Planet Mars: Prospects of Biogenic or Thermogenic Oil and Gas from Deeper Sources*

Prasanta K. Mukhopadhyay (Muki)[1]

Search and Discovery Article #70165 (2014)**
Posted August 11, 2014

*Adapted from oral presentation at AAPG Annual Convention and Exhibition, Houston, Texas, April 6-9, 2014

[1]Global Geoenergy Research Limited, Halifax, Nova Scotia, Canada (muki@global-geoenergy.com)

Abstract

Liquid water within the gullies of the Newton Crater from Mars (near the equator), oil-like hydrocarbons on the surface on Mars, methane in the atmosphere on Mars, and a list of publications on the geochemistry and astrobiology of carbonaceous chondrites have indicated that these petroleum hydrocarbons could be closely related to the simple to complex biological species similar to our Precambrian terrestrial environment (Nagy and Klaus, 1961; Hoover, 2011; Mukhopadhyay, 2012). Evidence of bacterial globule associated with carbonate minerals, salt, and petroleum-like substances in Mars may indicate the link between bacterial growth and generation of petroleum hydrocarbons on Mars. Recent evidence of the presence of deltaic sediments and petroleum-system elements within the earlier Martian geological time in the Eberswalde and Holden Deltas of Mars may have evolved both biogenic and thermogenic oil and gas. Our geochemical findings of carbonaceous chondrites show the possible presence of bacterially (or primitive algal) derived source rocks and three distinct thermal events. Based on the current knowledge gained from carbonaceous chondrites, the geology of various deltas on Mars, and recent evidence of hydrocarbons on Mars, the oil and gas resources could be discovered on Mars in the future. Our concept of possible presence of oil and gas on Mars may be derived from the following evidence: (a) both from the cracking of geopolymer to oil and gas within deeper oil- or gas-bearing conventional reservoirs or as unconventional resources in geological older sediments similar to Earth; (b) the thermal conversion of present bacterial bodies within the upper surficial materials of Mars; and (c) the high-temperature, volcanic or meteoric events (>250^{o}C) on bacterial mat or older source rocks could evolve methane, pyrobitumen, and PAHs.

Selected References

Hoover, R.B., 2011, Fossils of cyanobacteria in ci1 carbonaceous meteorites: Journal of Cosmology, v. 13/3.

Hoover; R.B., P.C.W. Davies; G.V. Levin, and A.Y. Rozanov, 2011, Front matter: Volume 8152: Proceedings, SPIE 8152, Instruments, Methods, and Missions for Astrobiology XIV, 815201 (http://dx.doi.org/10.1117/12.913634) (website accessed July 5, 2014).

Mukhopadhyay, P.K., 2011, Genesis of oil and hydrocarbon gases within Mars and carbonaceous chondrites from our solar system: Organic origin (source rocks or direct biogenic sink?: Proceedings, SPIE 8152, Instruments, Methods, and Missions for Astrobiology XIV, 815211 (http://dx.doi.org/10.1117/12.893836) (website accessed July 5, 2014).

Mukhopadhyay, P.K., D.J. Mossman, and J.M. Ehrman, 2007, The case for vestiges of early Solar System biota in Carbonaceous chondrites: Petroleum geochemical snapshots and possible future petroleum prospects on Mars Expedition, *in* Instruments, Methods, and Missions for Astrobiology X, R.B. Hoover, G.V. Levin, A.Y. Rozanov, and P.C.W. Davies, eds., Proceedings SPIE 6694, 66940C, p.1-16.

Mukhopadhyay, P.K., D.J. Mossman, and J.E. Ehrman, 2009, A universal unconventional petroleum system exists throughout our Solar System: SPIE Newsroom July 24.

Oehler, D.Z., and C.C. Allen, 2010a, Evidence for pervasive mud volcanism in Acidalia Planitia, Mars: Icarus, v. 208. p. 636–657.

Oehler, D.Z., and C.C. Allen, 2010b, Focusing the search for biosignatures on Mars: Facies prediction with an example from Acidalia Planitia, *in* Sedimentary Geology of Mars: SEPM Special Publication No. 102, p. 183–194.

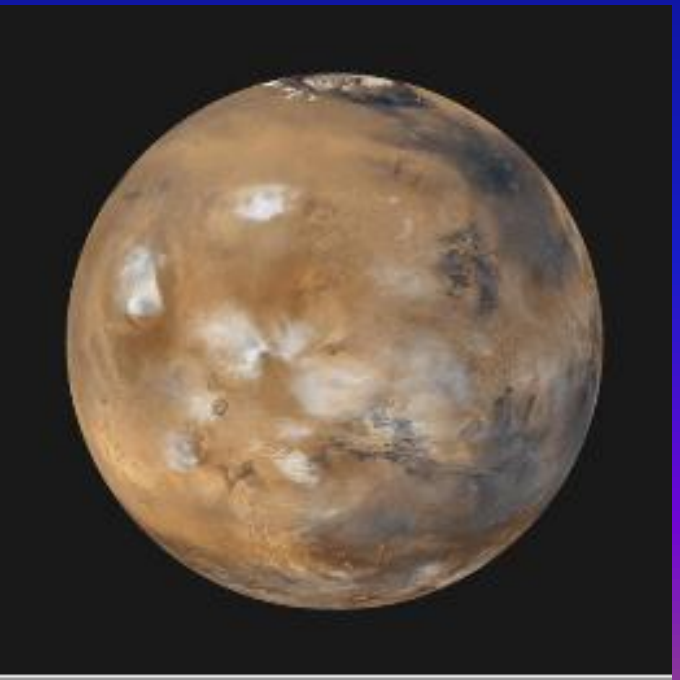
Frey, H.V., 2006, Impact constraints on, and a chronology for, major events in early Mars history: Journal of Geophysical Research: Planets, v. 111/E8.

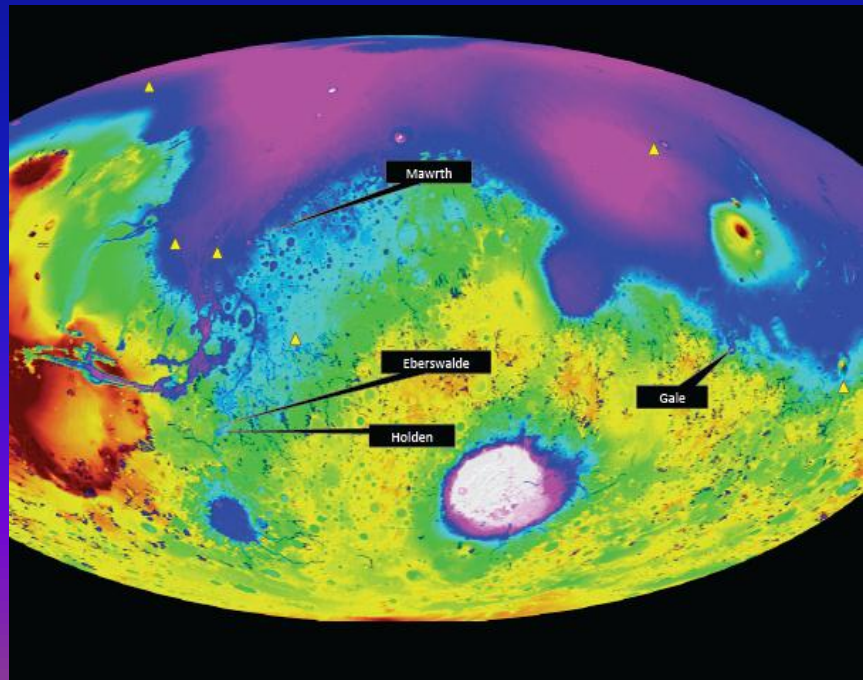
Website

Space Science [European Space Agency], Website accessed July 5, 2014. www.esa.int/esaSC/SEM565R03EF_index_1.html#subhead3

Planet Mars: Prospects of Biogenic or Thermogenic Oil and Gas from Deeper Sources

Prasanta K. Mukhopadhyay (Muki), PhD, P.Geo.
Global Geoenergy Research Ltd., Halifax, Nova Scotia, Canada
muki@global-geoenergy.com

