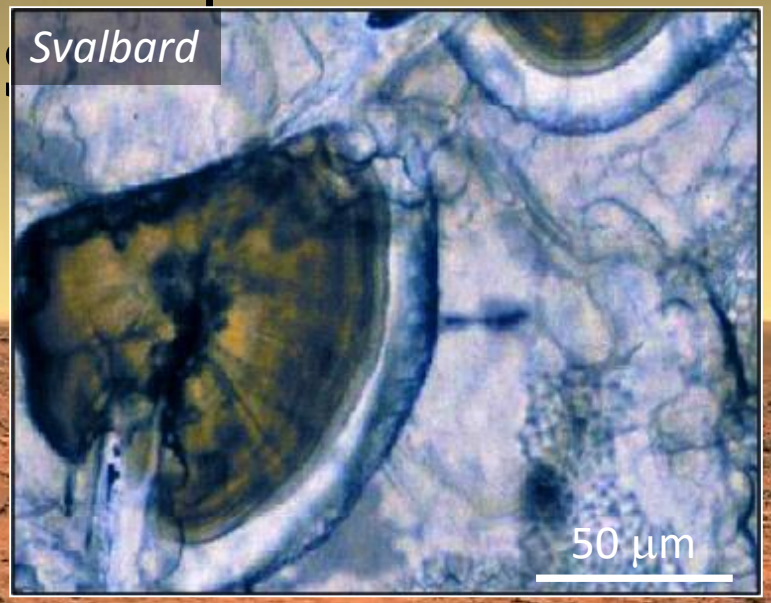


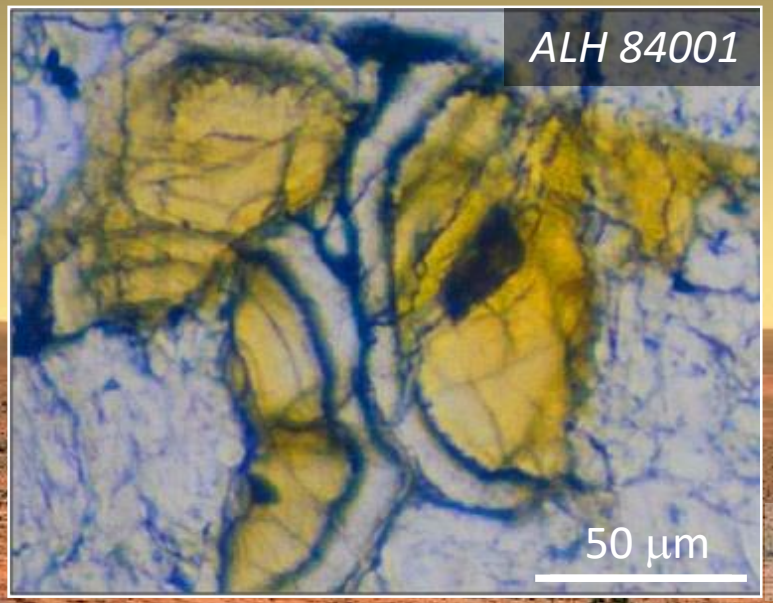
Sample and Thin section



McSween *et al.*, 2009, Science

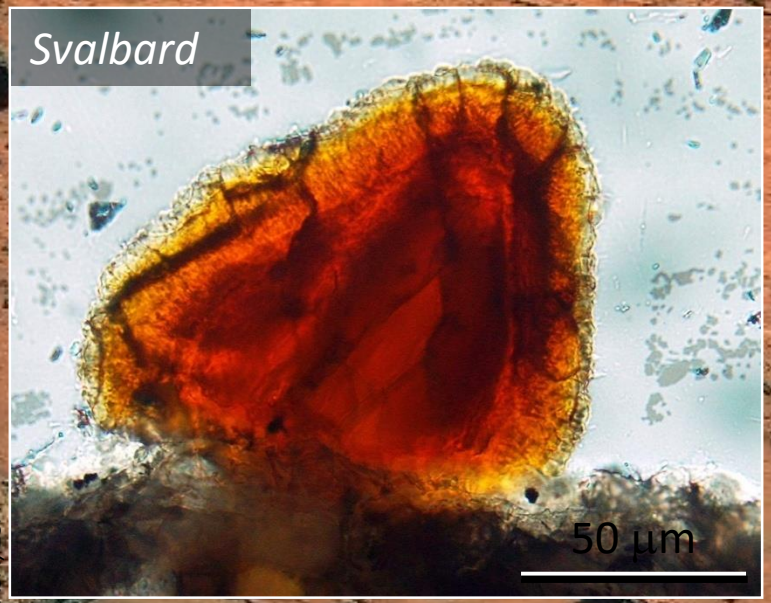
Example : Ultramafic basalt from

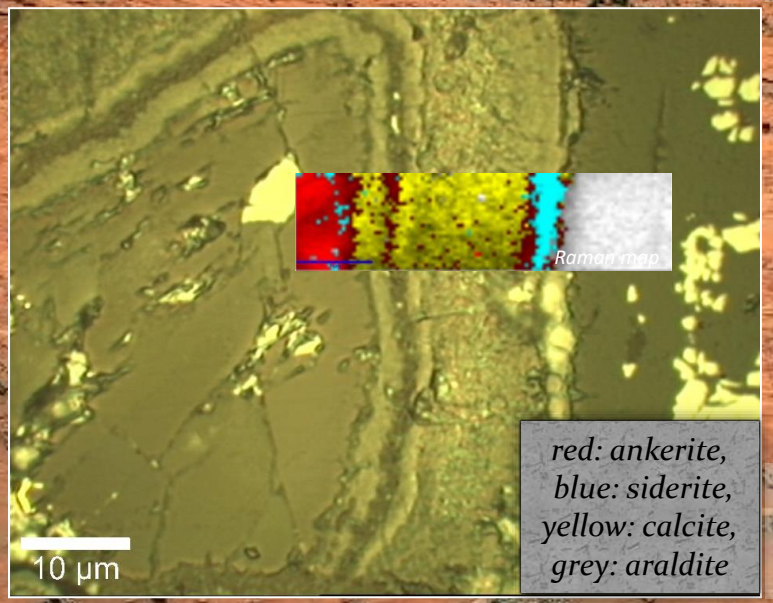




