Mars pictures reveal frozen sea

BBC News - Last Updated: Monday, 21 February, 2005, 18:07 GMT

A huge, frozen sea lies just below the surface of Mars, a team of European scientists has announced.

Their assessment is based on pictures of the planet's near-equatorial Elysium region that show plated and rutted features across an area 800 by 900km.

The team think a catastrophic event flooded the landscape five million years ago and then froze out.

"What we'd like is for the European Space Agency (Esa), with UK support, to send its next lander there"
Jan-Peter Muller, University College London

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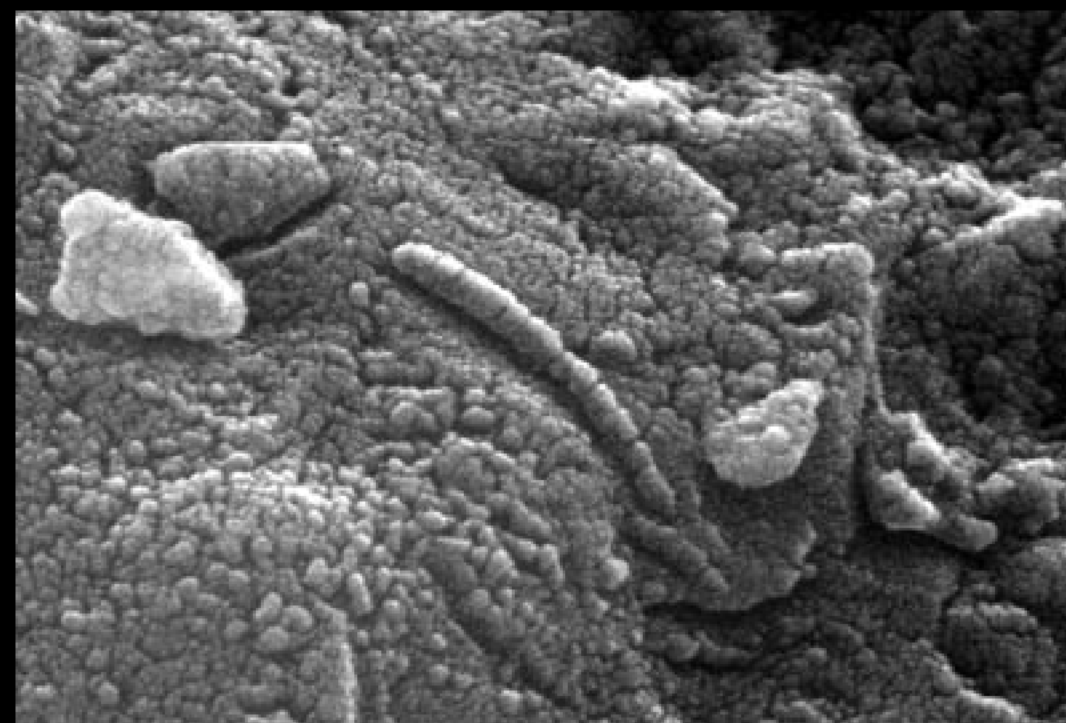

ALH 84001

- Collected in 1984
- Igneous rock
- Wrongly classified (diogenite)
- Crystallisation age of 4.5 Gy
- Left Mars 16 My ago
- Arrived on Earth 13,000 y ago
- First substantive paper claimed that carbonates were high-temperature (1993)
- Carbonates demonstrated to be of low-temperature origin deposited by fluids (1994)
- McKay et al. (1996)

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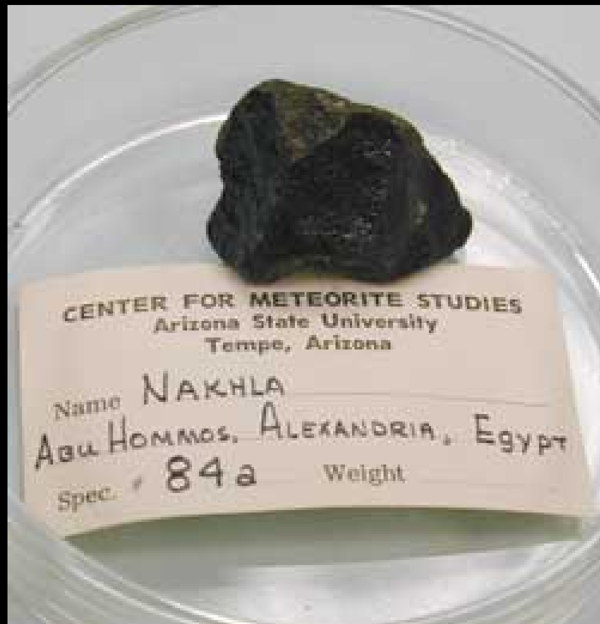

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LUNAR PLANET. SCI. XIV (1983)

NO UNUSUAL COMPOSITIONS OF THE STABLE ISOTOPES OF NITROGEN, CARBON AND HYDROGEN IN SNC METEORITES.