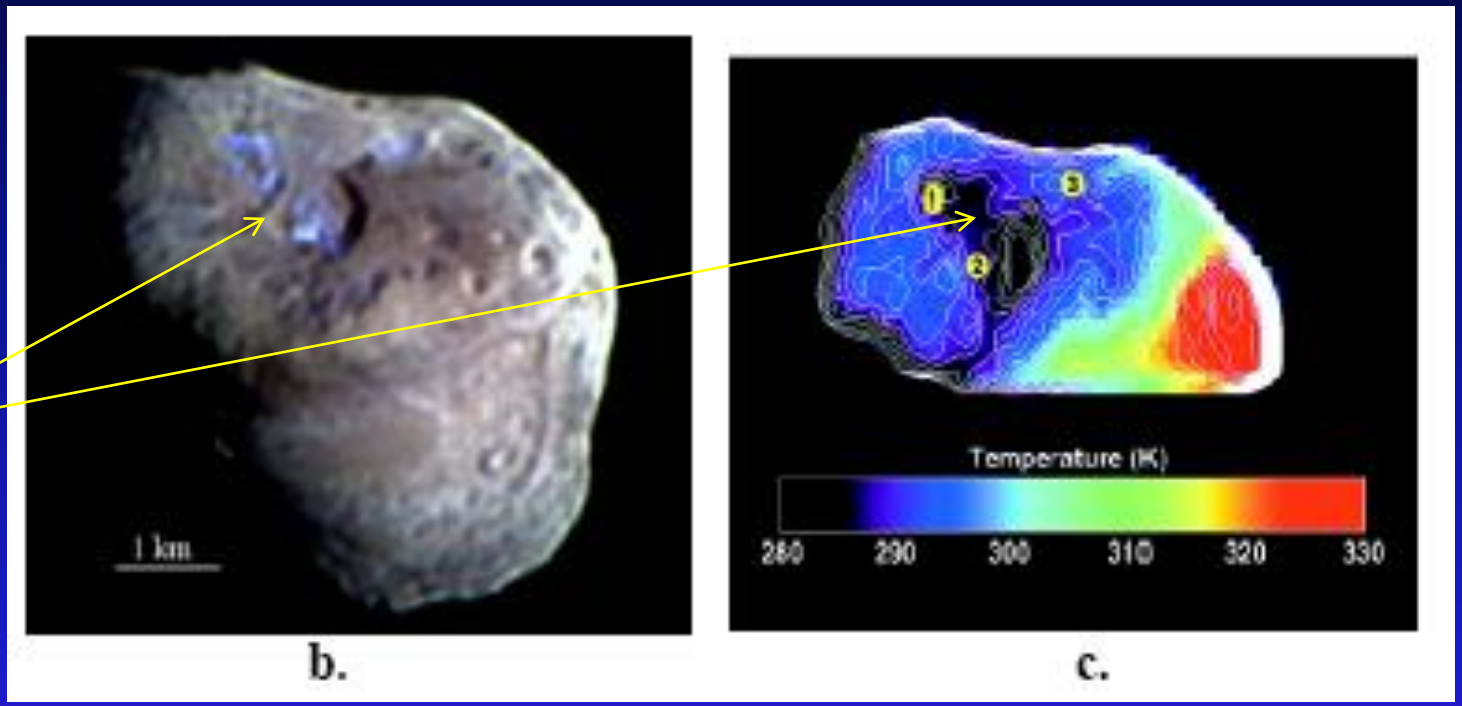




Water-ice and organics found in Comet Tempel 1

3 areas less than 0.5% of surface, 1.5 & 2μm ice bands

Ice?

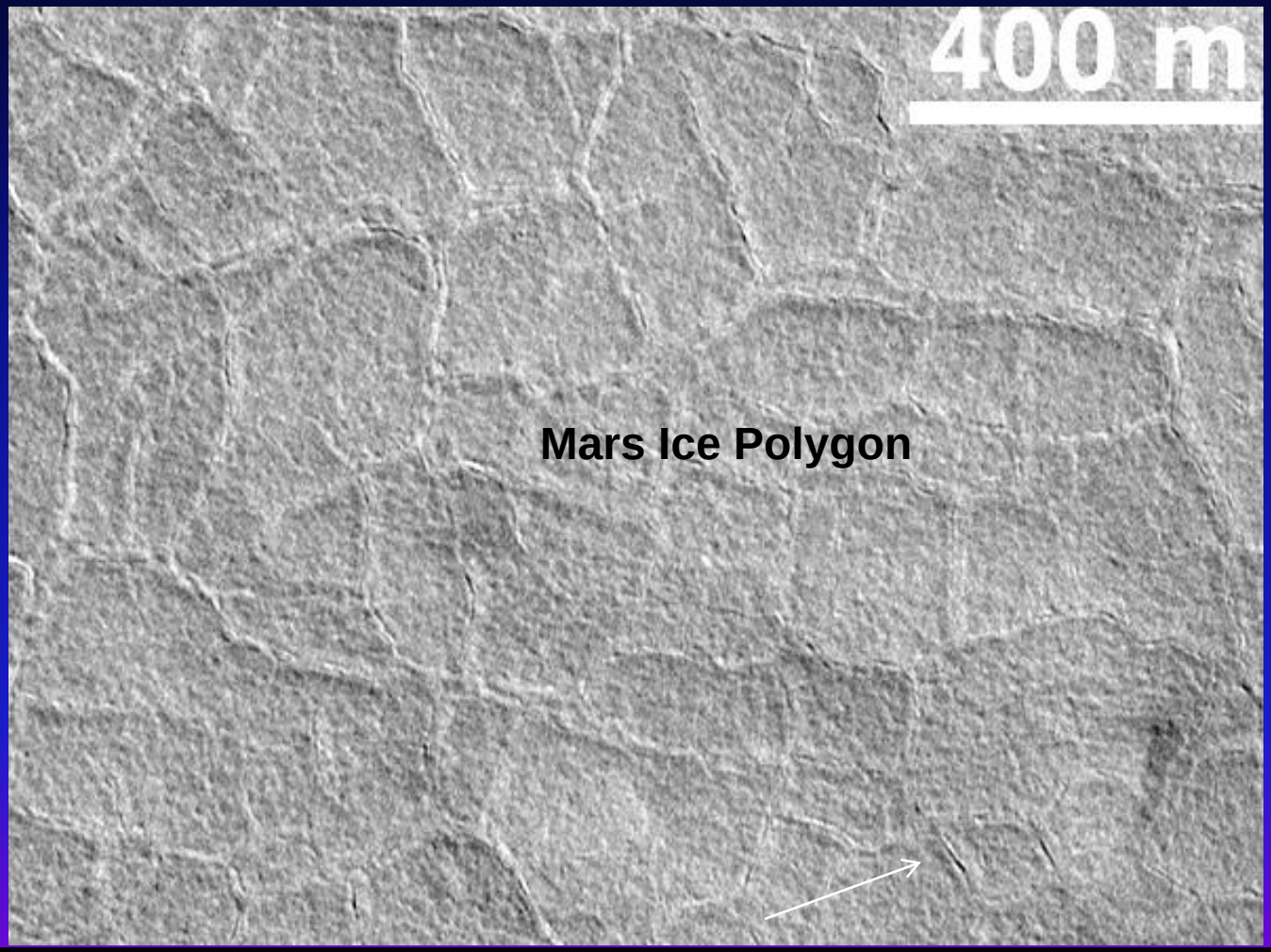


Ice could be surfaces of
lakes exposed by impacts – and organics
(HCs) in plenty

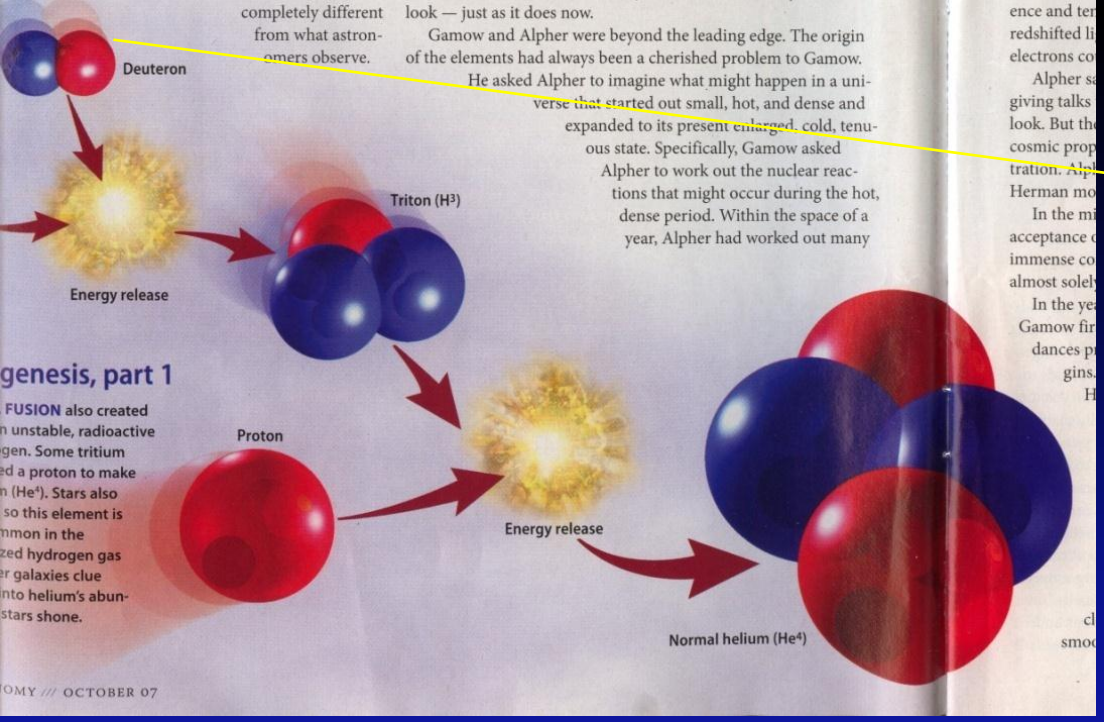
Water is Common Contituent
In the Universe

After Hoover (2011)

Evidence for Liquid Water on Mars - Permafrost Polygons



Double-Rimmed Permafrost Polygons in Siberia formed by Water-Ice Freeze-Thaw Cycles and on Mars