Optical microscope views of carbonate globules from Mars and Earth, ankerite and siderite.

Treiman *et al.*, 2002, EPSL





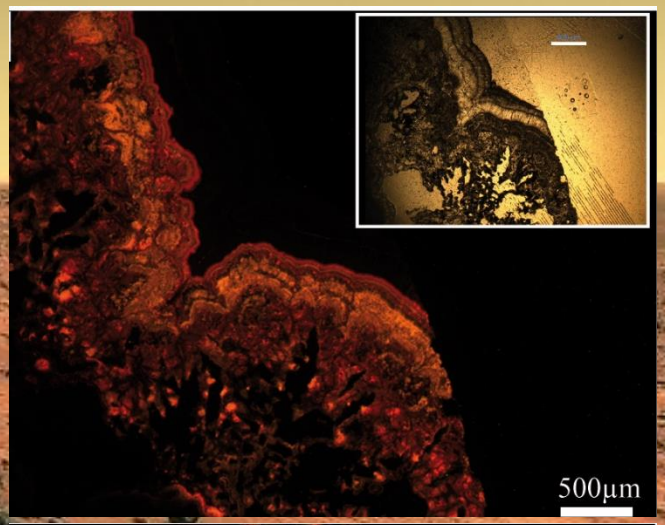
red: ankerite, blue: siderite, yellow: calcite, grey: araldite