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Traditionally,
Chassigny have beer
Shergottites (4 mem
More recently, thes
meteorites on the b
rites are highly di
are very similar tc
es) and pyroxenites
meteorites is their
1.31 Gy (1,2).
In order to ex
formed near the sur
planet Mars. Subse
suitable candidate
idea of a Martian o
lines of evidence a
The possibilit
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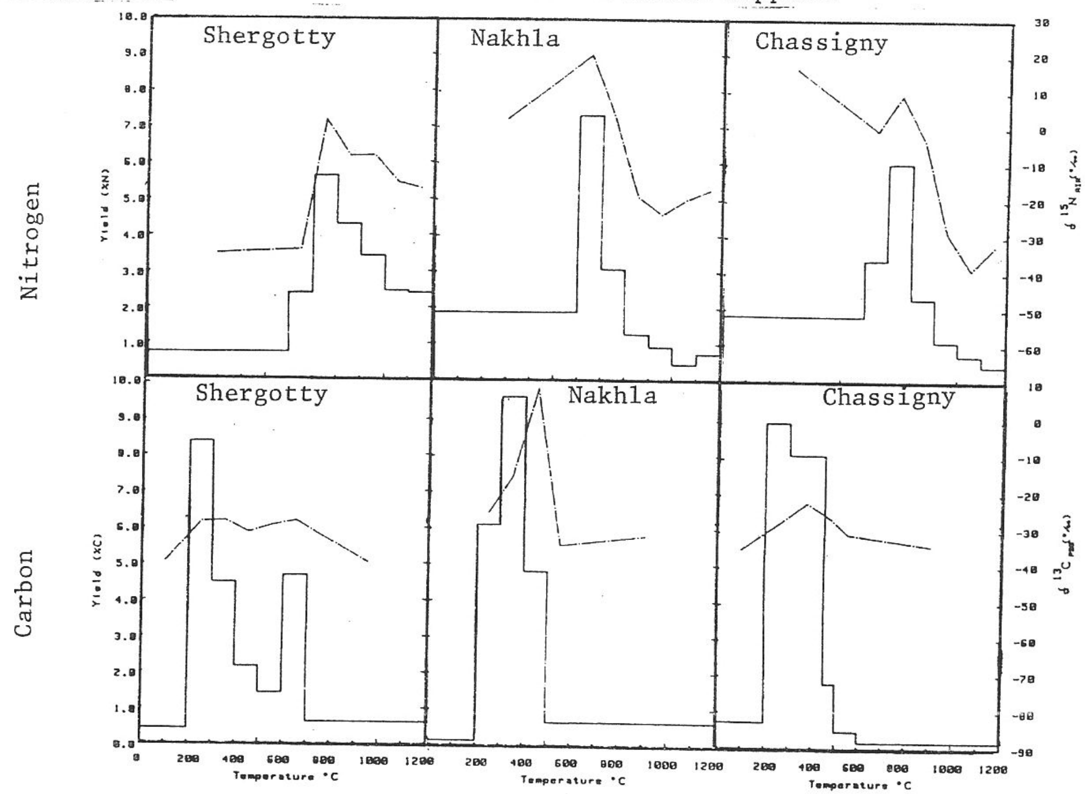
mechanism (unknown)

Mars might have been expected to be similarly outgassed but no evidence of such a process is available from our data.

Acknowledgements We thank the SERC for financial support.



References 1. Gale et al. EPSL 26, 195-206 (1975) 2. Wood & Ashwal PLPSC12, 1359-1375 (1981) 3. Weinke Meteoritics 13, 660-664 (1978) 4. Nyquist et al. Meteoritics 14, 502 (1979) 5. McSween & Stolper Sci. Am. 242, 44-53 (1980) 6. Nier et al. Science 194, 68-70 (1976) 7. Owen et al. JGR 82, 4635-4639 (1977) 8. Floran et al. GCA 42, 1213-1229 (1978) 9. Bunch & Reid Meteoritics 10, 303-315 (1975) 10. Ashworth & Hutchison Nature 256, 714-715 (1975) 11. Donahue et al. Science 216, 630-633 (1982).