Hydrogen came at the beginning of BBN and Carbon came later after the destruction of first set of stars when first elements evolve are the main components for all possible presence of all oil and gas on Mars

Concept

Possible Formation of Hydrocarbons

Primordial abiogenic PAHs present even today everywhere in the Universe. From this abiogenic PAH forms a **Geopolymer which acts as Feedstock for the early Primitive Life on the Comet** in a quiet environment possibly in an anoxic water base. From this early life (posssibly cyanobacterial clusters) forms the earliest source rocks on Comet and Planets

Salient Features of My Presentation

- **Carbonaceous Chondrites – Morphology, Petrography, Geochemistry, and their Implications as Hydrocarbon Source Rocks similar on Earth.**

- **Possible Hydrocarbons on Mars: Concepts and Selected evidence. Petroleum Systems, Methane, and Mud Volcanoes**

Sequence of Events for My Talk
Stage I – Carbonaceous Chondrites

- **Carbonaceous Chondrites – Morphology, Petrography, Geochemistry, and their Implications as Extraterrestrial Source Rocks (including from Mars)**

Comparison of Carbonaceous Chondrites and Terrestrial Source Rocks

Composition of Carbonaceous Chondrites

Kerogen (>5%)
(Total Organic Carbon: 1.0 - 5%)
Metals: 1.8%; Nitrogen: 0.2%; Silicates: 83%
Water: 11 - 20%

Kerogen Composition within CCs
Carbon: 77.5%; Hydrogen: 7.5%; Nitrogen: 1.5%
Oxygen 12%; Sulfur: 1.5%

Terrestrial Source Rock

(dispersed organic matter)

- TOC: 1-10%
- Minerals: 70-80%
- Water: negligible -10%

Terrestrial Kerogen Composition (mineral-matter-free basis)

Carbon: 69-77.5%, Hydrogen: 7.5%
Nitrogen: 1.5%, Oxygen: 12%
Sulfur: 0.01 to 1.5%

Carbonaceous Chondrites as biologically derived source Rocks Evidence

1. Depositional Environment should be under water and anoxic to preserve organic carbon and hydrogen

2. **Organic Richness and Organoclasts Variability Primitive bacterial and algal variabilities**

? Presence of any cellular or plant components

3. Biomarker variability and source rock type (hopane, sterane, pristane, phytane, etc. and Type I, II, and III)

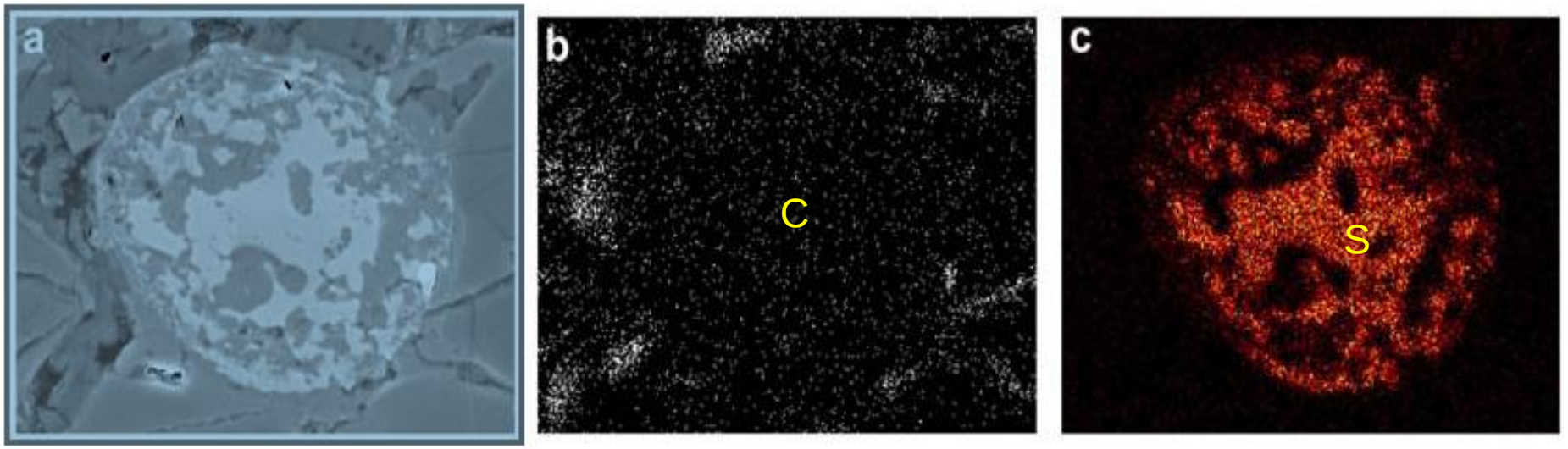
Possible Early Generation of Oil and Gas Due to Lability of Cyanobacteria

Carbonaceous Chondrites as Source Rock: Richness/Types, Maturation Events, and Biomarker Contents

Morphology, Source Rock Potential and Maturation

Murchison Meteorite: SEM & EDS of C & S Maps

(Mukhopadhyay, Mossman, and Ehrman, SPIE Astronomy Media paper, 2009)



SEM image of a sample from the carbonaceous meteorite Murchison showing partially mineralized organic remnants. (b) EDS carbon map and (c) sulfur map of the same remnants. In 2004 the group of Hoover described this type of organic component as a well-preserved bacterial cell with possible flagella.[8] % Ro = 1.21.

Courtesy:
Jim Ehrman & David Mossman,
University of Mount Allison, NB)

GLOBAL GEOENERGY RESEARCH LTD.

Total Organic Carbon and Rock-Eval Pyrolysis Data of Three CC's

Name of CCs	Total Organic Carbon (wt %)	S_1 (mg HC/g Rock)	S_2 (mg HC/g Rock)	S3 (mg CO_2/ g Rock)	T_{max} (°C)	Hydrogen Index (mgHC/g TOC)	Oxygen Index (mg CO_2/ g TOC)	PI (S_1/ S_1+S_2)
Murchison	1.03	0.33	0.41	2.73	400	40	265	0.45
Orgueil	2.60	1.82	0.26	3.69	551	10	142	0.88
Tagish Lake	2.94	0.27	0.02	1.73	300	1	59	0.93

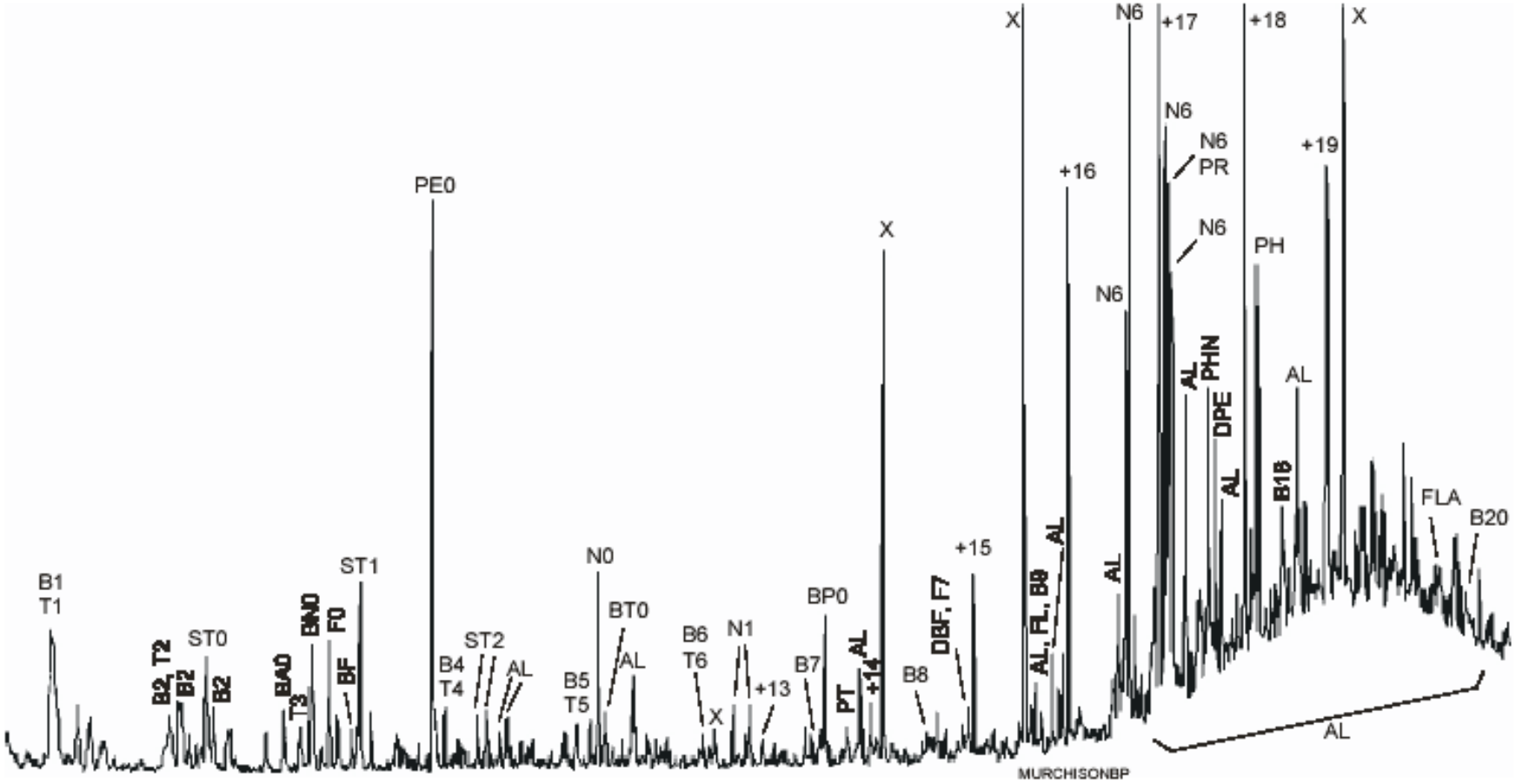
Reflectance of Organic Components and Predicted Temperature (modified from Mukhopadhyay et al., 2007)

