Hydrocarbons in the Solar System — Biogenic Source Rock Signatures in Carbonaceous Chondrites and Comet Dust*

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Please refer to related article by the author, "Planet Mars: Prospects of Biogenic or Thermogenic Oil and Gas from Deeper Sources," Search and Discovery Article #70165 (2014).

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Abstract

Previous analysis of various carbonaceous chondrites (CC) and comet dust by various scientists since 1960s, recent findings of abundance of water, oil and gas within various Saturn and Jupiter moons, and key geological features and methane on Mars may suggest the presence of abundant petroleum hydrocarbons within our Solar System. Recent geochemical and other analytical data of various CCs indicate that CCs are organic-rich and contain abundant macromolecular components and oil-like extractable biomarkers that closely resemble terrestrial hydrocarbon source rock kerogen and bitumen usually observed in shale and carbonates. The bacteriomorphic microstructures preserved in these CCs closely resemble remnant palynomorphs of microbial (prokaryotic and archaeoprokaryotic) ecosystems established on Earth over 3.5 Ga ago. This data could be quite significant for future oil and gas prospects on Mars in the future as the early geology of planet Mars and Earth is quite similar, and both planets had water for a long period of time (except for the initial phase of planet formation). Similar to oil-prone source rocks on Earth, these extraterrestrial palynomorphs and their geochemical signatures within the CCs (including from Mars) and comet dust thus could be linked to biogenic and thermogenic hydrocarbons in the Solar System. Consequently, the Solar system possibly represents a connected biosphere with transfers taking place on dynamic timescales in millions of years. Now the question that is before us is how life has been transported in various planets of the Solar System. It was suggested that life could be transported in the Solar System planets possibly either from the (a) purging the primordial "comet dust" or (b) slow impact of

carbonaceous meteoritic showers. The presence of oil and gas in the deltaic, other deeper section of the Martian crust and atmosphere would be quite pertinent in developing the future greenhouse effect and human settlement on Mars.

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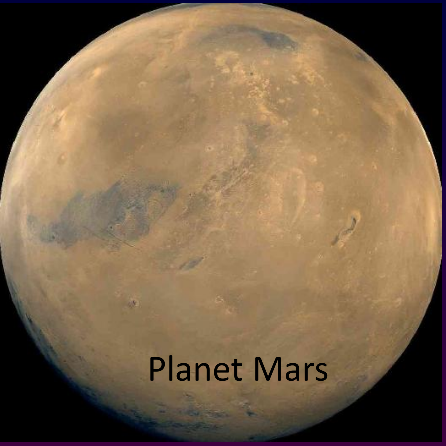
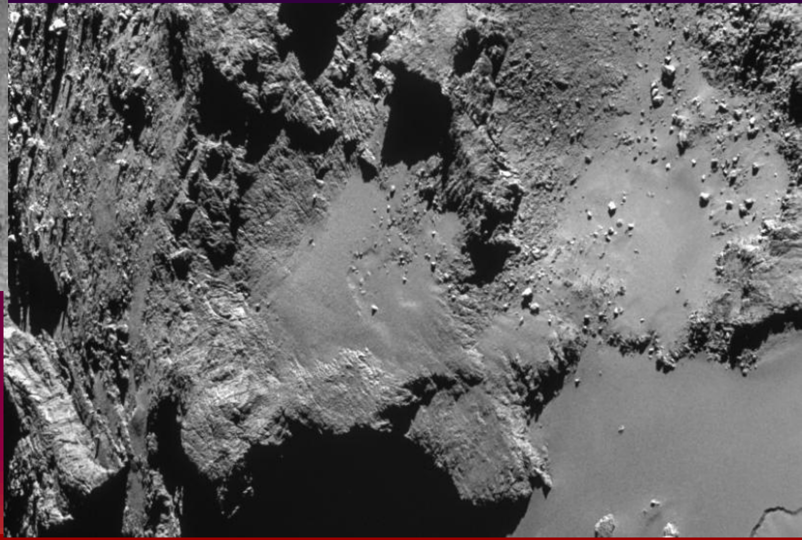


Rosetta is at Comet 67P/Churyumov-Gerasimenko studying the Comet minerals and organics



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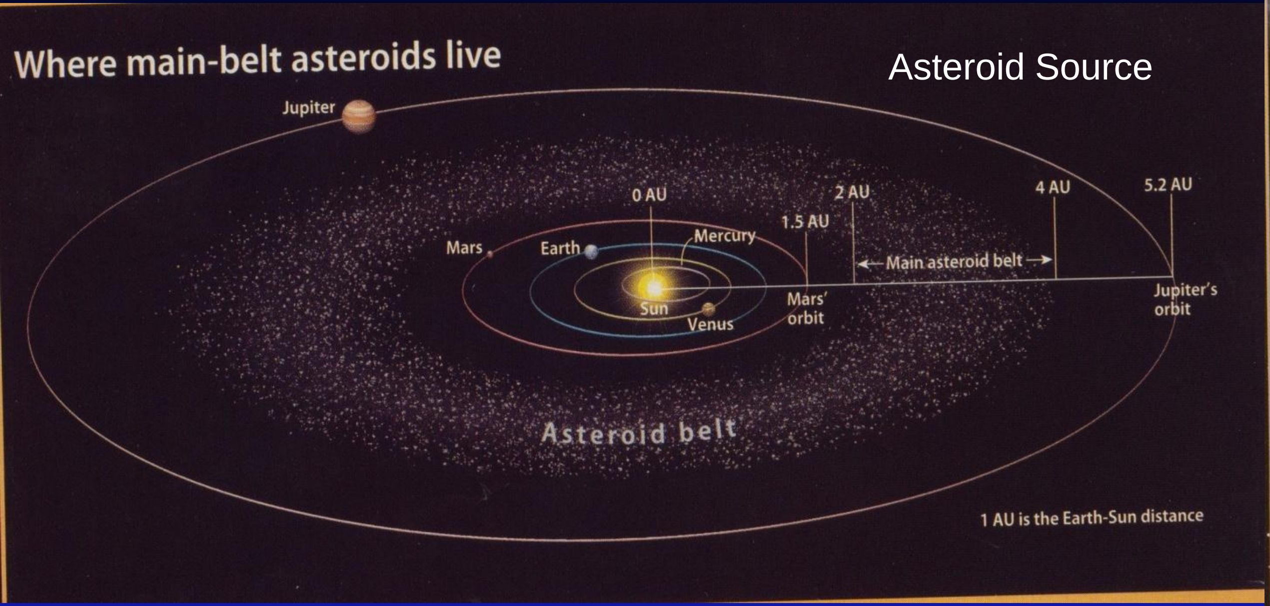
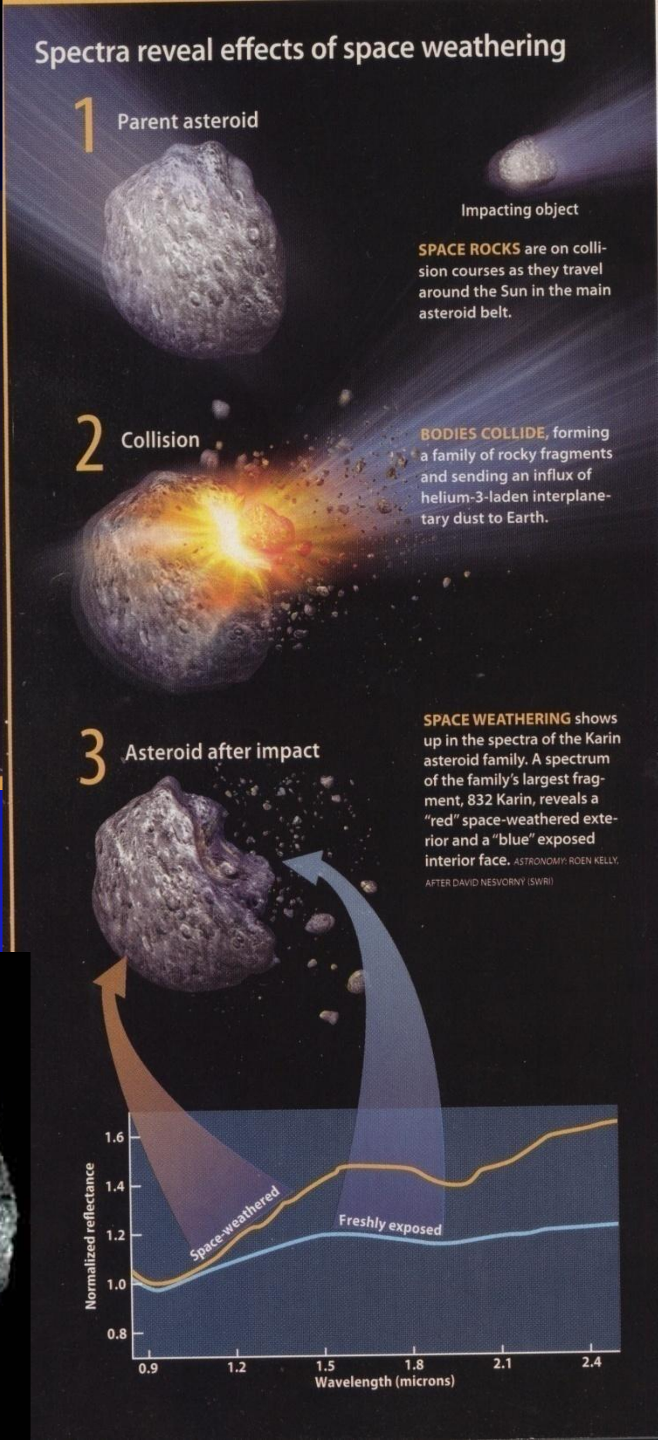
Life and Hydrocarbons in the Universe