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IPW

Martian atmospheric carbon dioxide and weathering products in SNC meteorites

R. H. Carr, M. M. Grady, I. P. Wright & C. T. Pillinger

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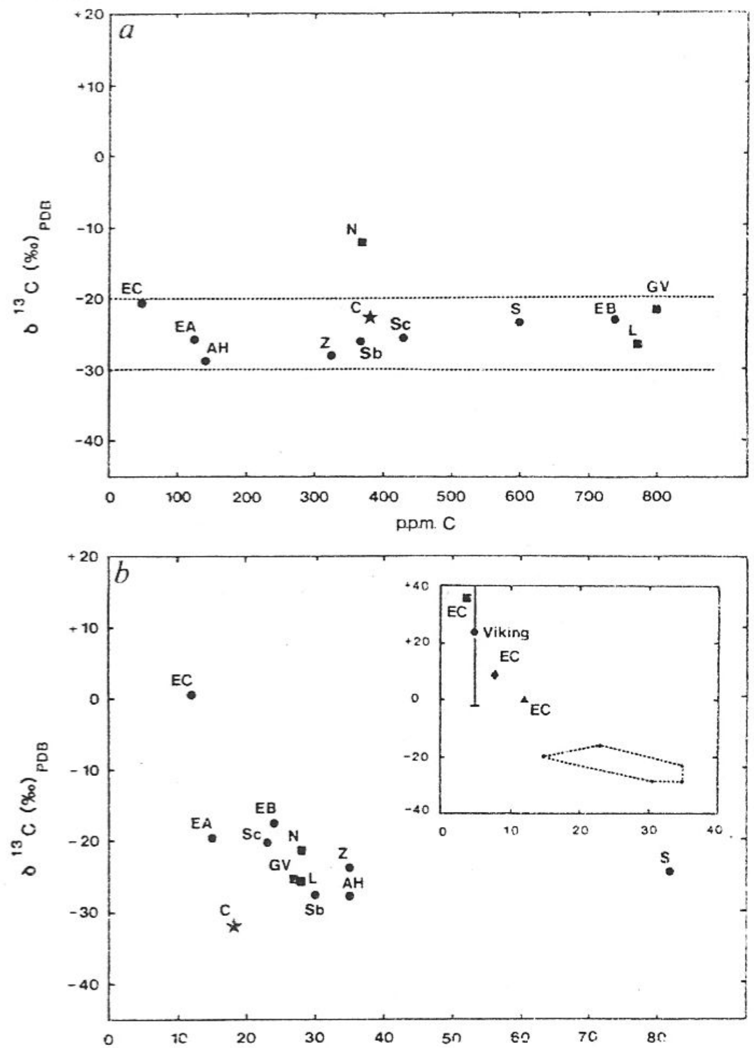
SNC meteorites—four shergottites, three nakhlites and Chassigny—are postulated to have originated on Mars[1]. Their late crystallization ages (<1,300 Myr compared with 4,600 Myr for other igneous meteorites) and the presence, in shock-produced glass in EETA79001, of noble gas[2] and nitrogen[3] components resembling the martian atmosphere provide evidence for such a provenance. If this interpretation is correct then carbon dioxide, by far the most abundant constituent of the martian atmosphere[4], should also be present. The stepped combustions described here show that most of the carbon present in the samples can be ascribed to terrestrial contamination. EETA79001, however, contains 4.6 p.p.m. of an isotopically distinct component enriched in ^{13}C ($\delta^{13}C = +36‰$), whereas high-temperature carbon of inferred igneous origin in this meteorite and other SNCs has a $\delta^{13}C$ value of about −30‰. The $^{12}C/^{13}C$ ratio of the isotopically heavy component is within the error limits of Viking measurements[4] in the martian atmosphere and, thus, strengthens the case for a planetary origin. Another carbon-containing species, believed to be carbonate, has been found in Nakhla ($\delta^{13}C$ = between +12 and +24‰) and may be a product of atmospheric weathering on Mars.