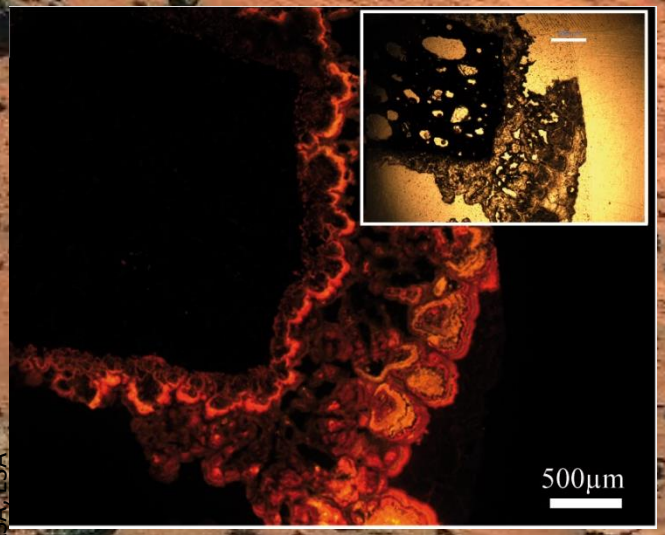
Optical microscope views of carbonate globules from Earth, ankerite, calcite and siderite with associated Raman map .

Bost, Westall, Ramboz *et al.*, *In preparation*

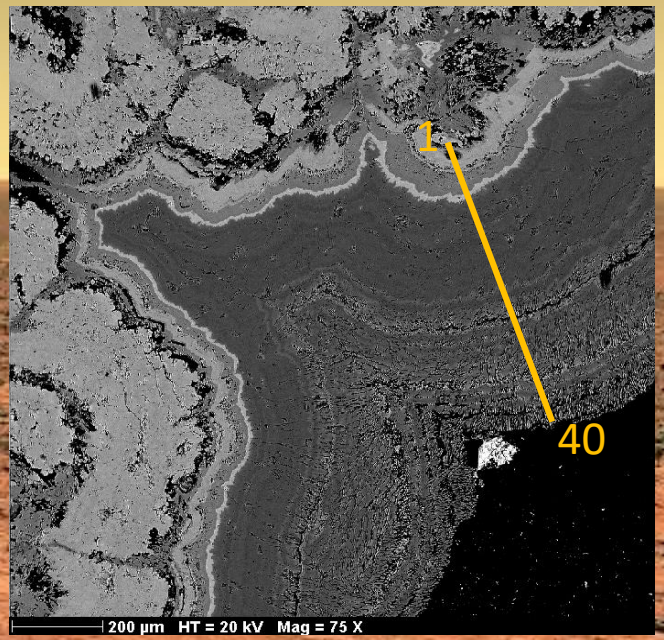
Example : Ultramafic basalt from Svalbard

Cathodoluminescence images





Backscattered imaging



Concretions of Fe and Mg,Ca- carbonates

Microprobe analysis

% de Ca, Mg, Fe :

sample	Fe	Ca	Mg	Total
1	0	47,774	52,226	100
2	0	45,312	54,688	100
3	0	14,356	85,644	100
4	0	7,224	92,776	100
5	0	13,985	86,015	100
6	0	9,347	90,653	100
7	0	28,248	71,752	100
8	0	52,860	47,140	100
9	0	10,067	89,933	100
10	0	50,322	49,678	100
11	0	13,965	86,035	100
12	0	9,657	90,343	100
13	0	17,671	82,329	100
14	0	17,941	82,059	100
15	0	49,547	50,453	100
16	0	47,797	52,203	100
17	0	61,208	38,792	100
18	0	54,719	45,281	100
19	0	45,616	54,384	100
21	0	36,971	63,029	100
22	0	37,521	62,479	100
23	0	54,991	45,009	100
24	0	55,713	44,287	100
25	0	46,624	53,376	100
26	0	51,259	48,741	100
27	0	46,393	53,607	100
28	0	46,185	53,815	100
29	2,918	39,133	57,949	100
30	0,000	16,083	83,917	100
31	0,000	18,777	81,223	100
35	17,744	6,746	75,510	100
36	18,394	7,527	74,079	100
40	0	16,402	83,598	100