- Implications on the relation between Water, Hydrocarbons. Carbonaceous Chondrites (CCs), Comet particles & dust
- Hydrocarbons and Organic Matter/Minerals within the CCs and Comets
- Why should the the Organic Matter in Earth be so similar to Mars during the first 2-3 Ga years
- PAHs (Geopolymer) is present in all universal extraterrestrial space and they are usually fluffy organic matter
- Could the PAHs in Comet and Carbonaceous Asteroids be base (as geopolymer) where the first life and associated hydrocarbons from those bacterial bodies may have originated and later transported to other Planets?
- Life and Life-Forming source rocks may be transported by purging of Comet Dust and transported with soft landings

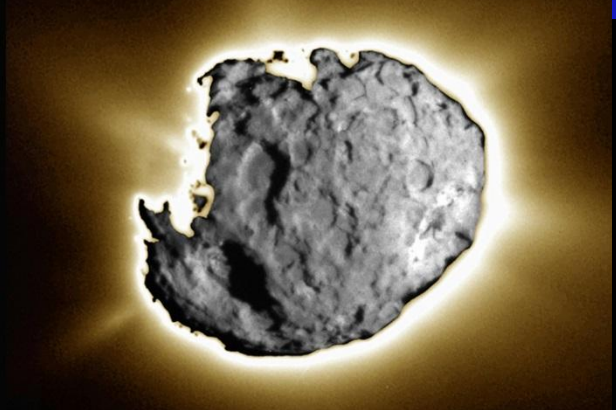
Carbonaceous chondrite is thought to represent the relic material of comets and some carbonaceous asteroids





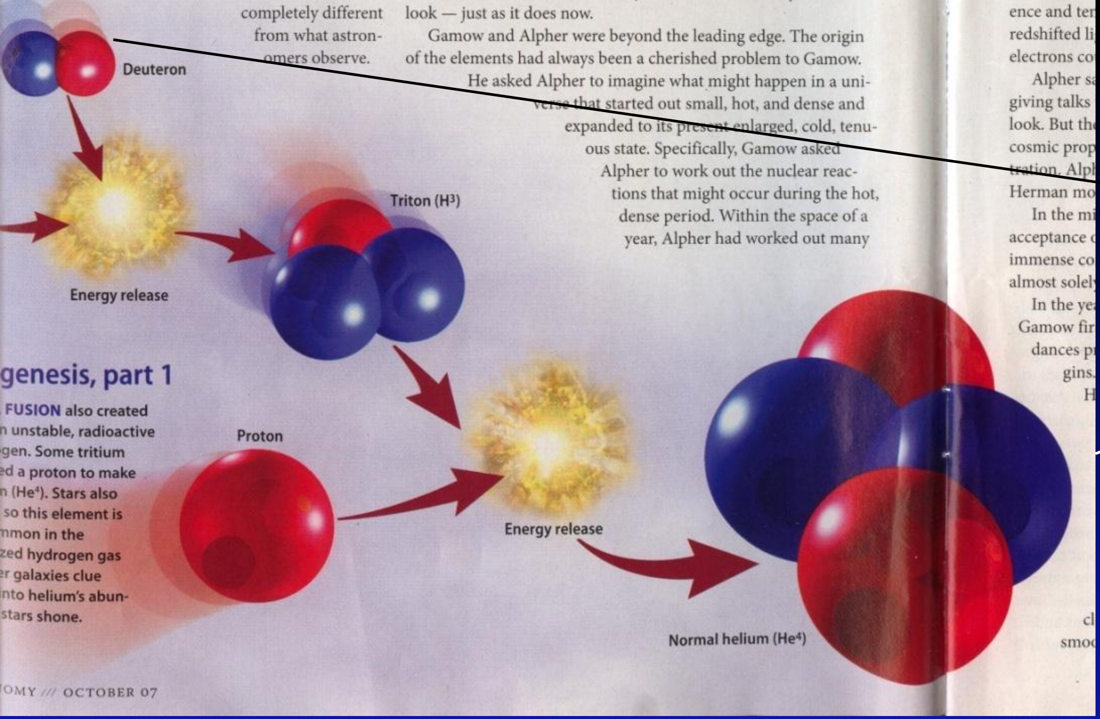
Comet 81 p/Wild 2

Comet Source



"Mean elemental composition of this Wild 2 Material is consistent with the CI meteorite composition." Flynn *et. al.*, Elemental Compositions of Comet 81P/Wild 2 Samples Collected by Stardust. *Science*, 314, 1731-35.

A large carbonaceous chondrite that fell near the French town of Orgueil on May 14, 1864.