Analyses of SNC meteorites were performed using a stepped combustion technique, similar to that of Swart *et al.*[5]; isotope measurements were made using a high-sensitivity static mass spectrometer capable of determining $\delta^{13}C$ values to a precision of ±3‰ or better on samples as small as 6×10^{-9} g carbon in the form of carbon dioxide (R.H.C., I.P.W., A. W. Joines and



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Organic Cosmochemistry

- High-Performance Liquid Chromatograph (HPLC)
- Gas Chromatograph - Mass Spectrometer (GC-MS)
- Gas Chromatograph - Isotope ratio Mass Spectrometer (GC-IRMS)
- Dual-inlet Isotope Ratio Mass Spectrometer (IRMS)
- Thermo-Gravimetric - Evolved Gas Analyser (TG-EGA)
- C,H,N Elemental Analyser
- Pyroprobe
- Hydrous Pyrolysis
- Supercritical Fluid Extraction (SFE)
- Preparation Suite (6 fume-cupboards, organically clean laboratory)

Other Facilities

- Several stable isotope ratio mass spectrometers, extraction systems, laser probes, chemical preparative laboratories, and support equipment
- High sensitivity carbon stable isotope ratio mass spectrometer (*MS86*)
- High sensitivity nitrogen stable isotope ratio mass spectrometer (*Finesse*)

And what is a 'black shale' ?

(from www.blackshale.com)

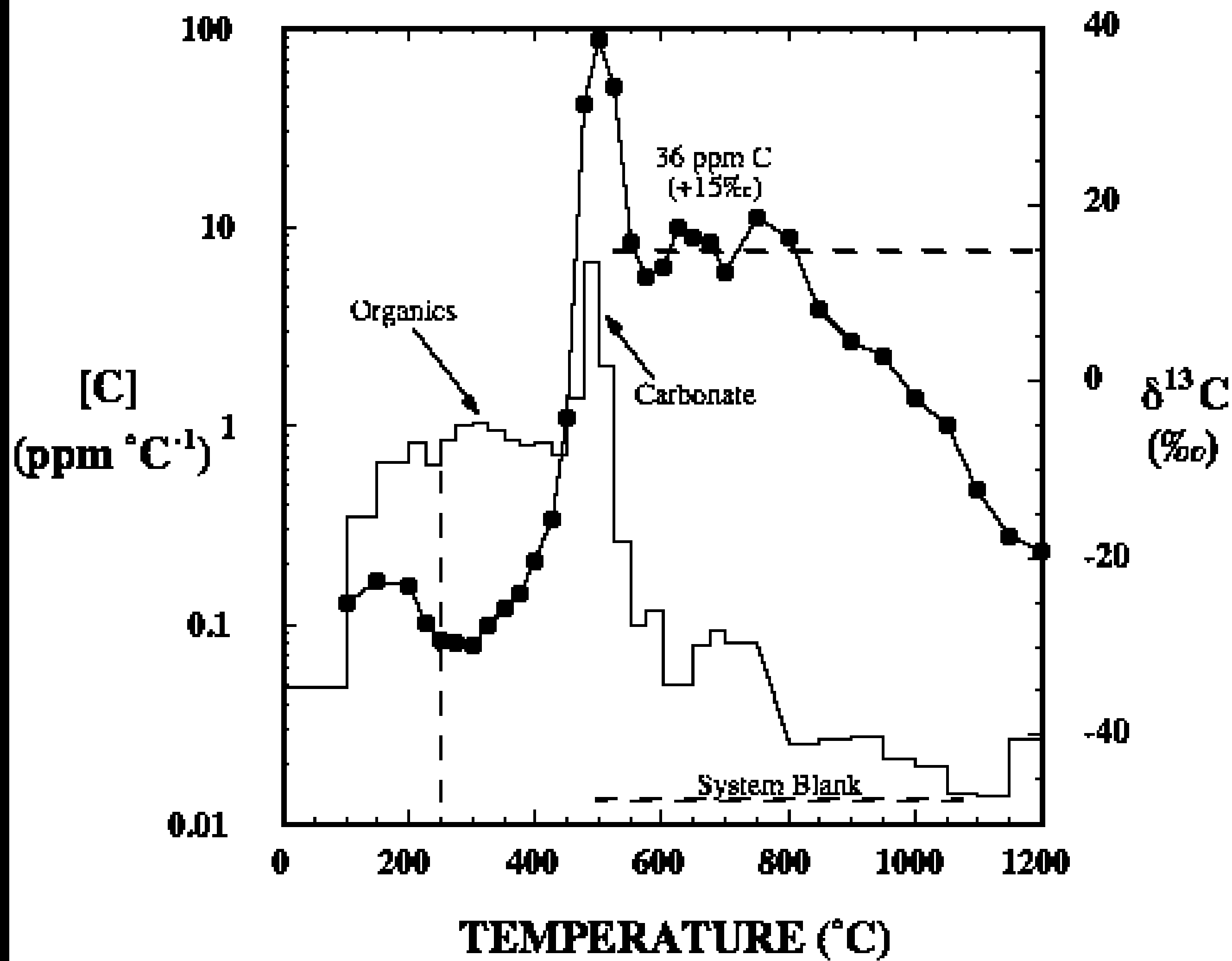
According to the Dictionary of Science and Technology:

