In Situ Detection of Organics on Mars

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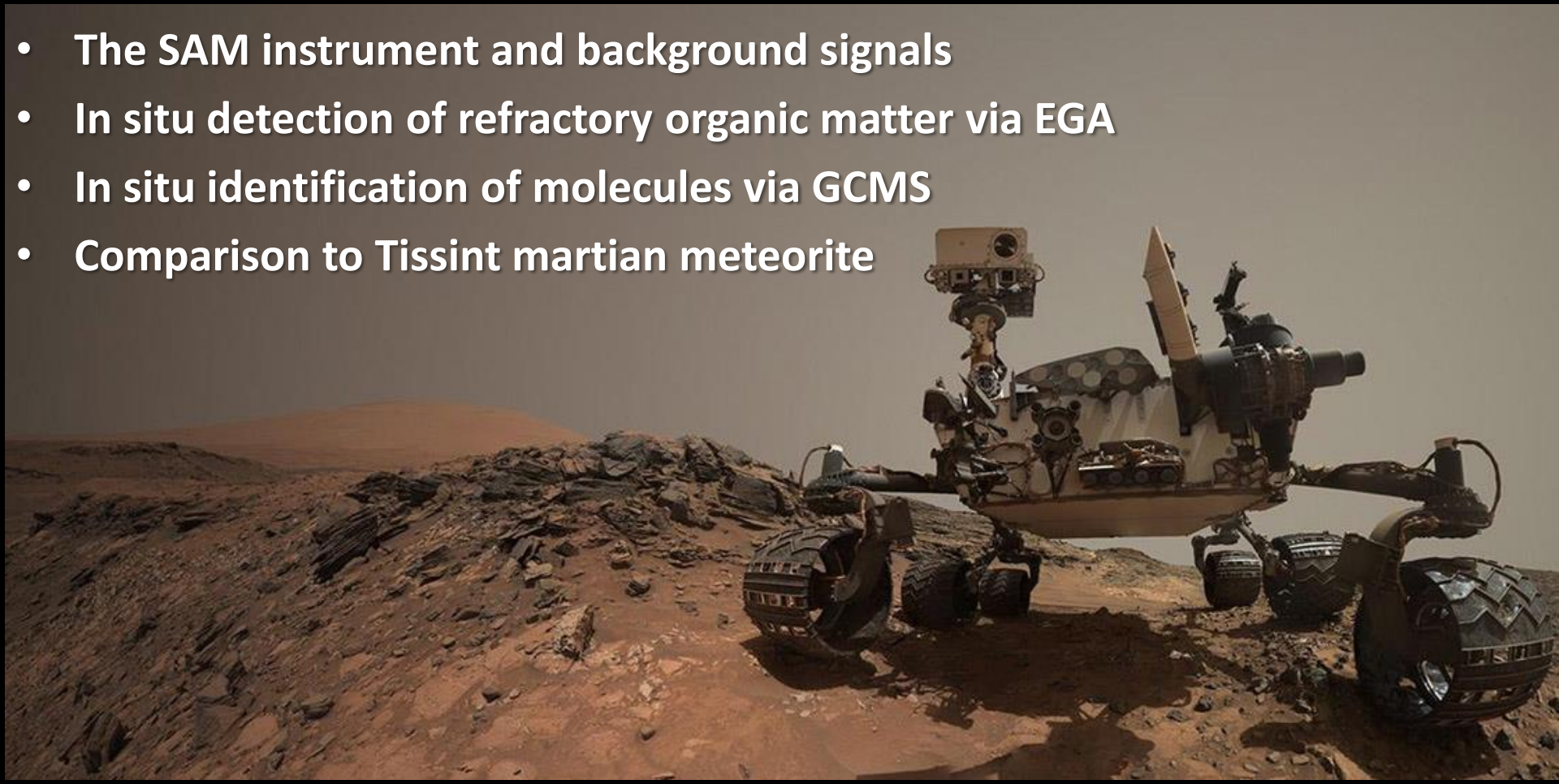
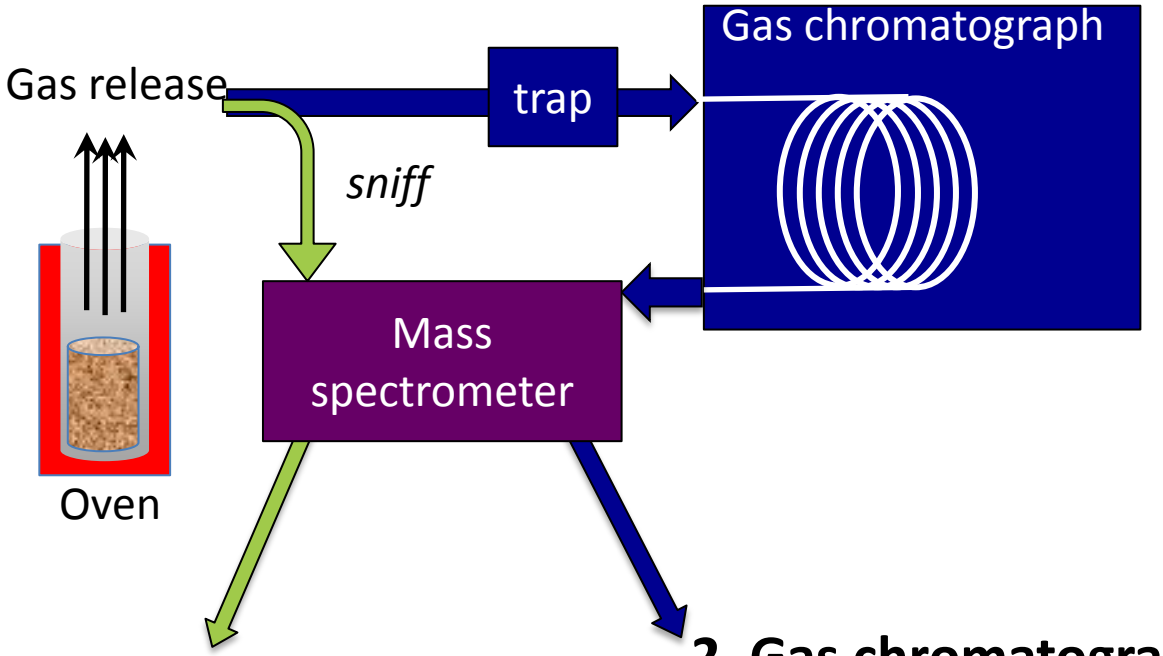
the SAM and MSL teams