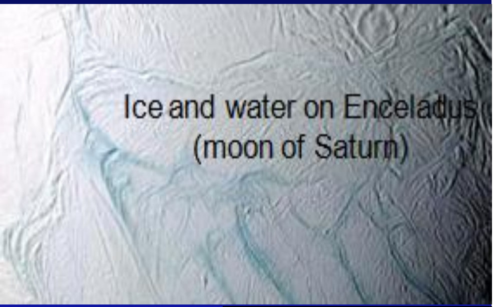


Formation of hydrogen
at the very first
minute of "Big Bang"
and formation of He
By BBN

Formation of Lithium during BBN.
Carbon possibly came from the first
destruction of stars after the BB

Water, Life, and Hydrocarbons co-exist universally as hydrogen is universal

Abundance of Water in Planets, Comets, and Asteroids



Courtesy: Hoover, 2011 (Journal of Cosmology)

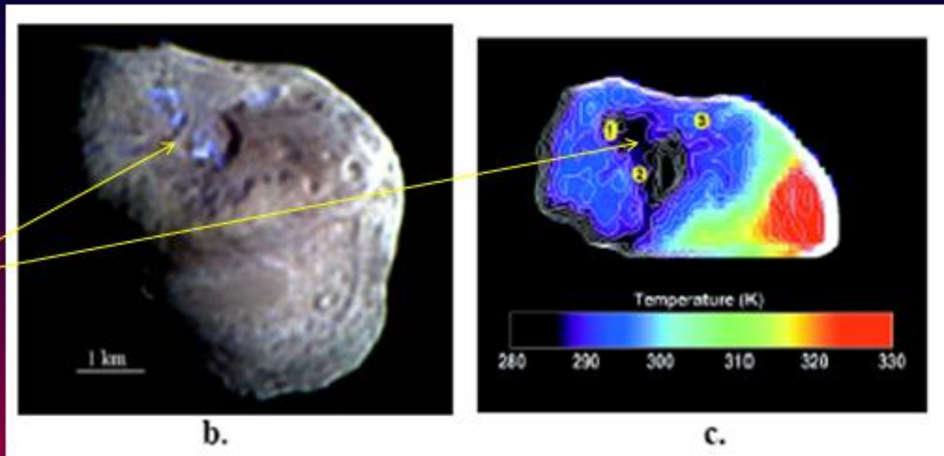
Deuterium/Hydrogen Ratios

OBJECT	Species	D/H x 10^{-6}	Reference
Proto-Solar Nebula	H_2	21 ± 5	Geiss and Gloeckler, 1998
Local Interstellar Medium	H	16 ± 1	Linsky *et al.*, 1993
PLANETS			
Venus (Atmosphere)	H_2O	16,000±200	Donahue *et al.*, 1982
Earth (Oceans)	H_2O	149 ± 3	Lecuyer *et al.*, 1998
Mars (Atmosphere)	H_2O	780±80	Owen *et al.*, 1988
Saturn	H_2	15-35	Griffin *et al.*, 1995
Jupiter	H_2	21 ± 8	Lellouch *et al.*, 1996
Neptune	H_2	65 ± 2.5	Feuchtgruber *et al.*, 1997
Uranus	H_2	55 ± 15	Feuchtgruber *et al.*, 1998
COMETS			
Comet P/Halley	H_2O	310±30	Eberhardt *et al.*, 1987, 1995
Comet Hyakutake	H_2O	290±100	Bockelee *et al.*, 1998
Comet Hale-Bopp	H_2O	330±80	Meier *et al.*, 1998
CARBONACEOUS METEORITE			
Orgueil CI1 Meteorite	Kerogen	370±6	Halbout *et al.*, 1990
Orgueil CI1 Meteorite	Amino Acids	315-545	Pizzarello *et al.*, 1991
Orgueil CI1 Meteorite	Carboxylic Acids	180-310	Pizzarello *et al.*, 1991
CM, CV & CR Meteorites	Kerogen	370±6	Halbout *et al.*, 1990
SNC AND STONY METEORITES			
LL 3 Meteorites (Clays)	-OH	780±120	Deloule and Robert, 1995
Mars - SNC Meteorites	H_2O	530±250	Watson *et al.*, 1994

Water-ice and organics found in Comet Tempel 1

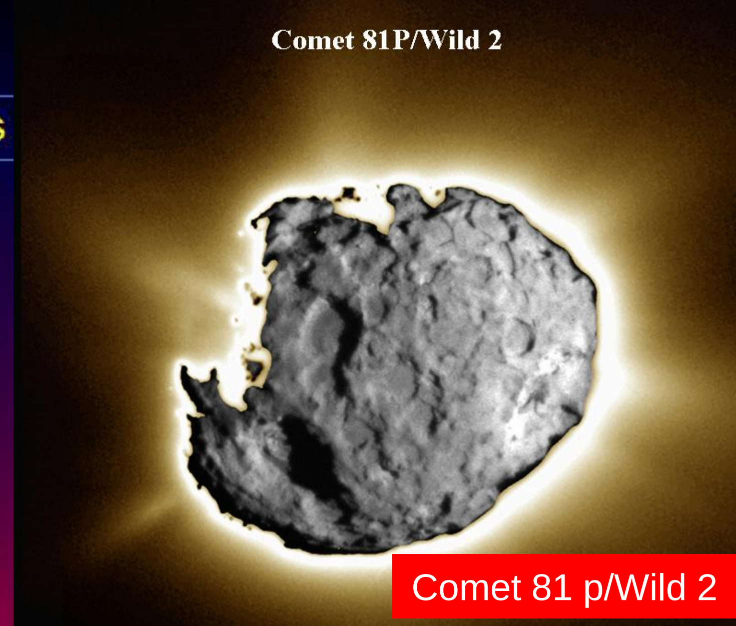
3 areas less than 0.5% of surface, 1.5 & 2μm ice bands

Ice?



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

After Hoover (2011)