"A thinly bedded shale that is rich in carbon, sulfide, and organic material; formed by anaerobic decay of organic matter."

According to the Glossary of Geology (4th ed.):

A dark, thinly laminated carbonaceous shale, exceptionally rich in organic matter (5% or more carbon content) and sulfide (esp. iron sulfide, usually pyrite), and more commonly containing unusual concentrations of certain trace elements (U, V, Cu, Ni). Fossil organisms (principally planktonic and nektonic forms) are commonly preserved as a graphitic or carbonaceous film or as pyrite replacements. Syn.: biopelite (...)

Stepped Combustion Data from ALH 84001,106



CORDIS News

ESA prepares for mission to Mars
[Date: 2004-02-24]

- Undeterred by the apparent failure of the UK's Mars probe Beagle2, the European Space Agency (ESA) is looking ahead to 2009, the date foreseen for the launch of the ExoMars rover and its Pasteur payload of scientific instruments.
- 'Our intention is to define a multi-instrument package that will be able to fulfil a number of key tasks,' said Jorge Vago, a scientist working on ExoMars. 'It should be able to drill into the surface, retrieve and analyse samples, study the physical environment and look for evidence of biomarkers - clear signs that life has existed on Mars in the past, or even survives to the present day.'

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Pasteur
Possible set of instruments

	Scope	Heritage	Mass
Drill	Soil sample acquisition at 1.5 m depth	Rosetta (but more complex)	11 kg (with 2 d.o.f. manipulator)
SPHS	Prepare samples for measurement, and distribute them to specific diagnostics	ESA Phase A studies output	5 kg (with milling and processing units)
PanCam	Viewing, colour pictures. On mast 1.5 m above surface, can rotate and tilt	MER Rover (NASA)	2 kg (excl. mast)
Optical Colour Microscope	Identify structures characteristic of biological activity	MECA (Beagle 2)	0.5 kg
Subsurface Electromagnetic Sounder	Subsurface water detection. Attached to drill system platform.	[Mars Topical Team]	1.5 kg
Raman Spectrometer/LPS	Compare spectrum with those of known laboratory samples/Determine elementary atomic composition of sample	[ESA GSTP]	1.5 kg
Oxi-GC/MS	Determine the composition and abundance of volatile or volatilisable components	COSAC (Rosetta)	7.5 kg
Life Marker Chip	Compare residues with known organic compounds	[new development]	3 kg

Aurora - Mixed Messages

- Put humans on Mars
- Develop a mechanical robot, capable of travelling 100 km
- Return samples of Mars to Earth
- Discover life

Scientific Campaign for the Investigation of Mars

- Let’s do things that others are not doing
- Let’s do things that interest European scientists
- Let’s remain realistic about the route towards understanding the workings of another world
- Should be part of *ESA’s Cosmic Vision*

Exobiology and geochemical science on the surface of Mars

Mars - what's new?

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Mars - what's new?