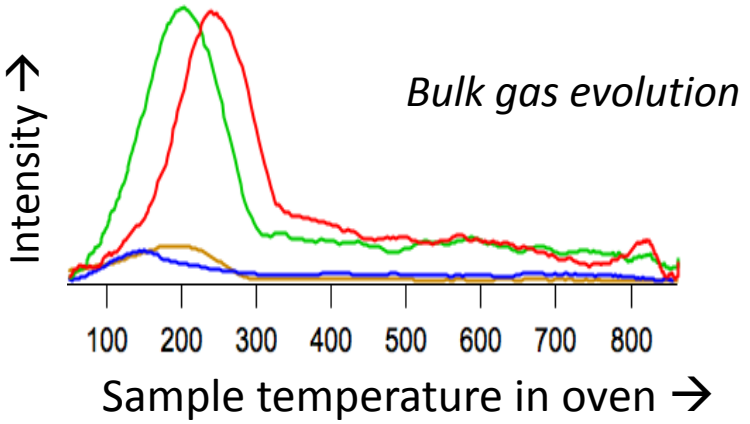
- The SAM instrument and background signals
- In situ detection of refractory organic matter via EGA
- In situ identification of molecules via GCMS
- Comparison to Tissint martian meteorite



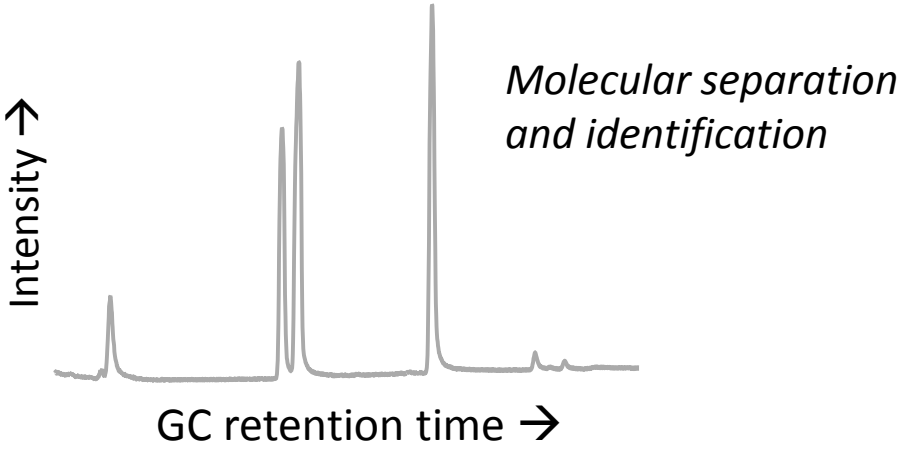
SAM measurements of organic volatiles from sample