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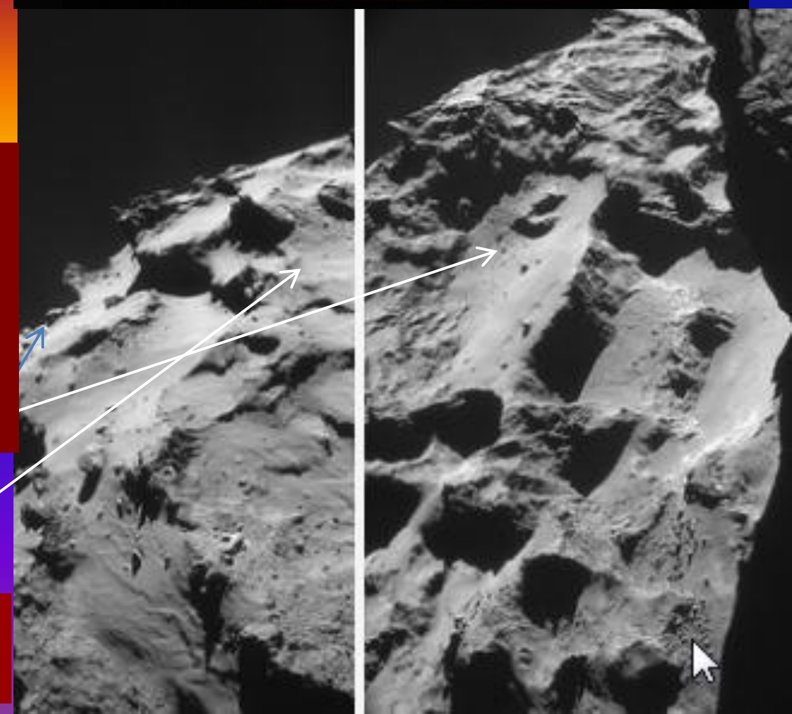
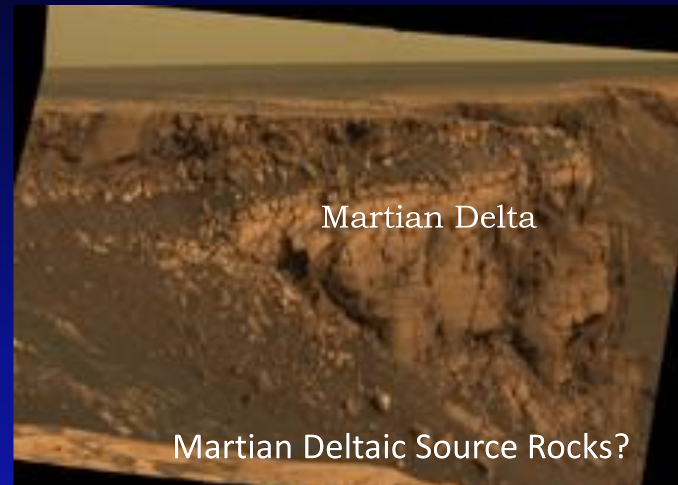


1. Why hydrocarbons and Life forming organoclasts co-existent in Comet?
2. Life transported to planets through comet dust purging or transported as bubbles with a soft landing?

PAH's mixed with Hydrocarbons?

Rosetta is at Comet 67P/Churyumov-Gerasimenko studying the Comet minerals and organics

Possible Source Rocks as in CCs, Mars, and Earth



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

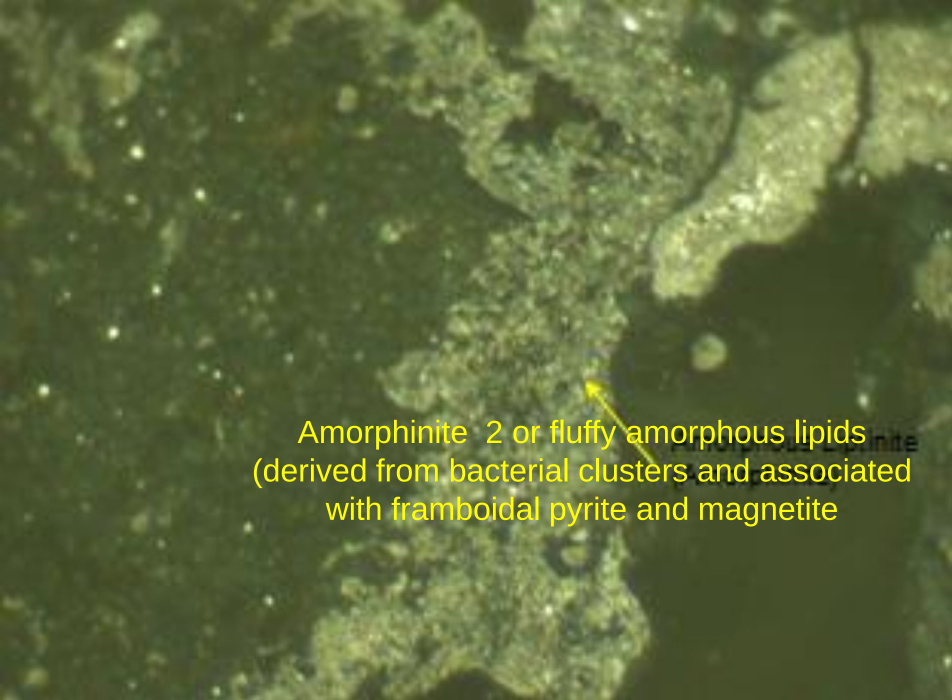
(dispersed organic matter)
Allende

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

Terrestrial Kerogen Composition (mineral-matter-free basis)

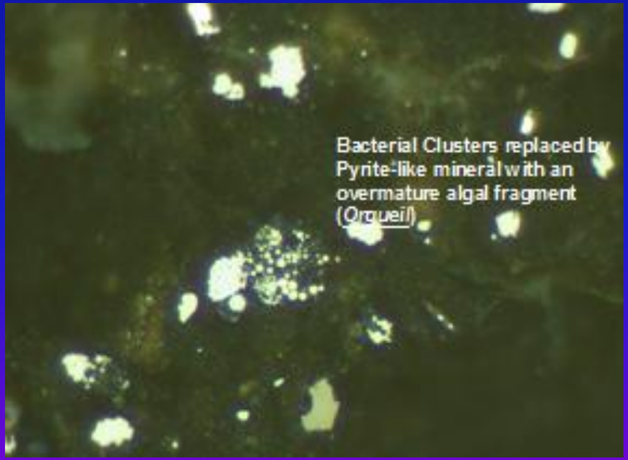
Carbon: 69-77.5%, Hydrogen: 7.5%
Nitrogen: 1.5%, Oxygen: 12%
Sulfur: 0.01 to 1.5%

Carbonaceous Chondrites as Source Rock Evaluation, SR Potential, Maturation, and Organic Geochemical Signatures