Name of Carbonaceous Chondrites	% R_o (number of grains measured)	Predicted Temperature (°C)	Maceral Name
Allende	4.9% (8)[a]	400-425	pyrobitumen
Dohfar	1.4-2.0% (4)[a]	150-200	pyrobitumen
Murchison	1.21% (3)[b] 0.65-0.83% (8)[a]	110-120	vitrinite-like organics solid Bitumen
NWA 3003	3.0% (6)[a,b]	250	pyrobitumen
Orgueil	0.7% (3)[a]	90-100	solid Bitumen
Tagish Lake	1.29 (2)[a]	120-130	solid Bitumen
Vigarano	5.1% (6)[a]	425-475	pyrobitumen
ALH 840001*	3.25%	250-275	pyrobitumen
EET*	7.5%	475-500	pyrobitumen

[a]solid bitumen measured;
[b]vitrinite-like grains measured
*New data

Carbonaceous Chondrites as Source Rock: Richness/Types, Maturation Events, and Biomarker Contents

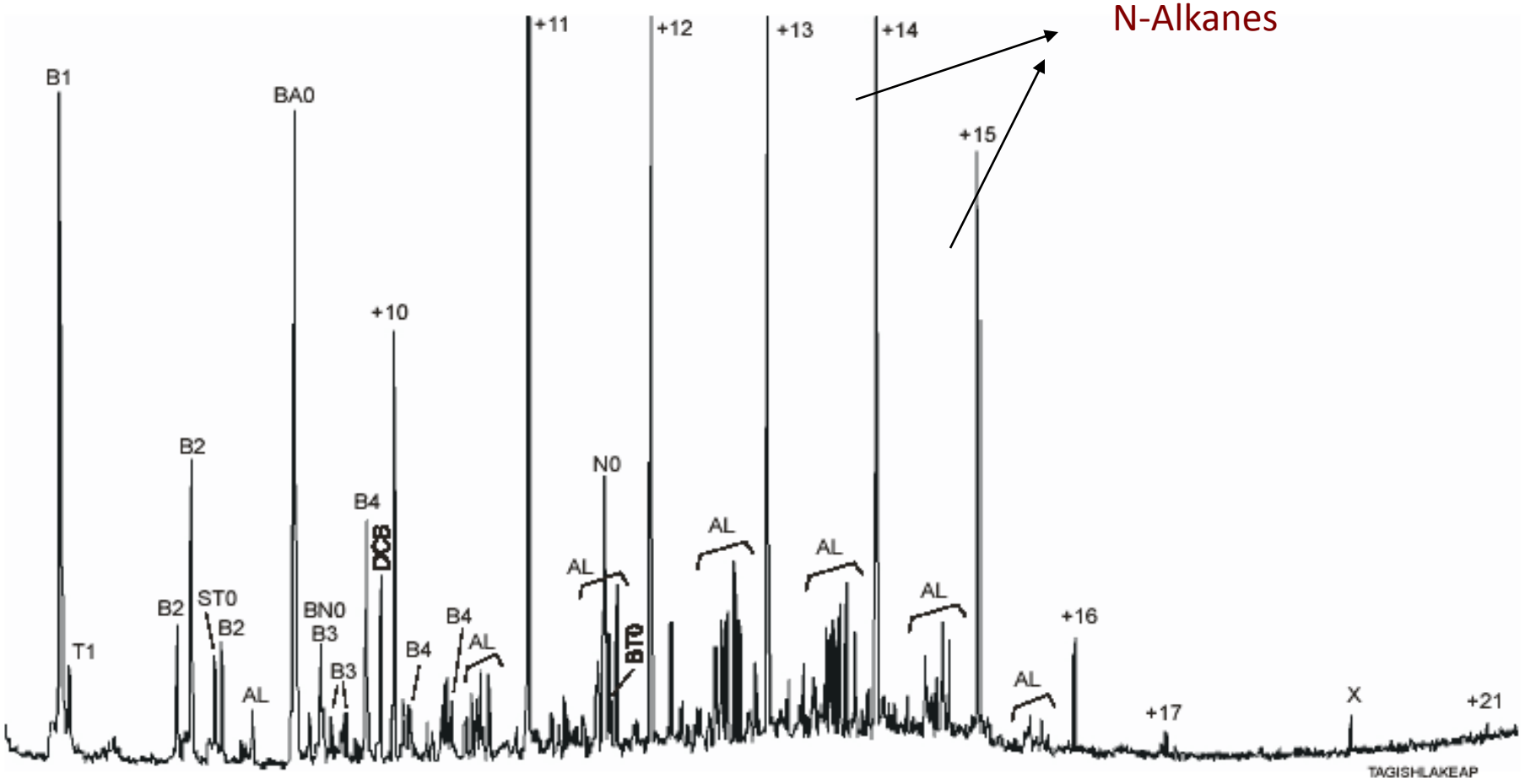
Biomarkers Evidence from PY-GC/MS
More evidence on GC/MS of hopanoids are required



Py-GC-MS chromatograms of the thermal extract of the Murchison

N: n-alkanes; AL: unspecified branched or cycloalkanes; PHN: phenanthrene; FL; fluorene; X: phthalate (possible contaminant)

GLOBAL GEOENERGY RESEARCH LTD.



Py-GC-MS chromatograms of the Pyrolyzed Part of Tagish Lake

N: n-alkanes; AL: unspecified branched or cycloalkanes; ;B: benzene.

Courtesy of Michael Kruge

Sequence of Events for My Presentation
Future Prospects of Oil and Gas on Mars

- **Possible Hydrocarbons on Mars: Concepts and Selected Evidence**
- **Petroleum Systems, Methane, and Mud Volcanoes**