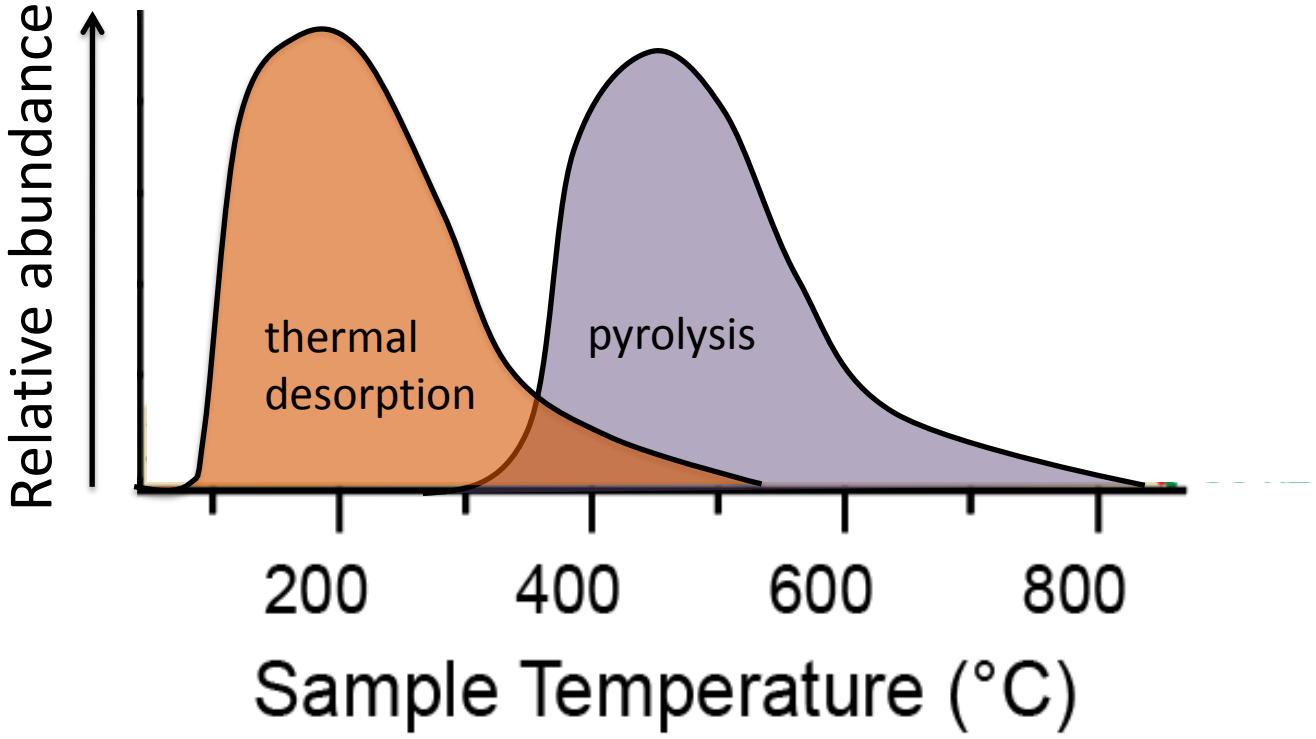
1. Evolved gas analysis (EGA)



2. Gas chromatography mass spectrometry (GCMS)



What happens to a sample when its heated under helium?