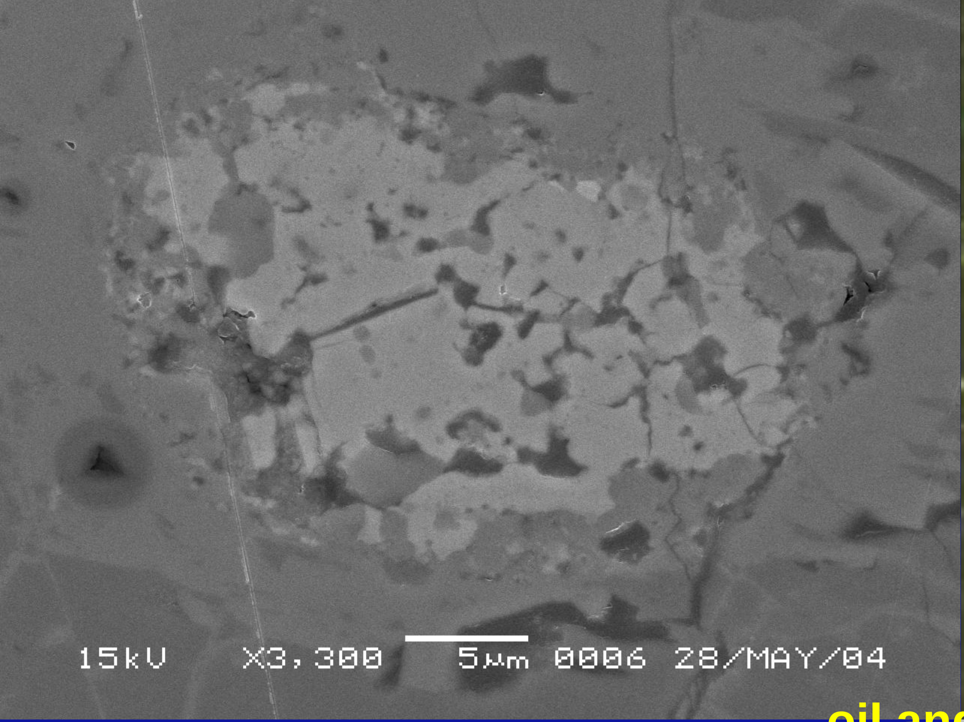
Murchison CC

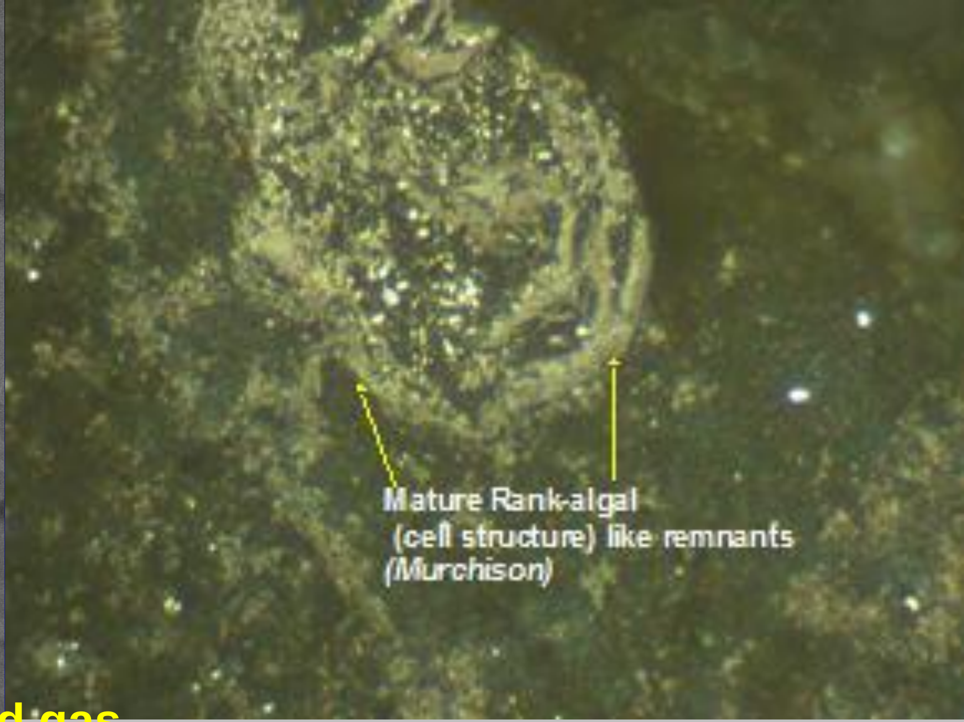
Tagish Lake CC



Orgueil CC

Bacterial Clusters and Amorphous Liptinite 2 (Amorphinite) and formation of Kerogen Type source rocks in the CCs

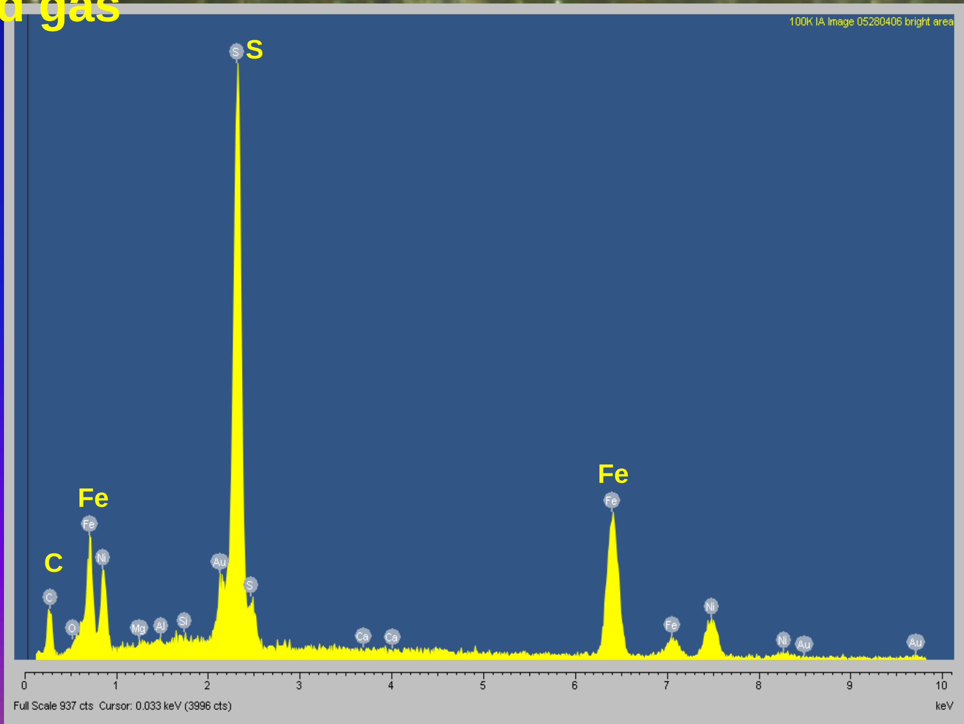




oil and gas

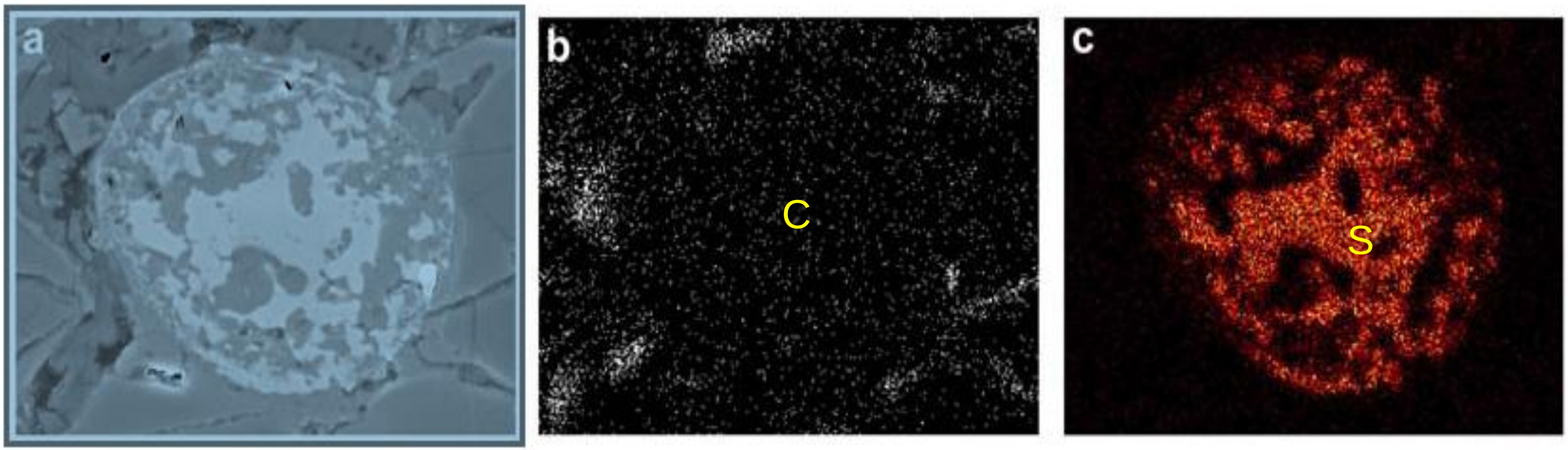
Algal-like components mostly replaced by pyrite (Murchison) in SEM