Bost, Westall, Ramboz *et al.,In preparation*

A collection of varied samples

Volcanic rocks

Scories 09IT01

Komatiite 10ZA09

Komatiite 11CA02

Sedimentary rocks

Chert 00AU04

Chert 00AU05

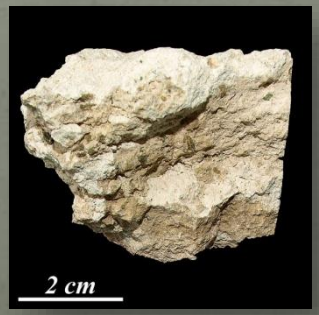
Minerals

Aragonite 12FR02

Apatite 12UN05

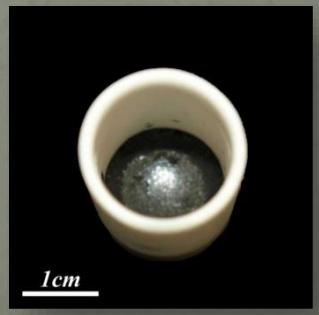
Epidote 12PK01

« weathered rocks »



Carbonate 11CY04

Artificial materials



Basalt 11AR02

Structure and organisation

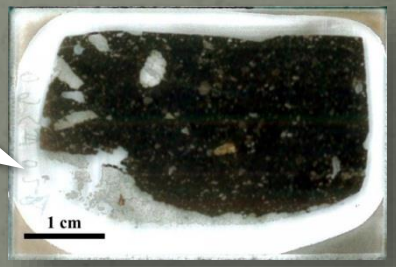
Nomenclature and database

Classification

Sampling

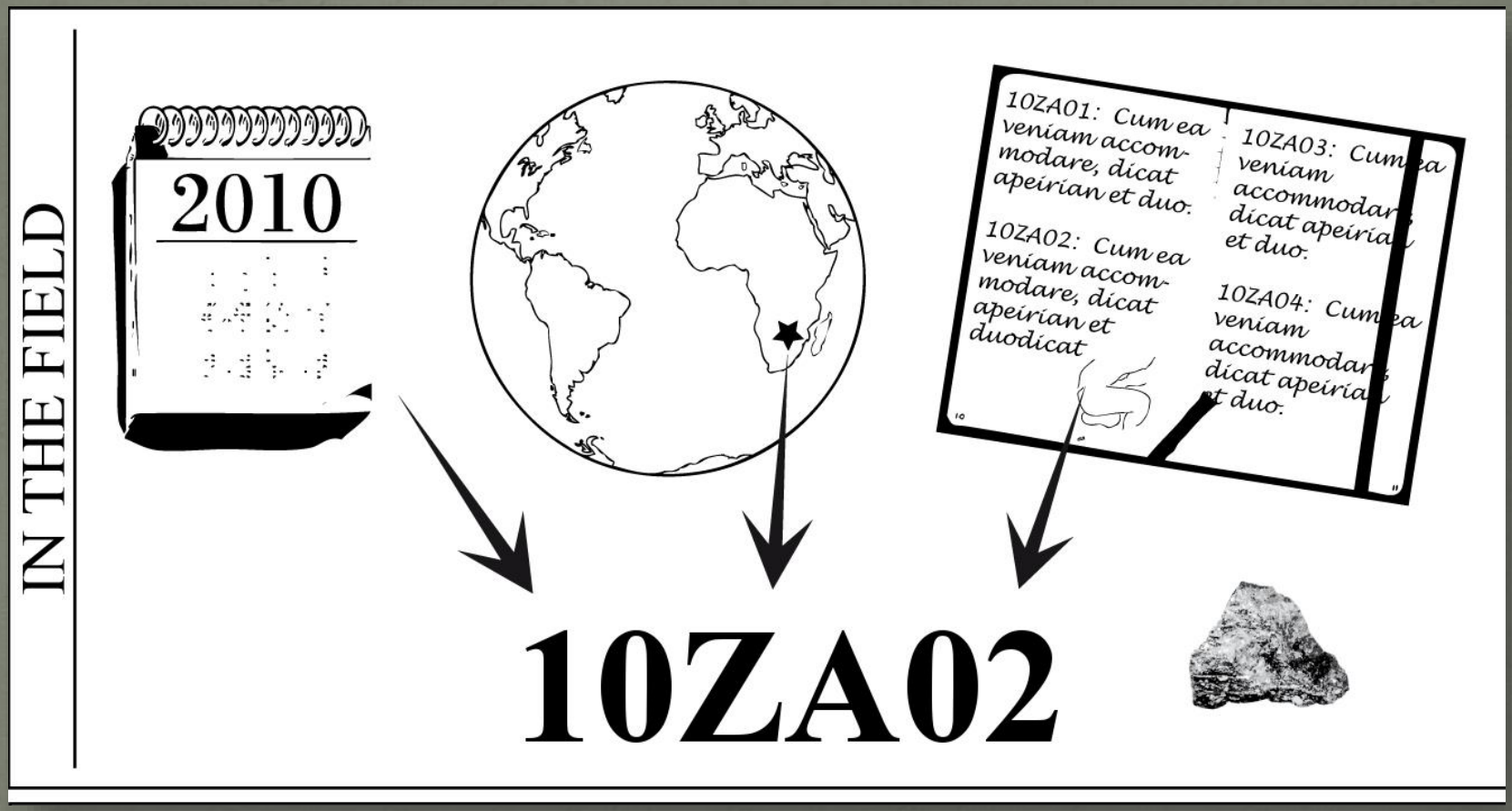
Initial sample

1st order sample



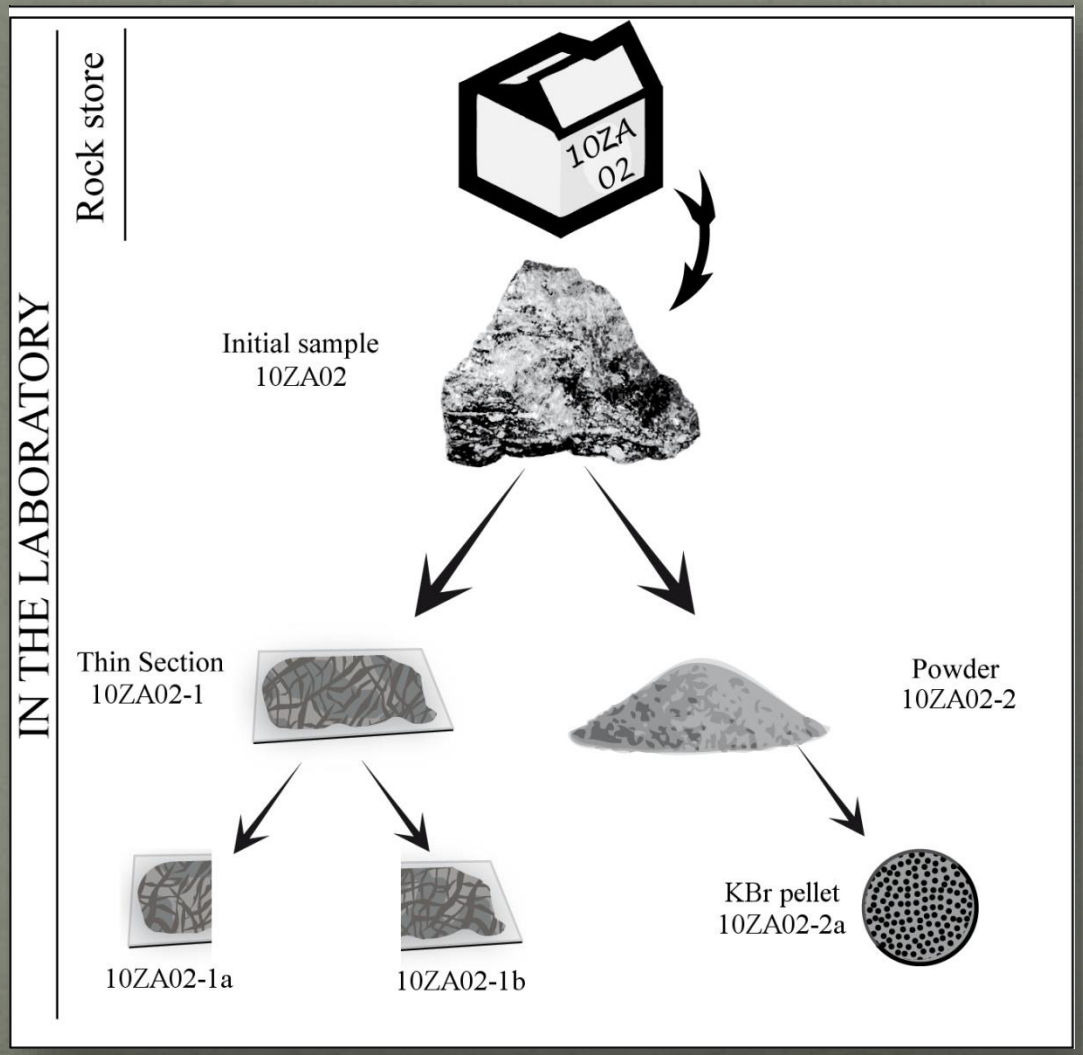