- Trace atmospheric gases - methane, formaldehyde
- Sulfur-bearing minerals and rocks - jarosite, epsomite
- Sedimentary rocks - evidence from layering and other morphological features
- Relatively recent fluid-related activity

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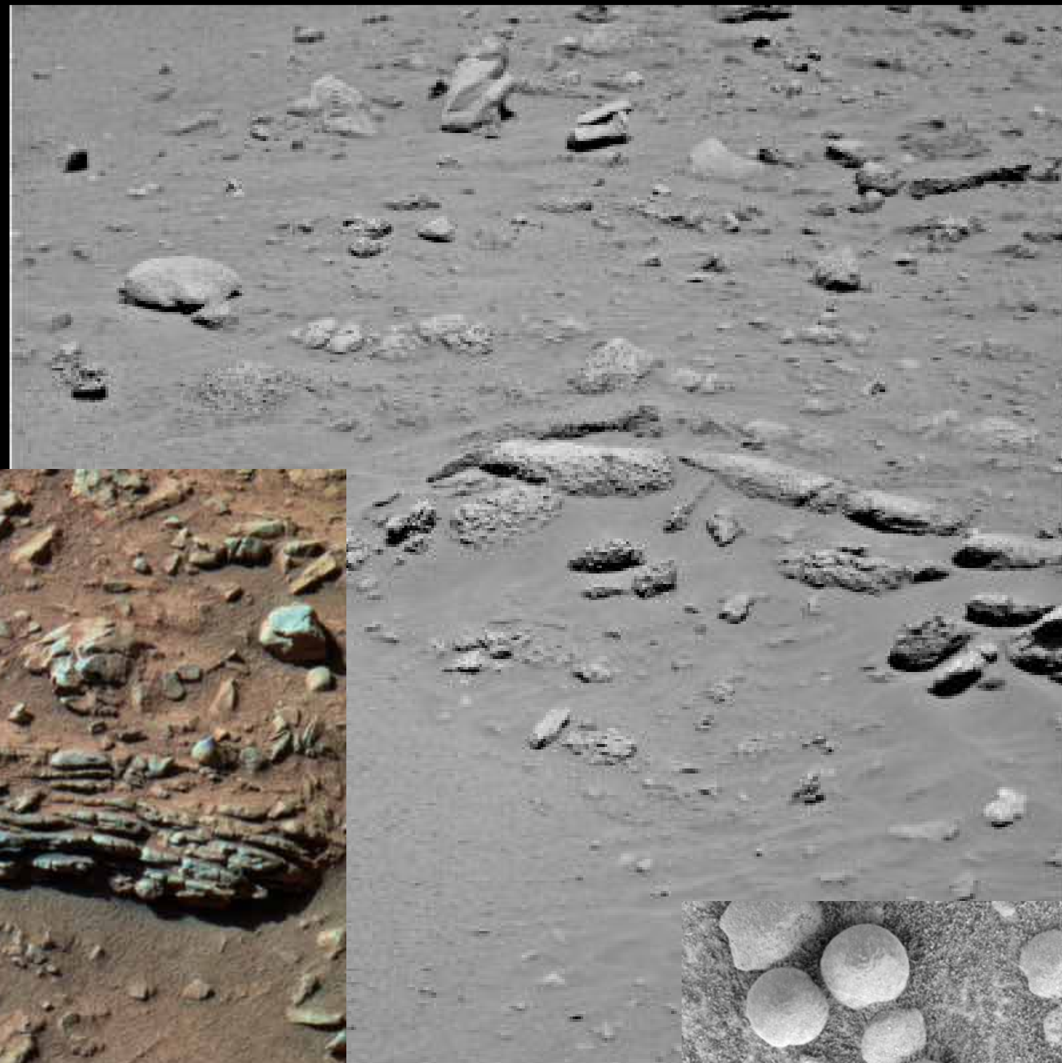