Evidence of Biogenic and Thermogenic Hydrocarbons on Mars

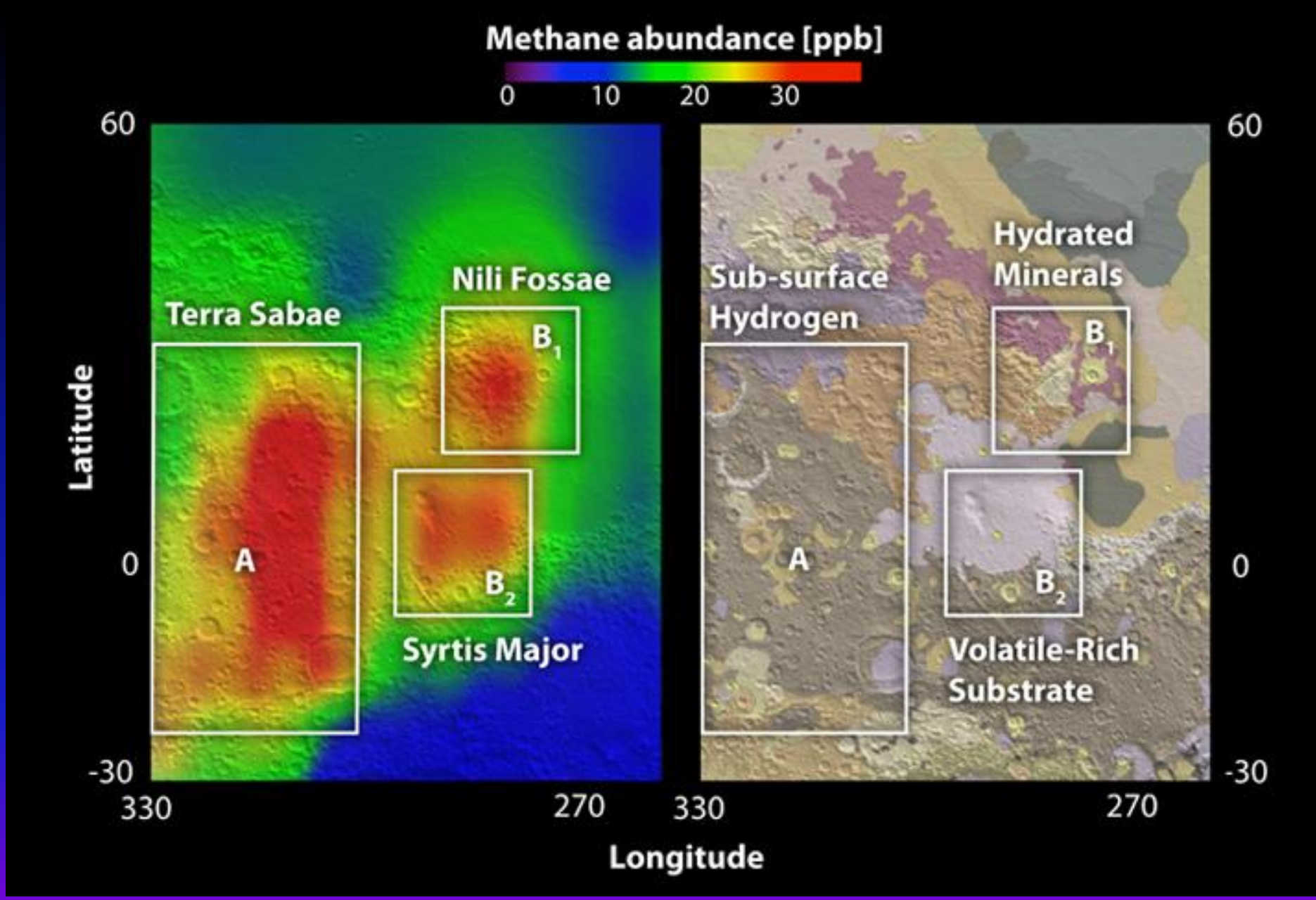
Comets Mars & Other Planets

Earlier Evidence

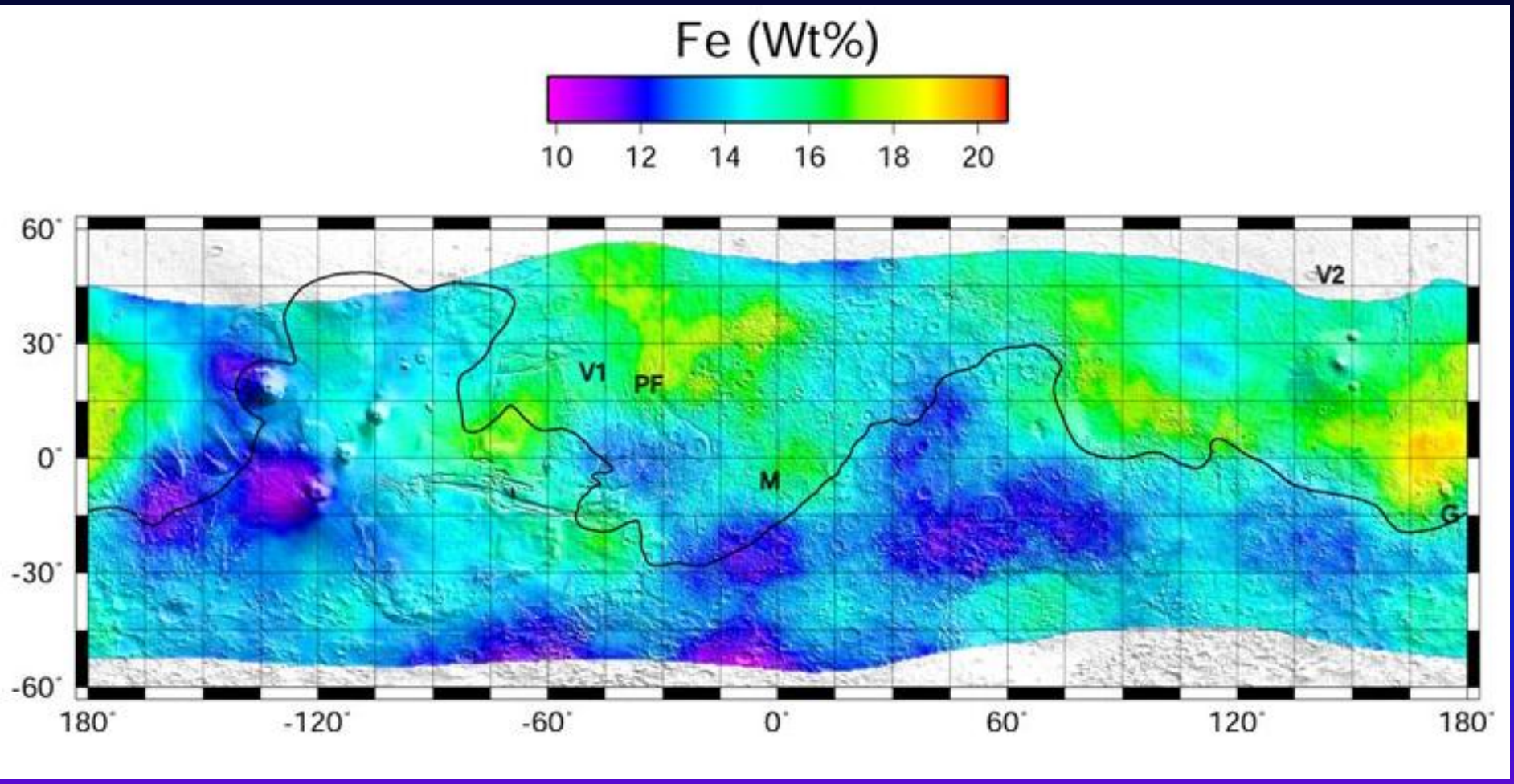
- **Water & Methane on Mars**
- **Water and Methane in Europa and Encyladeus**
- **Seasonal Temperature variation on Mars**
- **Carbonaceous Chondrites as an evidence of source rocks on Mars, Comets and Asteroids. Direct evidence of source rocks would be deeper in the Martian interior**

Future Areas and Possible HCs

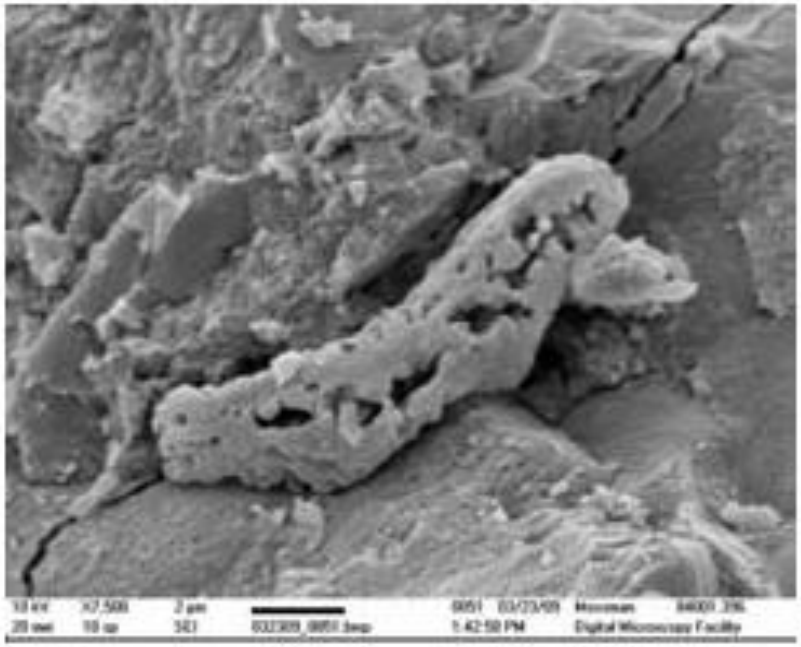
- **As life and hydrocarbons are always associated on Earth, search for Life should be associated with organic-rich dark shales within Martian interior**
- **As Crude Oil migrated on the Martian Surface from deeper source will be bombarded with high radiations, the prospect of methane and Asphalt or Heavy Oil most likely would be hydrocarbons in the Martian soil**

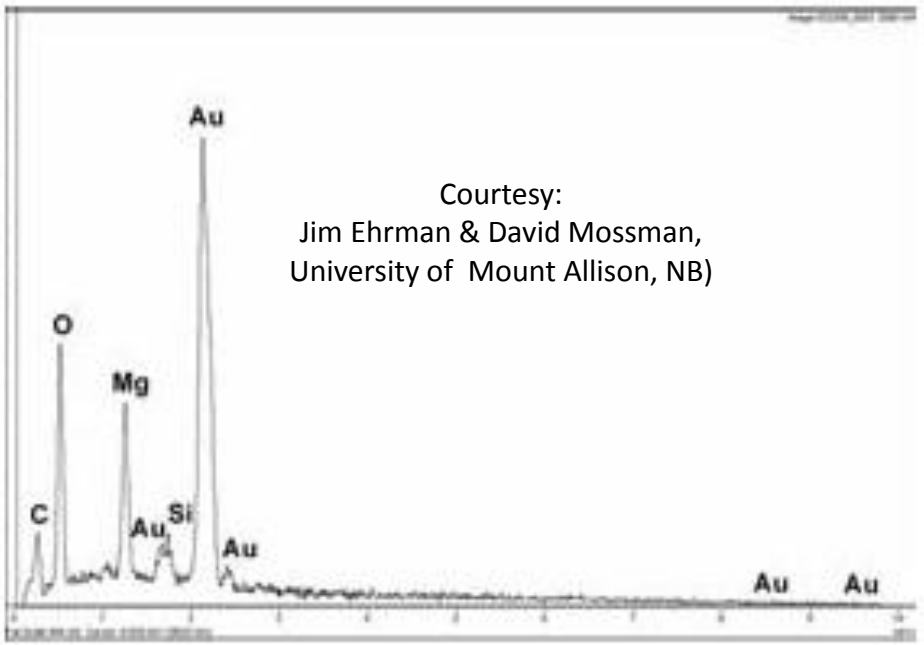


Methane and Hydrogen Abundance on Mars Surface



Mars Fe^{+} map from the Mid-latitude area (the map is based on Mars Odyssey Mission)