SEM/EDS of the same zone above showing presence of C, Fe, and S possibly suggesting the replacement of organics by iron sulfides



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)

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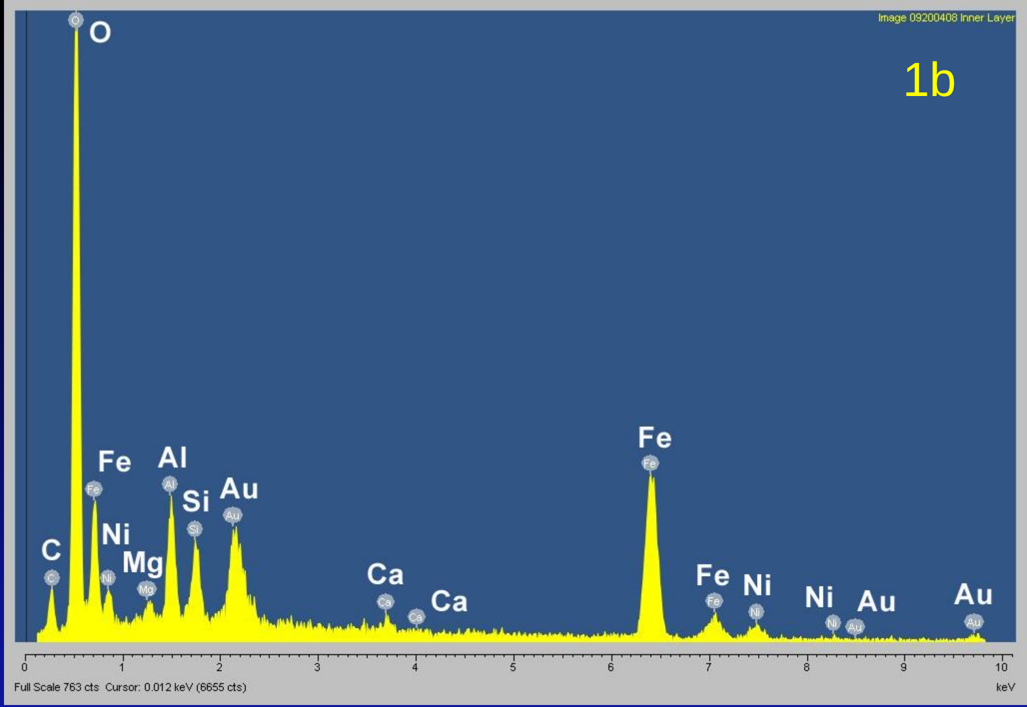


1. Organoclasts in Martian CC (ALH 840001)

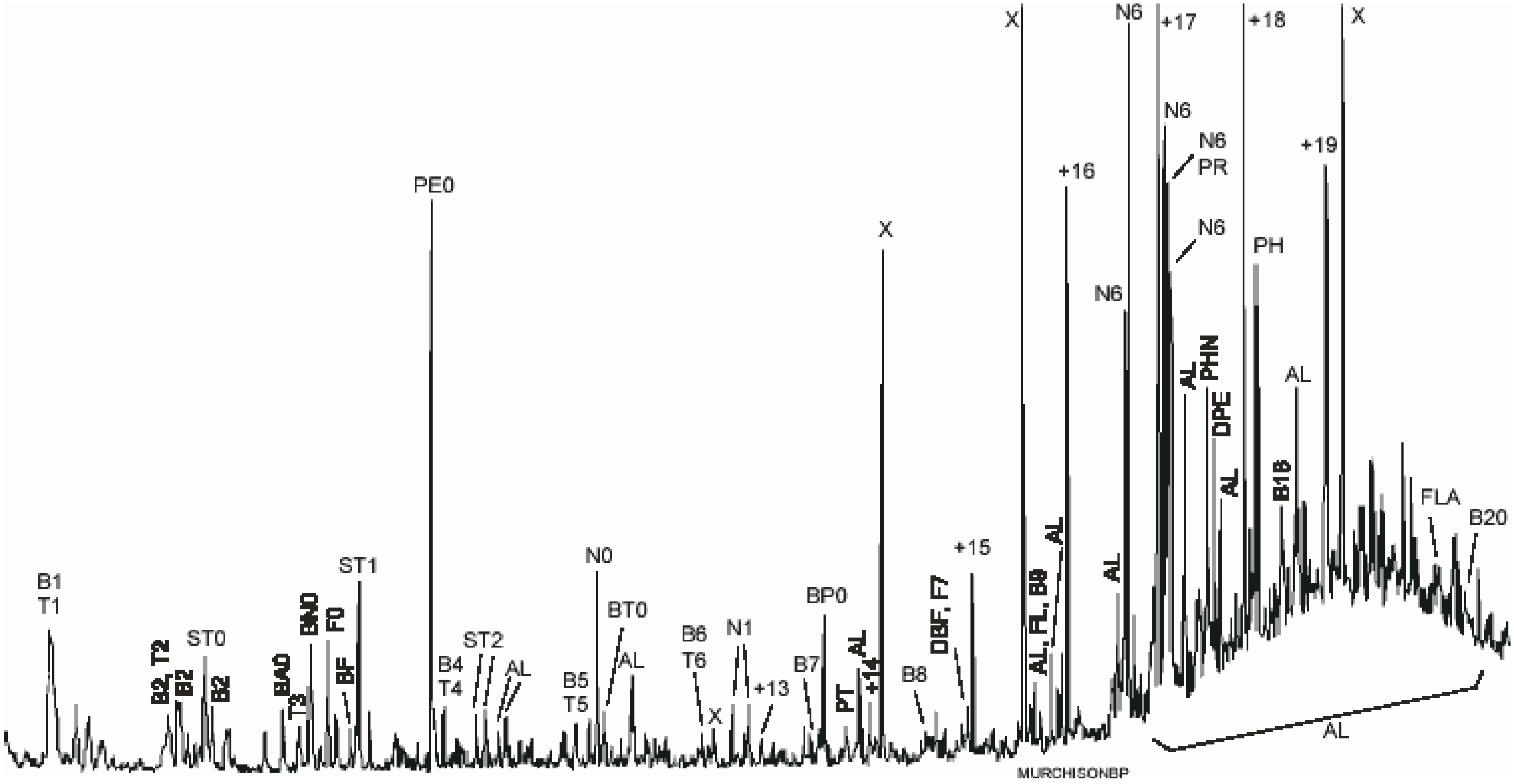
: a. SEM image; b. EDS data of earlier image (Mukhopadhyay, 2009)