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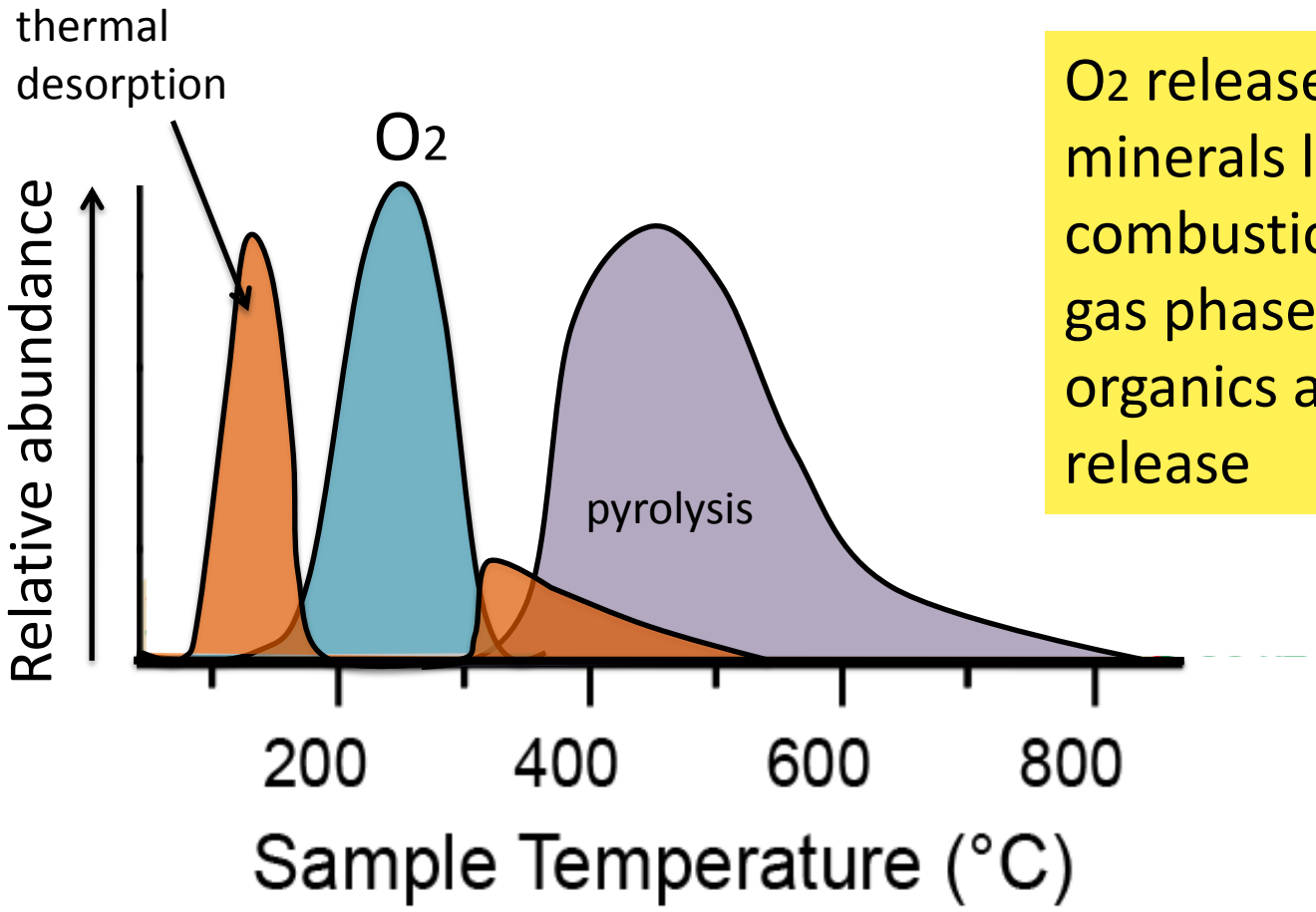
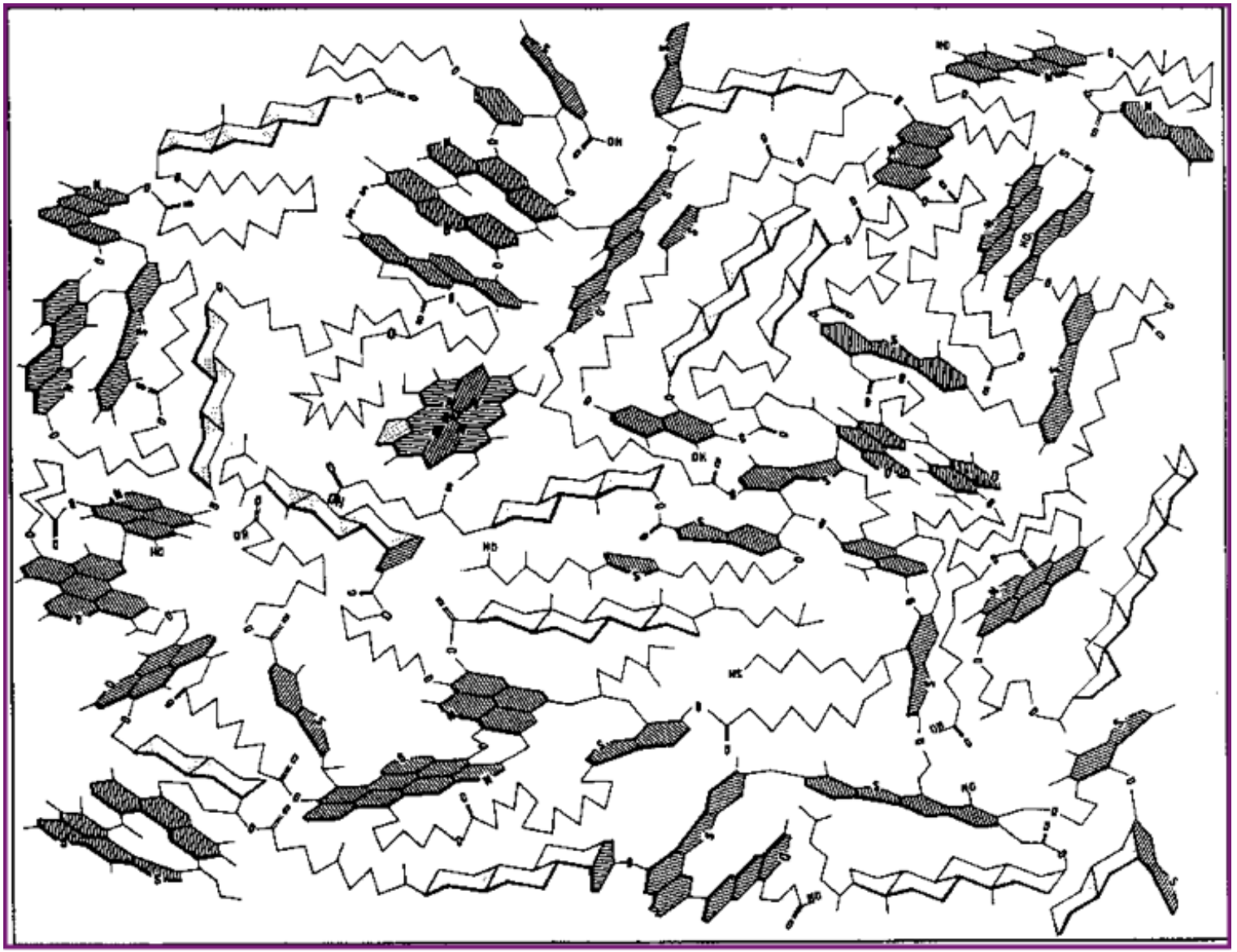