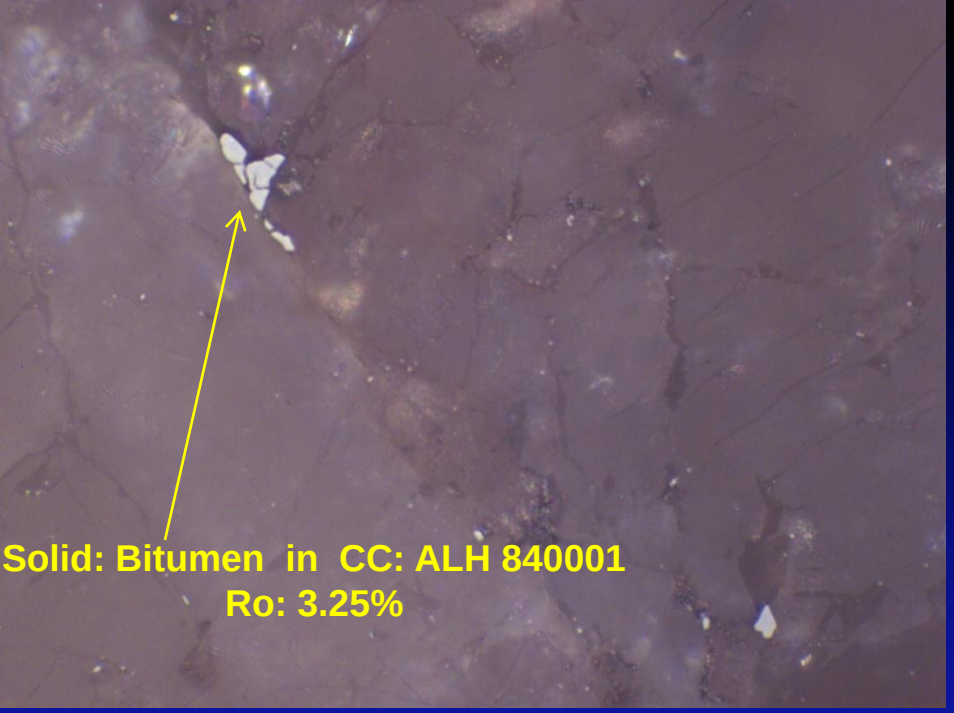
Courtesy:
Jim Ehrman & David Mossman,
University of Mount Allison, NB)

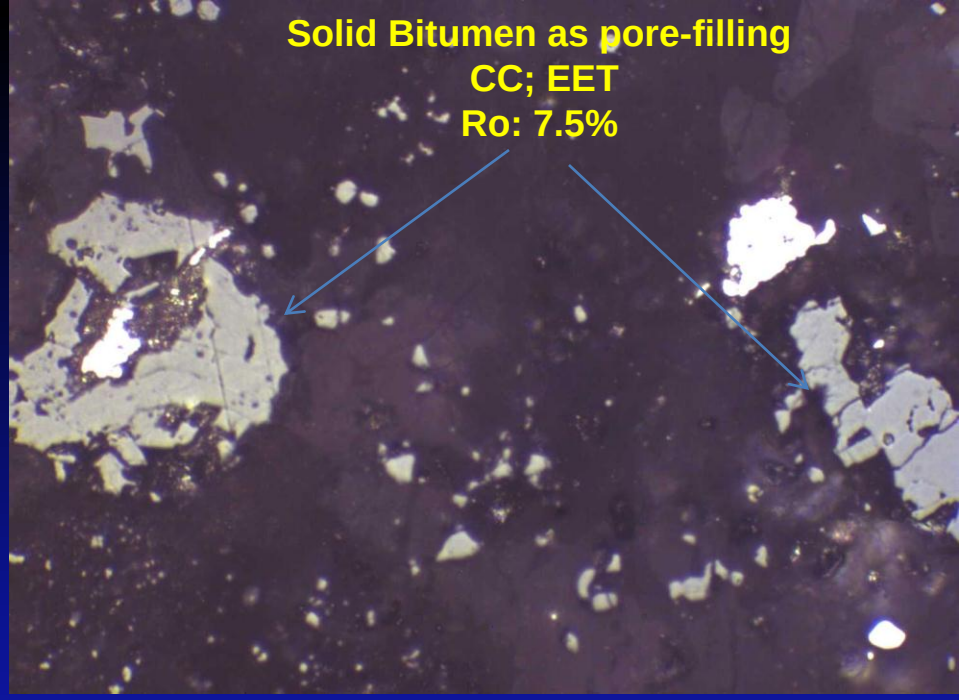
(after Mukhopadhyay, Mossman, and Ehrman, SPIE Astronomy Media paper, 2009)

Figure 5. (left) Evidence of organic remains (possibly bacterial bodies, central part of the SEM image) from the ALH840001 CC partially replaced by minerals. (right) EDS image of elements present in the same region of the organic remains. Si: Silicon. % Ro = 3.25.

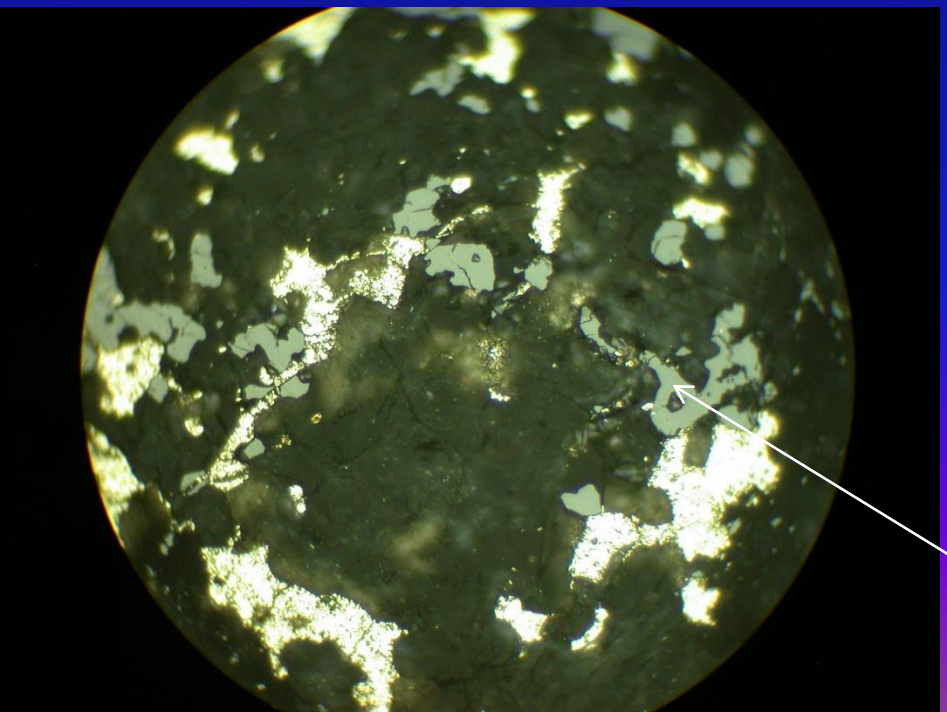
SEM (left) and EDS (right) of ALH 84 0001

GLOBAL GEOENERGY RESEARCH LTD.