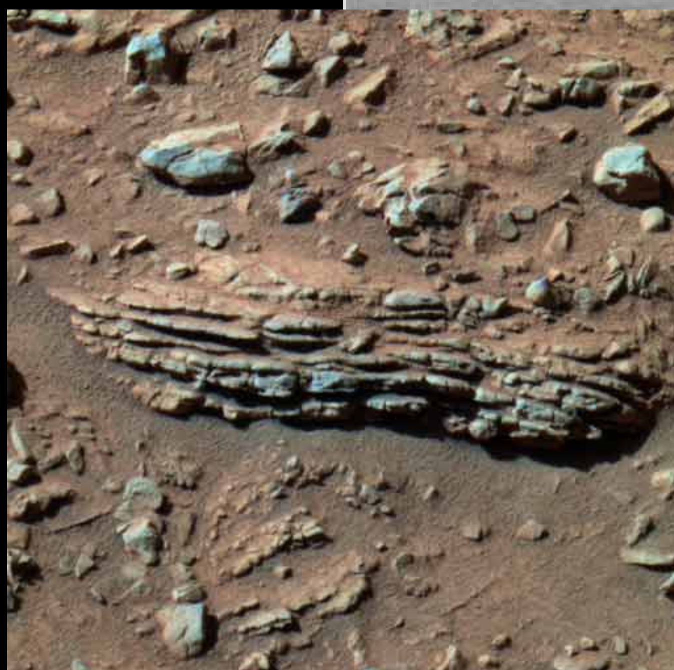

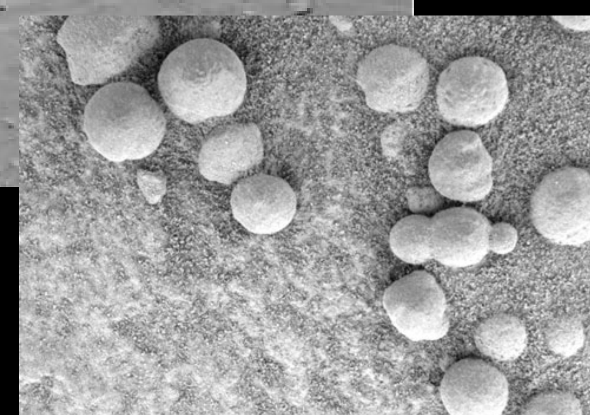

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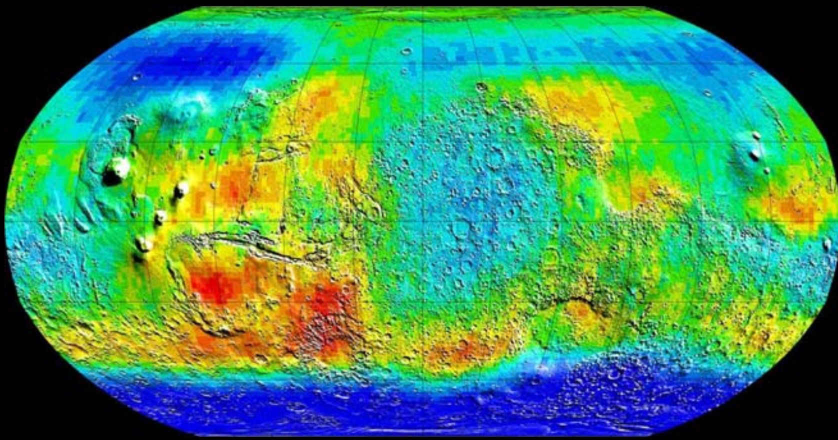