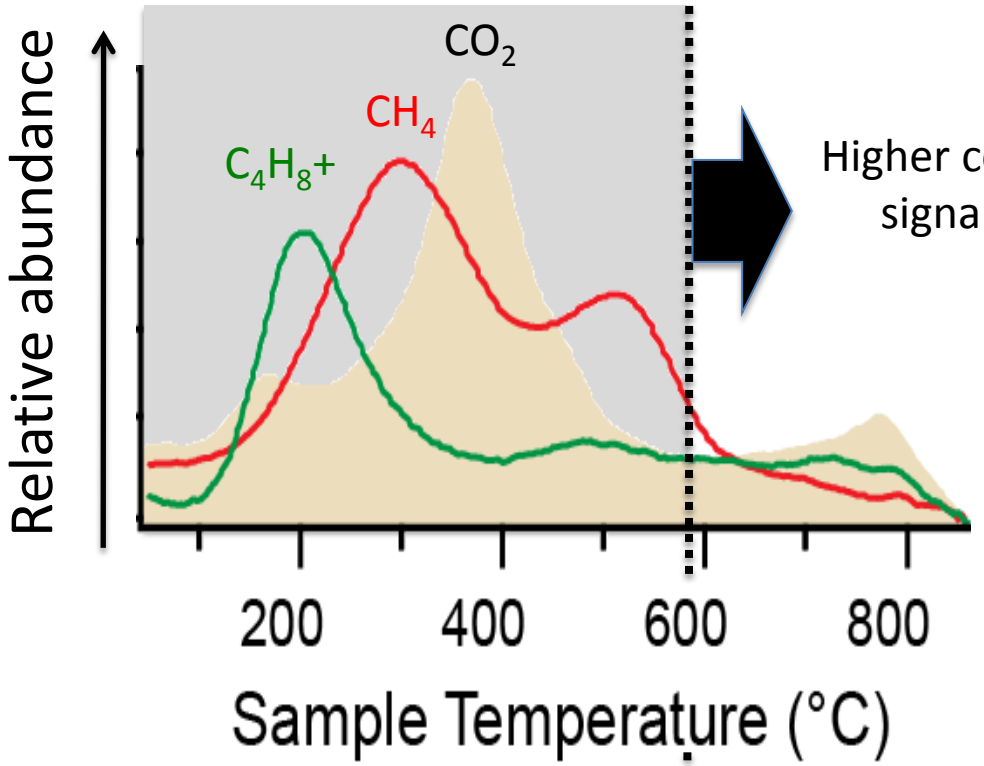
O_2 release from minerals leads to combustion of gas phase organics and CO2 release