2. Solid bitumen within Martian CC: ALH 840001 (Ro: 3.25%)

Maturation and Predicted Temperatures of Organoclasts or Solid Bitumen

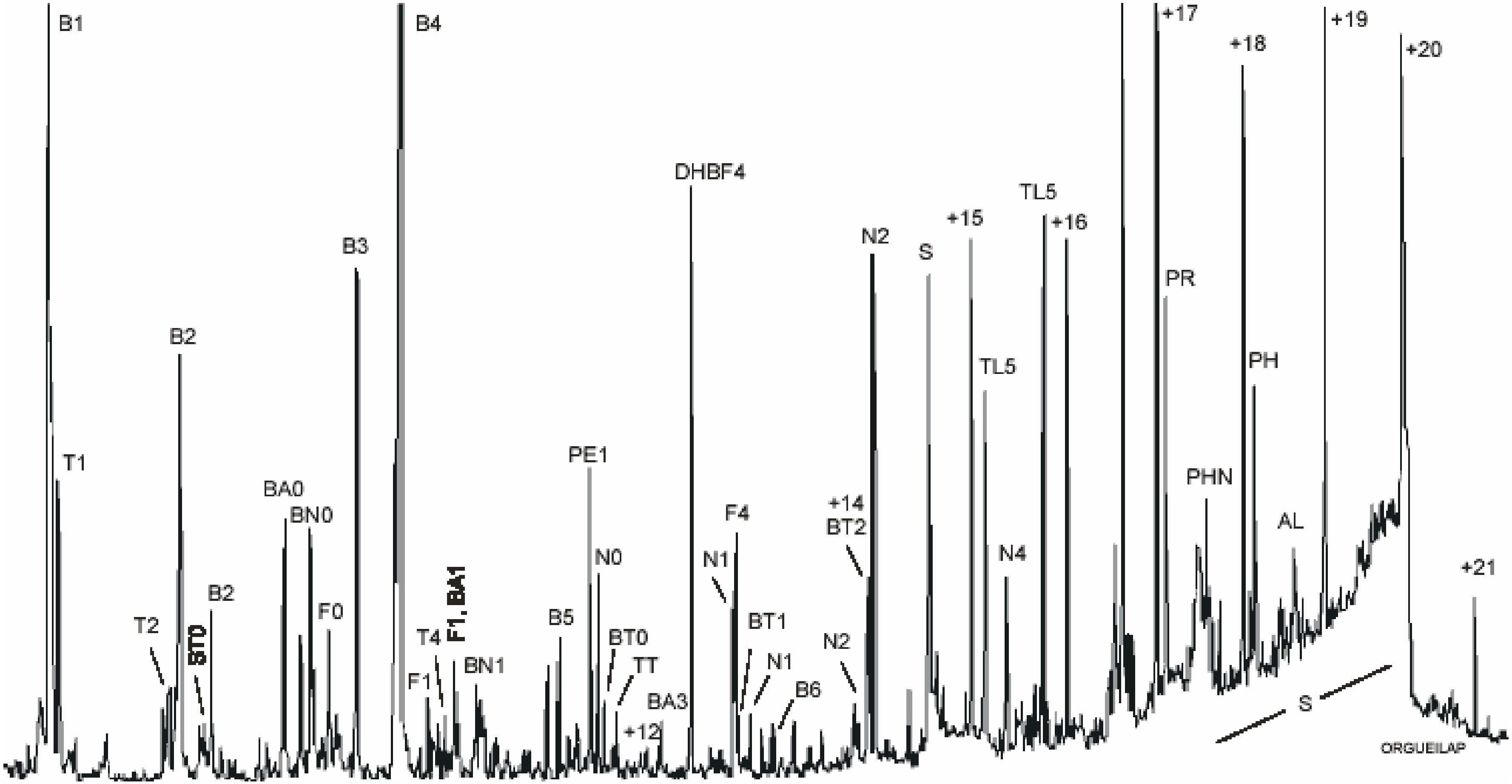
Name of Carbonaceous Chondrites	% R_o (number of grains measured)	Predicted Temperature (max) (^oC)	Maceral Name
Allende	4.9% (8)[a]	400-425	pyrobitumen
Dohfar 735	1.4-2.0% (4)[a]	150-200	pyrobitumen
Murchison	1.21% (3)[b] 0.65-0.83% (8)[a]	110-120	vitrinite-like organics solid Bitumen
NWA 3003	3.0% (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

a = solid bitumen; b = vitrinite-like components



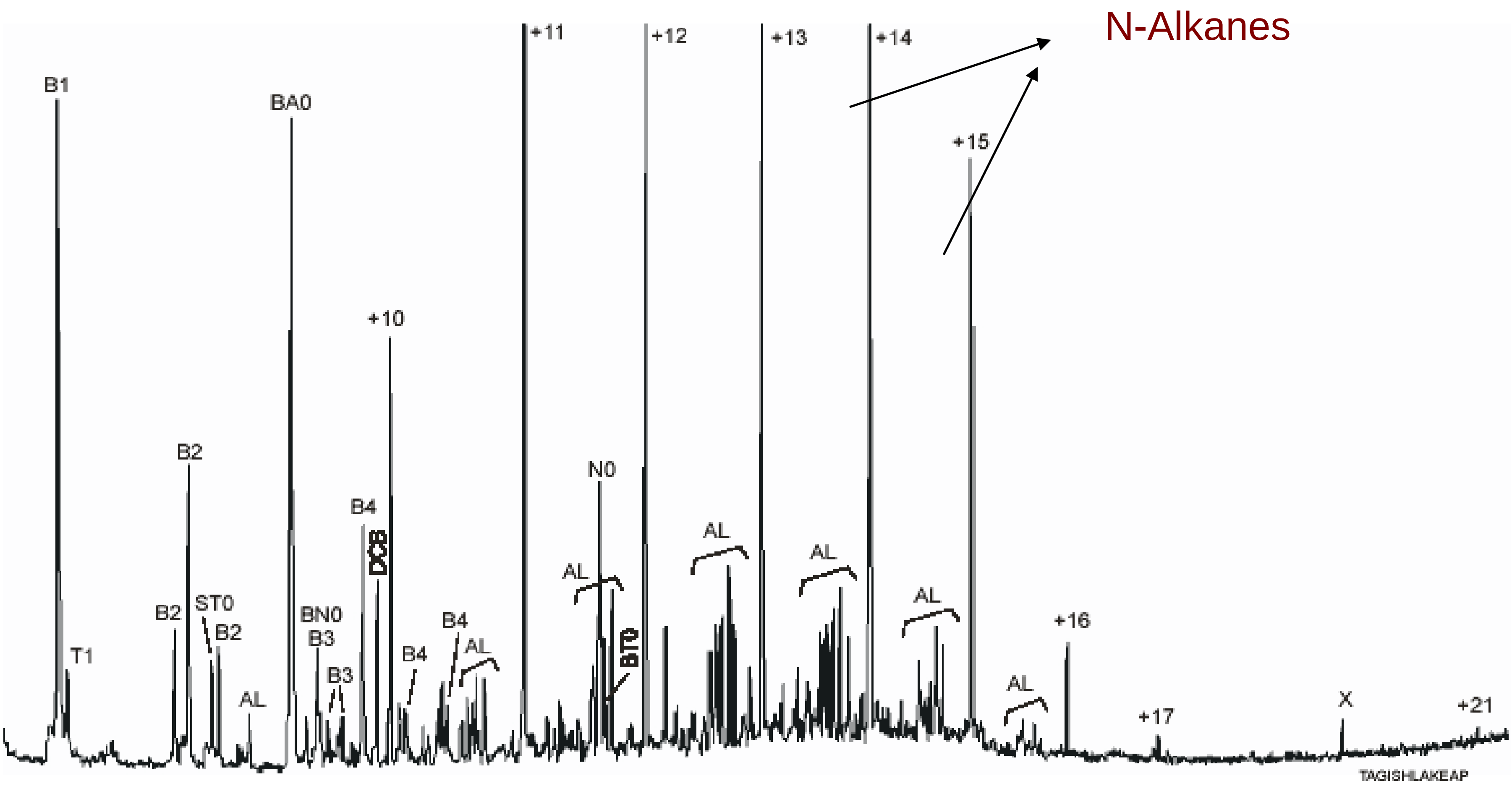
Py-GC-MS chromatograms of the thermal extract of the Murchison