2nd order sample

Nomenclature - 1



Initial Sample

Nomenclature-2



1st order sample

2nd order sample

Data

Origin (locality)

Petrographic data (typ of rock, mineralogy, analogy…)

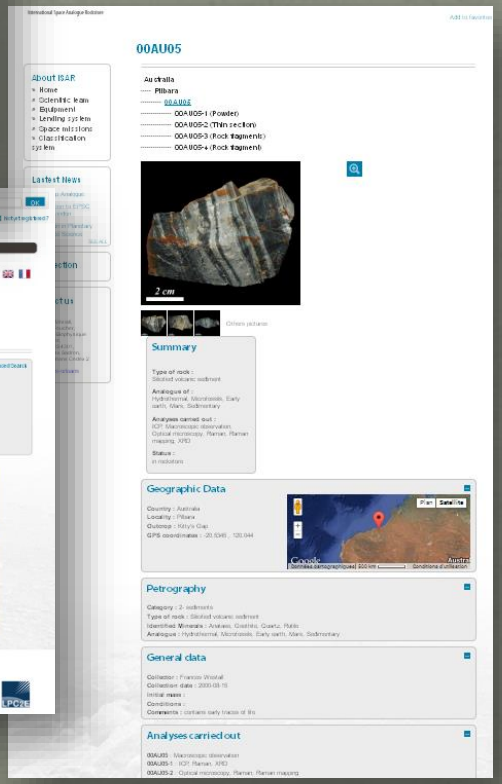
Analysis (optical microscopy, Raman spectroscopy …)

Type of sample (slab of rock, powder, thin section…)