Hydrocarbons (pyrobitumen) within ALH 840001

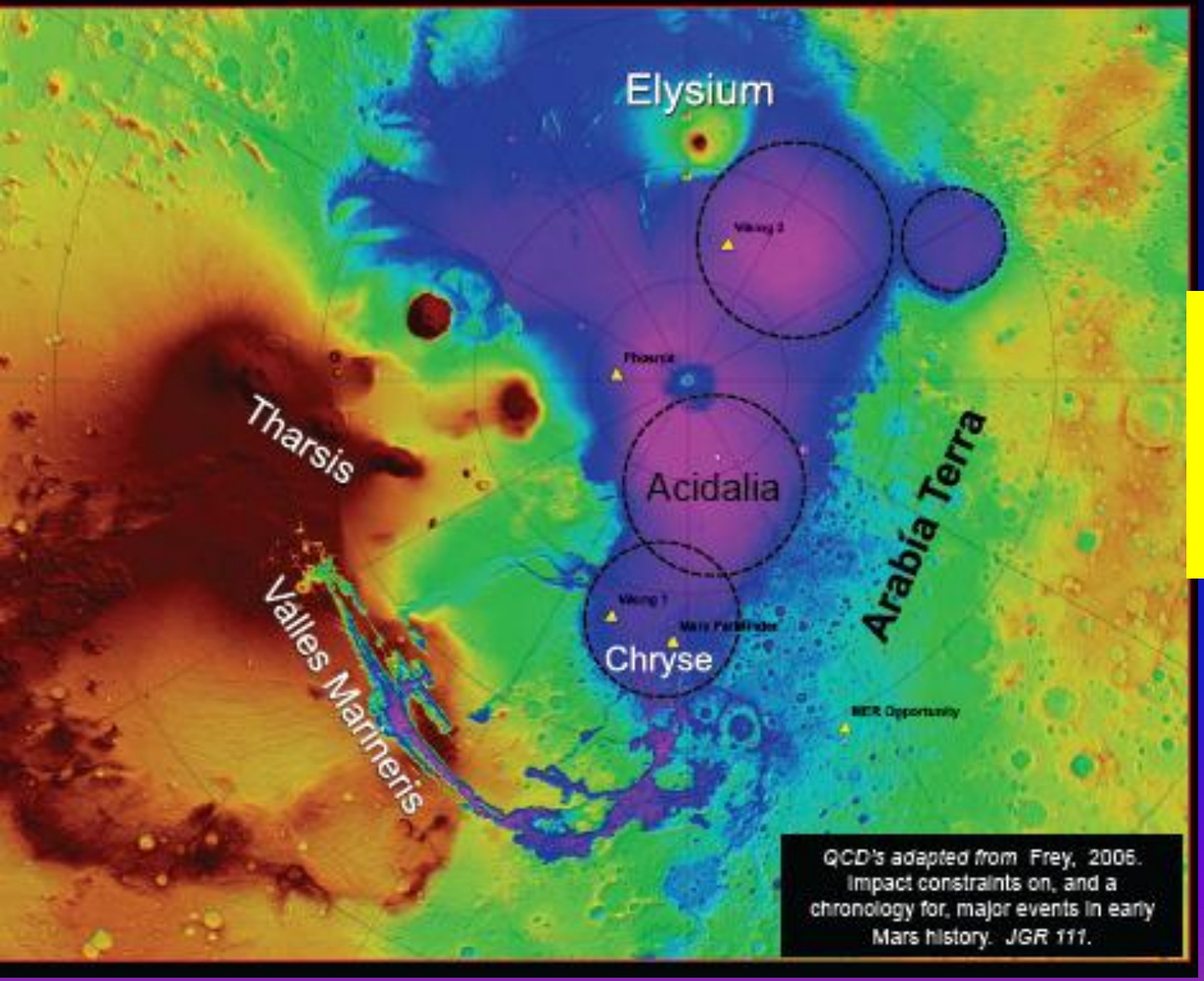


Incident White Light Microscopy Magnification X 550)

Solid: Bitumen and ore minerals
in CC: ALH 840005
Ro: 3.25%

GLOBAL GEOENERGY RESEARCH LTD.

Regional Setting



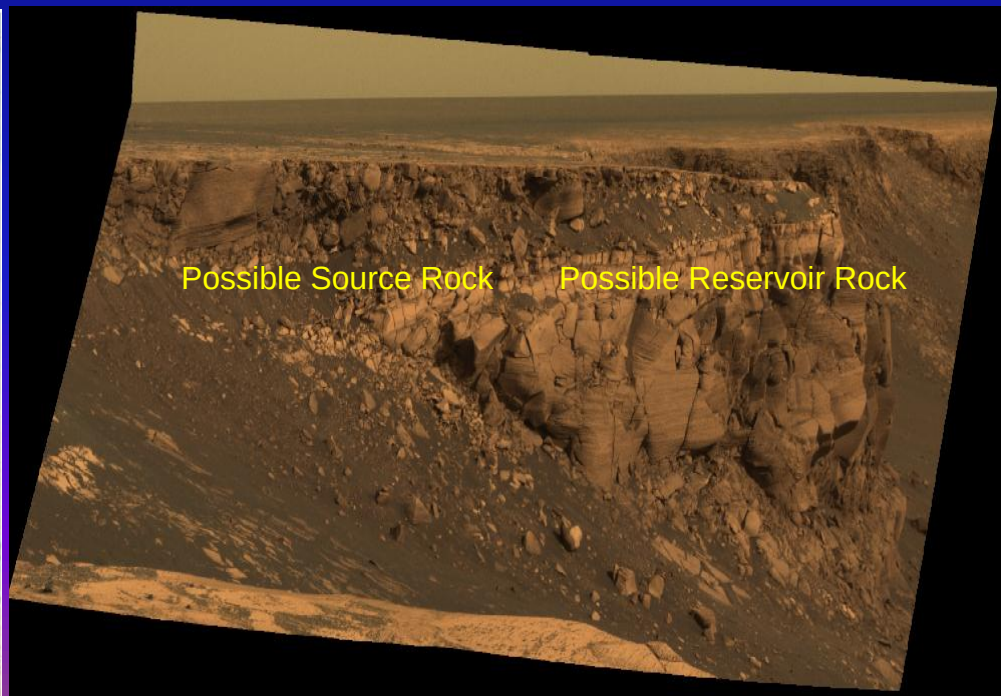
Regional Settings of possible Source and Reservoir Rocks on Mars (after Oehler, 2010)

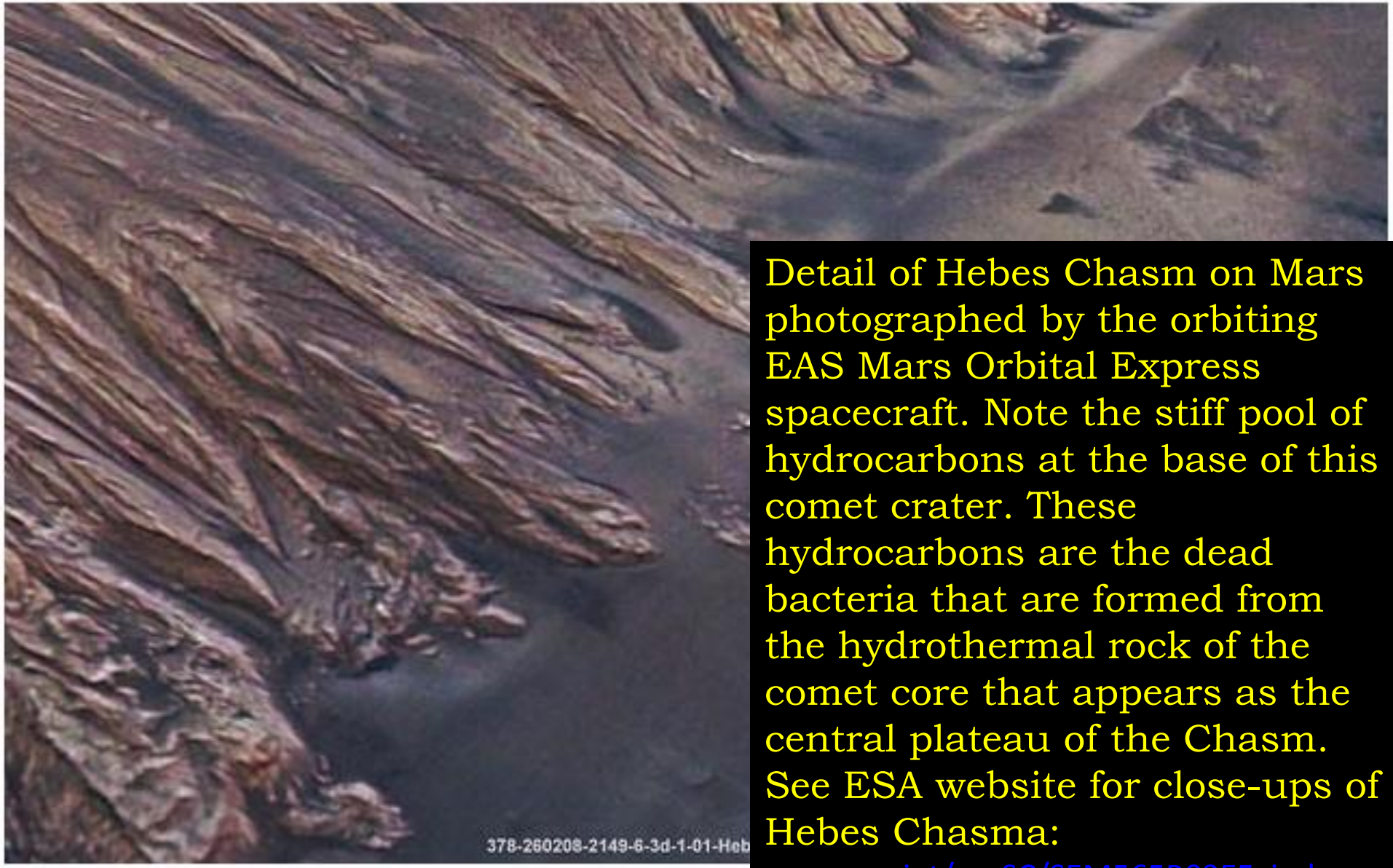
Mars

Petroleum Systems Exists on Mars ?