Macromolecules



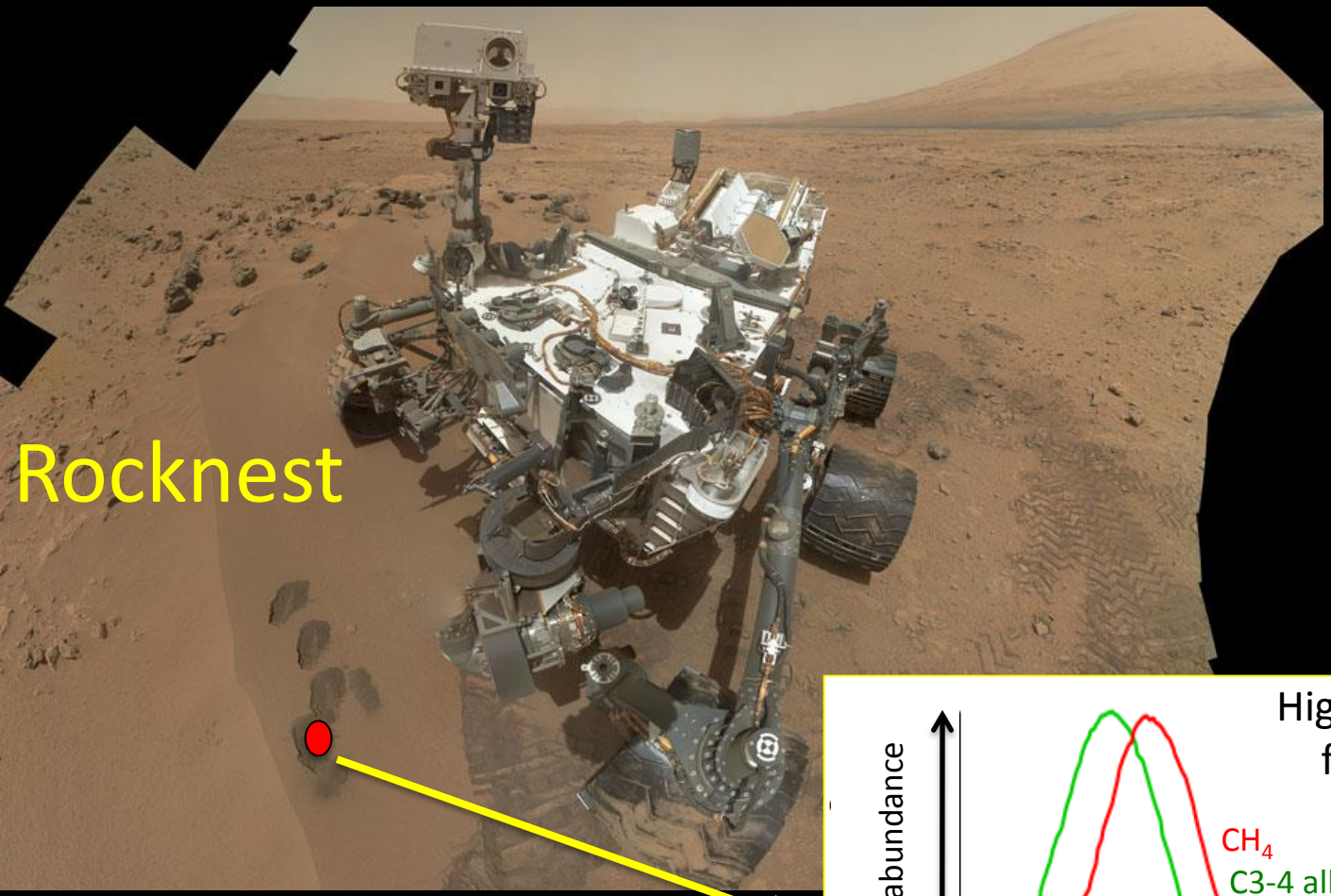
Killops and Killops, 1993

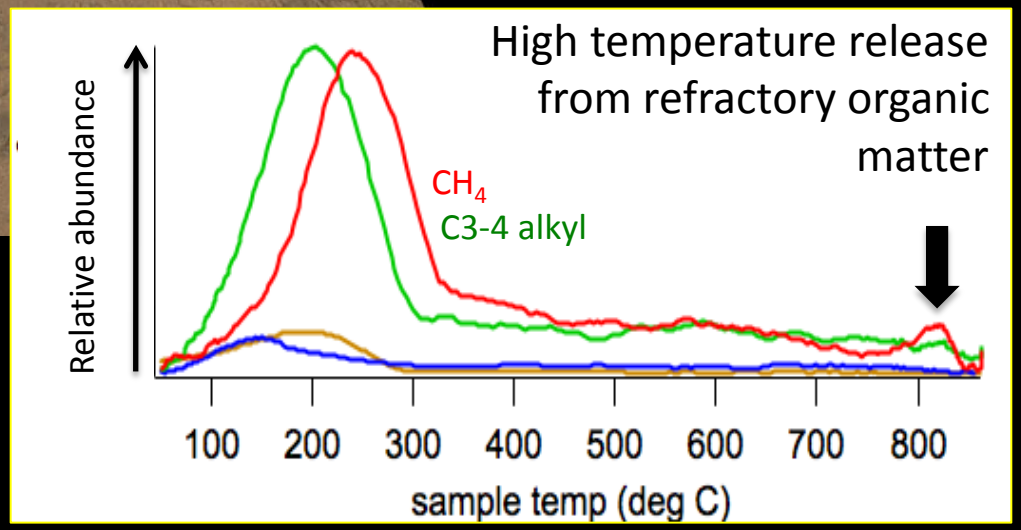
Character of SAM background in Evolved Gas Analysis (EGA)



Higher confidence that organic signals are indigenous to sample

The transition is dependent on sample chemistry



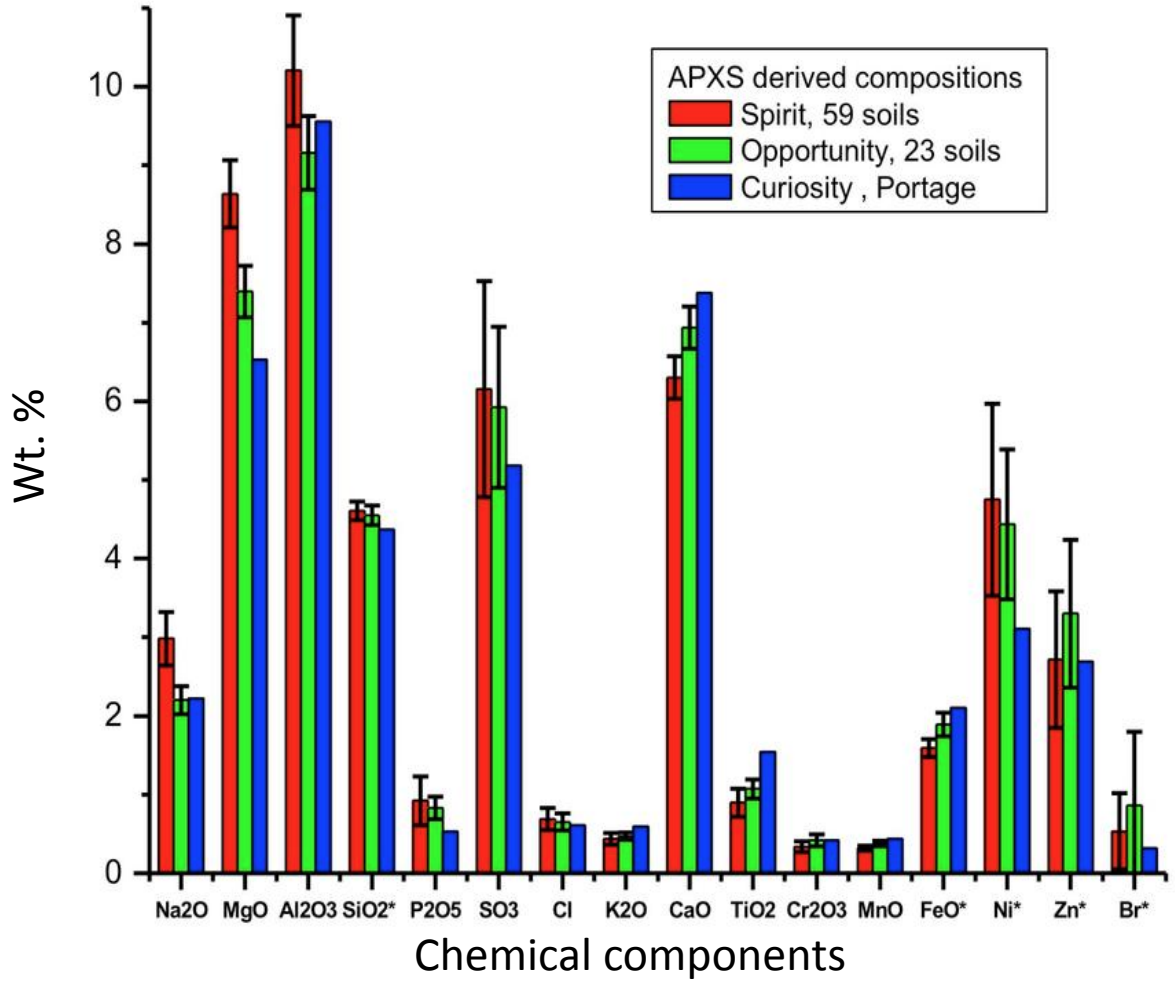


Rocknest Eolian Drift

- Gale Crater floor
- scoop site, first analysis by SAM

Eigenbrode et al, 2014 AGU Fall Meeting
Eigenbrode et al., in prep

Chemical composition of Gale, Meridiani and Gusev soils are basaltic and nearly identical in APXS measurements