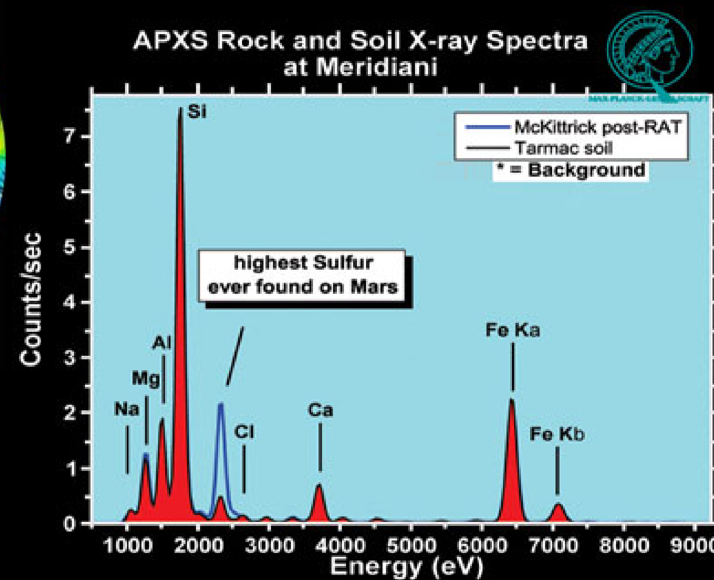

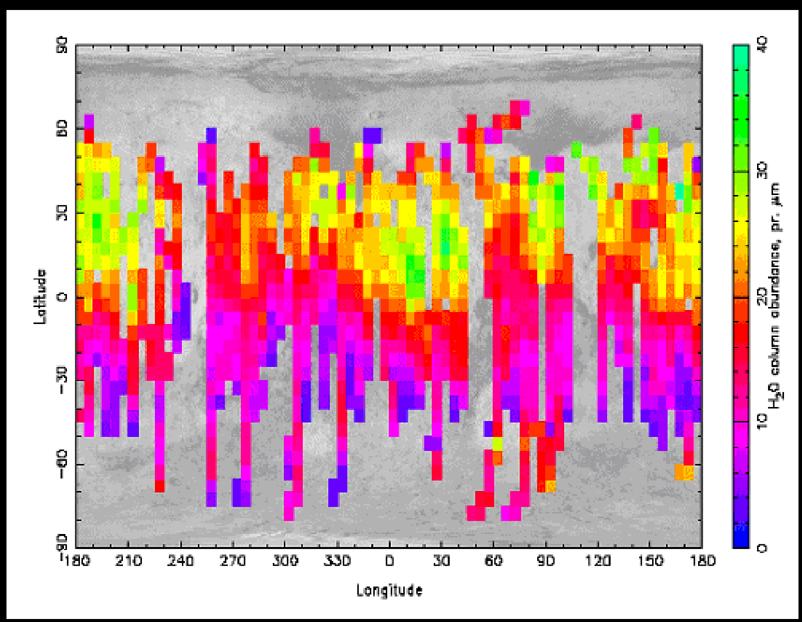

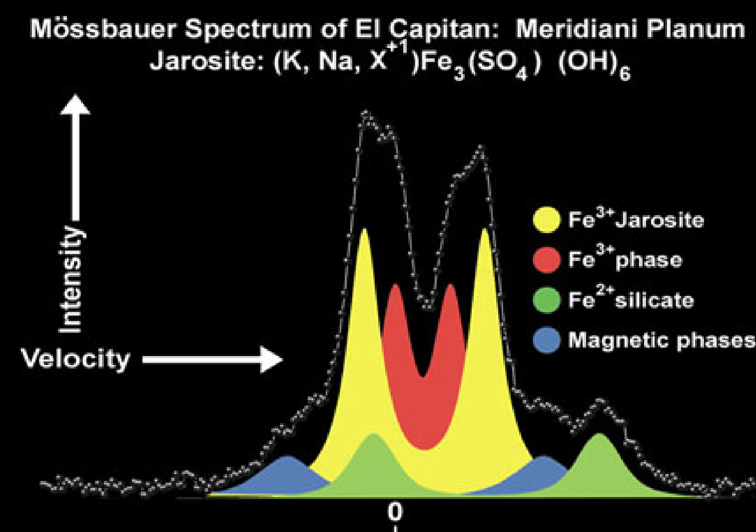

1700-1800

The Enlightenment

Chemistry

Mendel - birth of genetics

Darwin, “On the origin of species…”

Shrodinger, “What is life?”

Crick and Watson (etc.), structure of DNA

Miller-Urey synthesis

Discovery of *Homo habilis*

Genetic Engineering

Human Genome Project

Artificial life (Los Alamos Bug, Minimal Cell Project)

Present Day

Developments in the study of life on Earth

Life?

Yes

No

Yes

No

No

Maybe

No

Yes

No

…

…

…

…

Developments in the study of life on Mars

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What do we know about Carbon on Mars?

Atmosphere:

CO_2 (96%), CH_4, CH_2O (ppm-ppb)

Surface (inorganic):

Spectral signature of carbonate ("trace amounts in dust", "don't see massive regional concentrations")

Surface (organic):

No organic compounds at the surface (*Viking*)

Martian meteorites:

Many details (organics, carbonates, trapped gases, but issues of contamination and, in some quarters, pathological failure to accept they come from Mars)

Mars - our scientific destiny

"Follow the water" NASA (USA)

So, why not set our sights on
understanding the carbon cycle on Mars

No carbon cycle = no life
No life ≠ no carbon cycle
There *is* a carbon cycle on Mars

"Capture the carbon cycle" ESA (Europe)

[capture - "succeed in representing or describing (something elusive)"]

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Capturing the Carbon Cycle

Problems to bear in mind:

- Need to understand how carbon partitions between the different reservoirs - and what levels of activity

- ppm-ppb concentrations of atmospheric gases (a more difficult analytical challenge than on Earth)

- Detection of amino acids (so what? - present in carbonaceous chondrites)

- Detection of proteins, DNA, RNA (how do you distinguish the effects of terrestrial, biological contamination?)

- Should look for organic compounds in samples that are most relevant to the effects of fluid-related activity (epsomite!)