Online acces via web

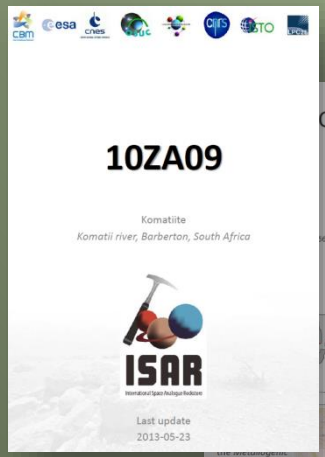
www.isar.cnrs-orleans.fr

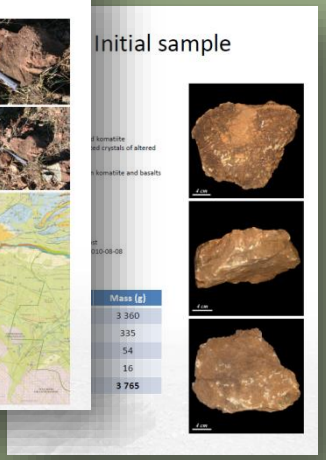
Database



For registered members

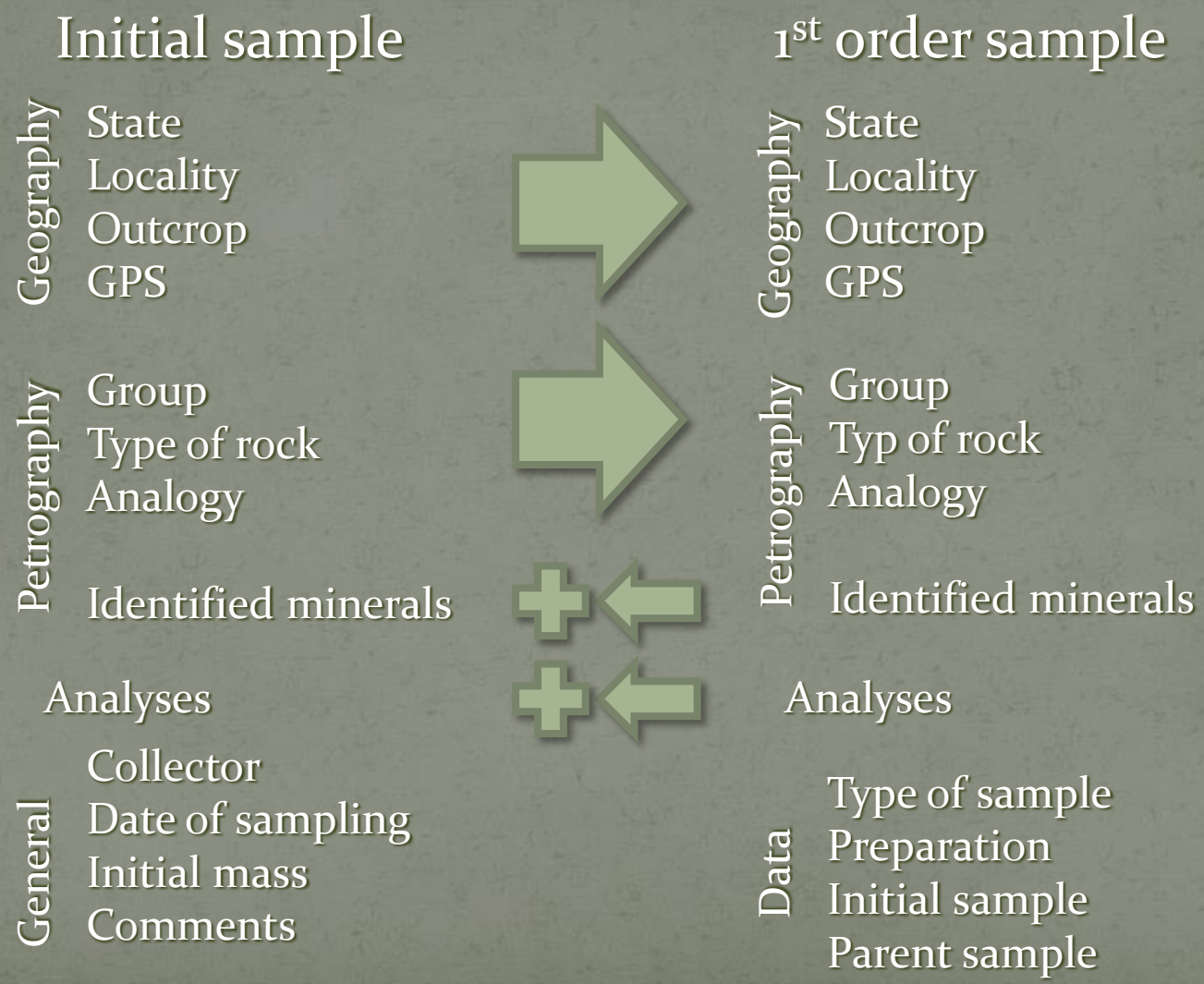
*pdf with details





+ data (.xls, .txt…)

Associated data



Summary

- A web site : **www.isar.cnrs-orleans.fr**
- ~ 60 samples including rocks and minerals
- Multiple types of data available for each sample
- A lending system

- Artificial samples
- Different analogues sites

ISAR
International Space Analogue Rockstore

Thanks

Reference:

Artificial basalts:
Bost et al., *Meteoritics and Planetary Science*, 2012, 47, 5, 820–831.

ISAR:
Bost et al., *Planetary and Space Science*, 2013, 82-83, 113-127.

Blind test:
Bost et al., *Planetary and Space Science*, 2015, 108, 87-97.

Or in my thesis manuscript, available using this link :

www.theses.fr/2012ORLE2027/document

And :

www.isar.cnrs-orleans.fr

nicolas.bost@cnrs-orleans.fr