- Global signature
- Composition suggests limited chemical weathering (Berger et al., 2013, *JGR*)

Yen et al., 2013, *LPSC* #2495; Blake et al. 2013, *Science*.

MSL Team's stratigraphy column

(Grotzinger et al, 2015)

Mudstones

Murray fm.

Pahrump Hills/Marias Pass

Confidence Hills

Mojave2

Telegraph Peak

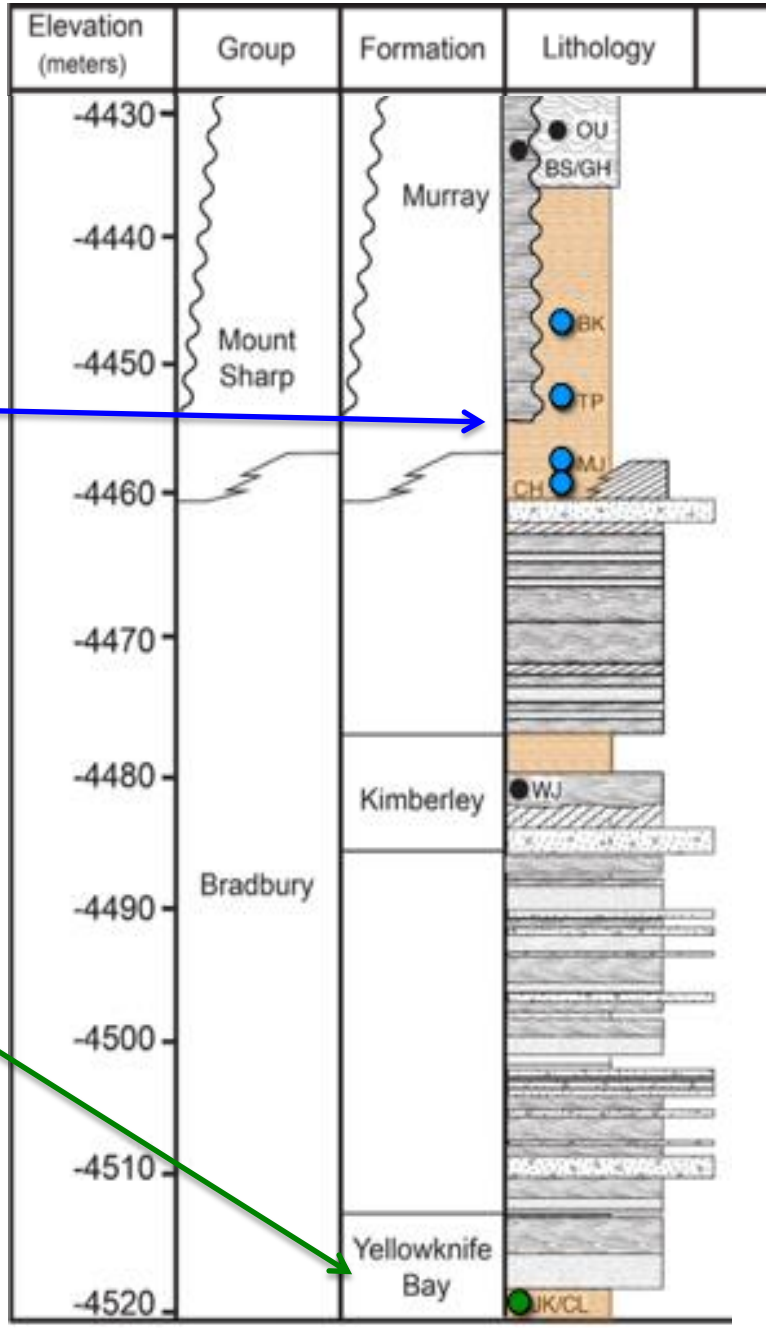
Buckskin

Sheepbed Mbr.