Possible particles of source rocks by wind transport (above left) or regularly stratified

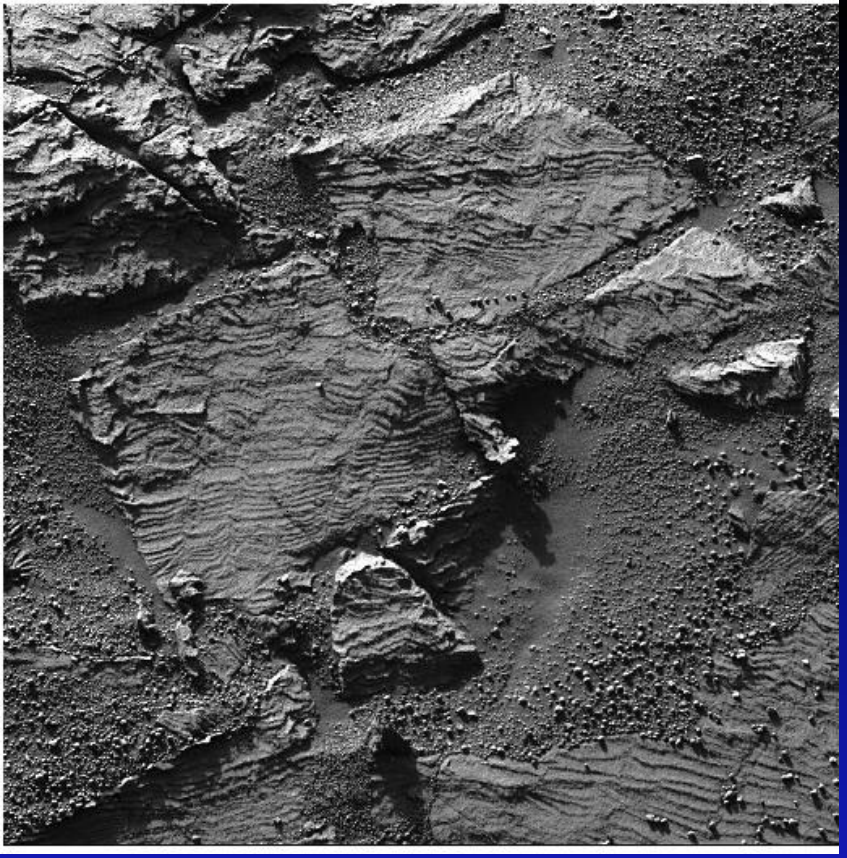
Possible Source and Reservoir Rocks on Mars (missing Lesli Wood pictures on source and reservoir rocks)



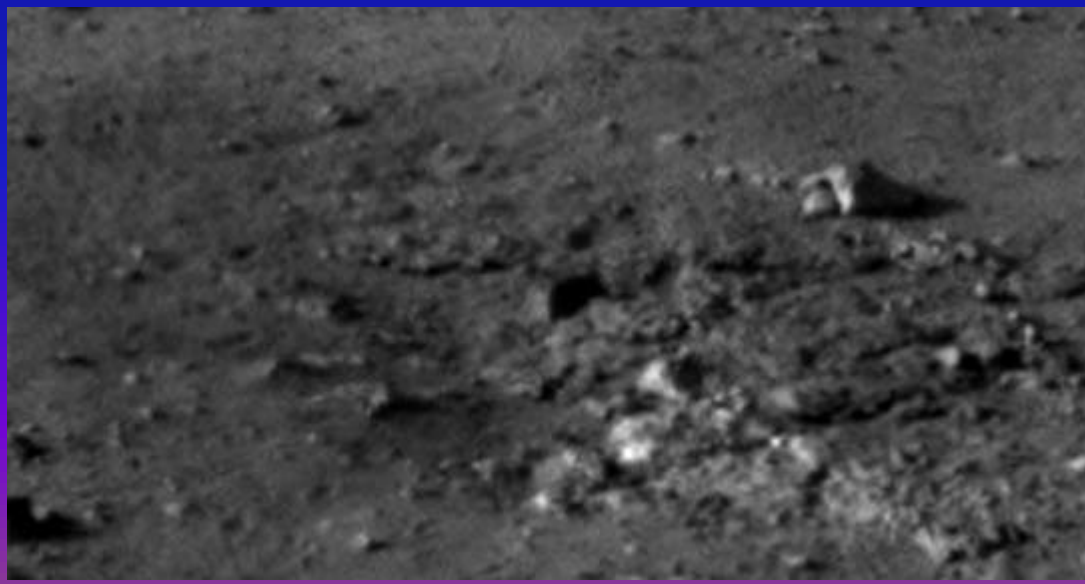


Hydrocarbons on Hebes Chasma, Mars

Detail of Hebes Chasm on Mars photographed by the orbiting EAS Mars Orbital Express spacecraft. Note the stiff pool of hydrocarbons at the base of this comet crater. These hydrocarbons are the dead bacteria that are formed from the hydrothermal rock of the comet core that appears as the central plateau of the Chasm. See ESA website for close-ups of Hebes Chasma: www.esa.int/esaSC/SEM565R03EF_index_1.html#subhead3

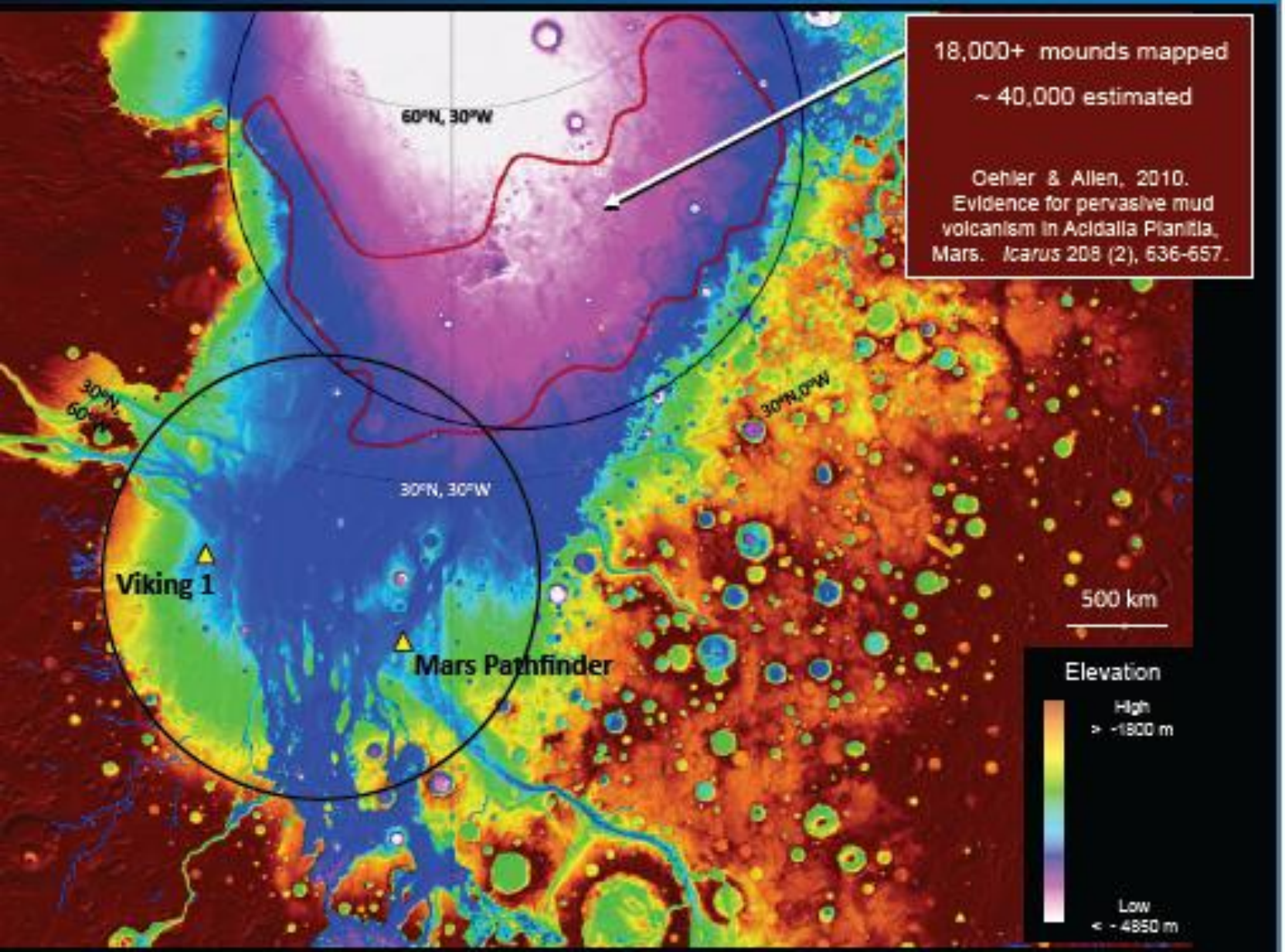


Area Chrysee on Mars :“Festoon” pattern of sand dunes showing that possibly the dunes form by waves in shallow water. A distinctive geometric pattern could be documented. Possible area of future petroleum systems could be documented.



Curiosity Image near Gale Crater and possible indication of some sort of hydrocarbon seepage (?)

Mud Volcanism in Acidalia (Mars)



Possible Petroleum Systems on Mars

1. Martian Surface and Soil may show Heavy Oil and Methane because of Major Radiation Effect of migrated oil from deeper sources

2. Primitive Life (cyanobacteria and algae) forming source rocks and oil should be present within the first 100 meter from the surface and deeper parts within the Martian Delta Complexes

Hydrocarbons, Source and Reservoir Rocks

- **Various sites for source rock development on Mars: Most Important sites would be older Delta Region or any cooler depositional environment and would have sheltered basins**
- **Methane originated mainly from a deeper Gas Hydrate source within an optimum pressure-temperature region on Mars similar to the marine basins on Earth.**
- **Origin of methane: Mud Volcanoes, Gas Hydrates, and Direct Transformation of Cynaobacteria close to the water associated with active volcanism**

Phoenix Mars Lander