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



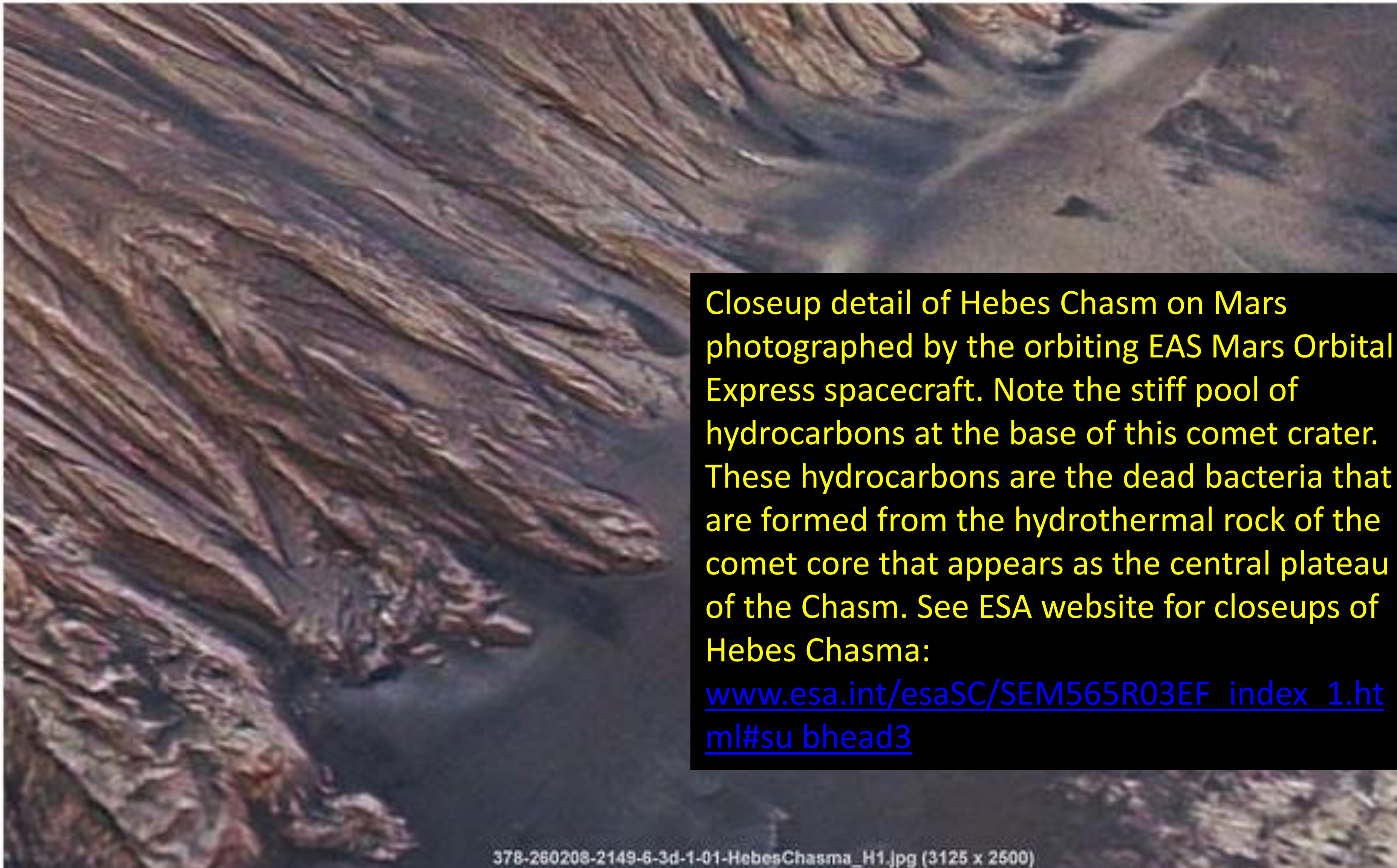
Py-GC-MS chromatograms of the Pyrolyzed Part of Orgueil

N: n-alkanes; AL: unspecified branched or cycloalkanes; PHN: phenanthrene; FL; fluorene; B: benzene; TL:tetralin; S: elemental sulfur; BT: benzothiophene



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

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



Closeup 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 closeups of Hebes Chasma:
www.esa.int/esaSC/SEM565R03EF_index_1.html#subhead3

Hydrocarbons on Hebes Chasma, Mars

Early Life and Petroleum Hydrocarbons in Early 2-3 Ga on Earth & Mars

- **Whether early life (> 2 Ga) and hydrocarbons interlinked? They have started from common string of source material as PAH-related Geopolymer**
- **Overwhelming relationship of Oil & Gas within Precambrian Sediments on Earth (4.0 to 2.0 Ga) and their genesis already linked to bacterial/algal fluffy organic carbon-rich source rocks suggesting similar oil- and gas-bearing source rocks within Mars (possibly within 4.0 to 2.0 Ga)**
- **Recent Data Comet Dust purged particles suggest definite presence of fluffy rich organic matter, possible source rocks**
- **Presence of abundant water and hydrocarbon-like compounds in Comet, such as in** is at Comet 67P/Churyumov-Gerasimenko

Hydrogen came at the beginning of BBN and Carbon came later after the destruction of first set of stars when first elements evolved to be the main components for all possible presence of all oil and gas on Comet & Mars

Possible Formation Of HCs ??

Possibility 1:
Mainly PAHs + other metals, H, He, and C? Later biogenic processes with formation of organic components & finally as source rock

Possibility 2:
Early PAHs as feedstock for later bacterial and algally derived source rocks or direct heating by Sunlight or volcano?

Possibility 3: . Life could be transported in the Solar System planets later from comet possibly from the (a) purging the primordial "*comet dust*"or as bubbles or (b) slow impact of *carbonaceous meteoritic* showers from asteroids.

Main Concept

In Comets, (1) Lighter HCs have been originated from early PAHs as an abiogenic source by lightning on which primitive bacterial growth formed

(2) Source rocks were formed later from that bacterial degradation within the early sediments

(3) The organic complex form the base geopolymer (complex of kerogen and solid bitumen)

(4) The oil and gas were formed later in comets from maturation of labile fluffy bacterial SR at a lower temperature in slightly deeper section within comet or asteroids