Yellowknife Bay

Cumberland

John Klein



Point Lake

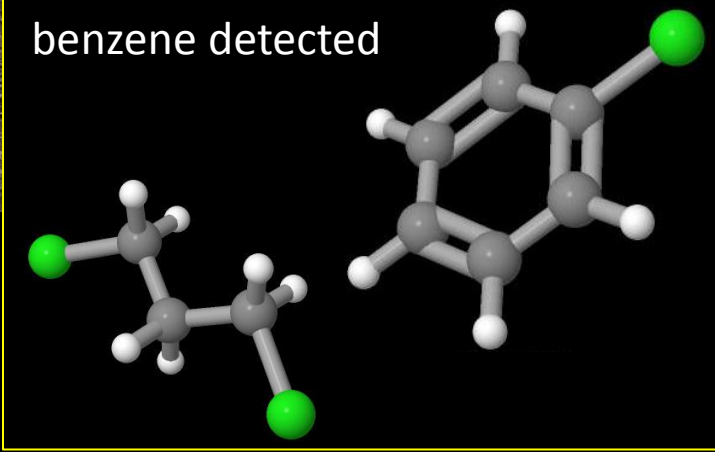
Gillespie Lake

Sheepbed mudstone

John Klein

Cumberland

Chlorinated C1-C4 chains and benzene detected



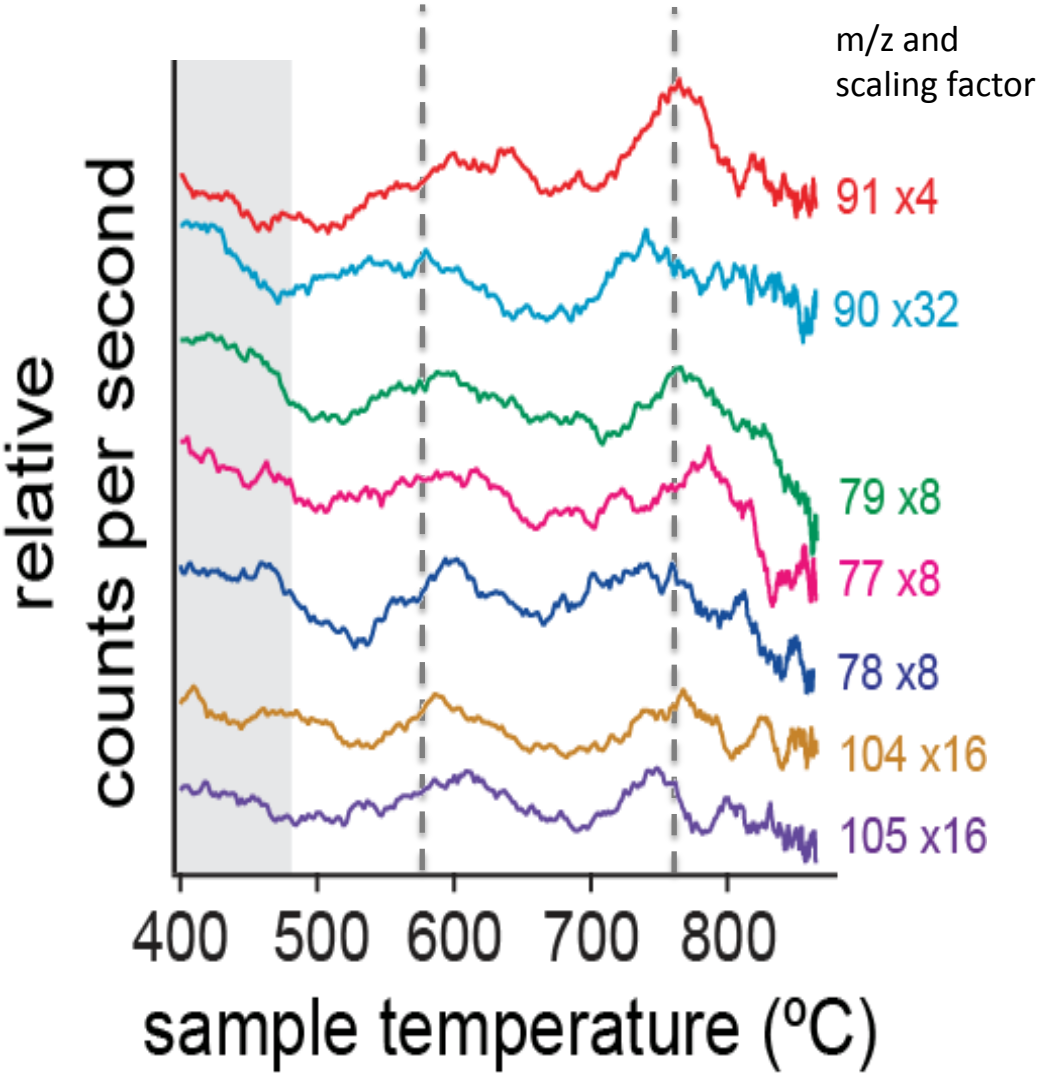
Freissinet et al., 2015, JGR

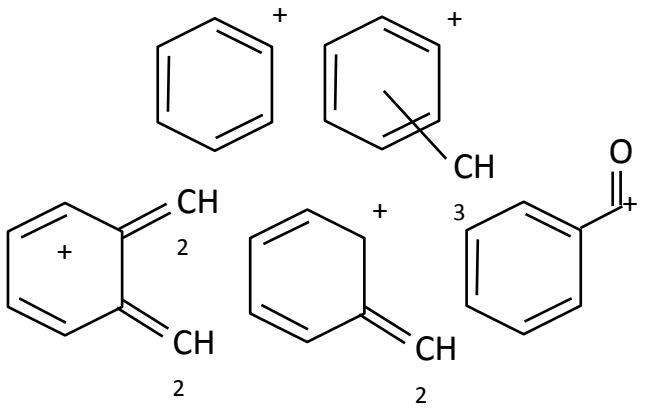
Yellowknife Bay

- **Gale Crater floor sediments**
- **drill sites analyzed by SAM**
- **lake deposit (Grotzinger et al., 2015, Science)**

SAM EGA of Cumberland

Single-Ring Aromatic Hydrocarbons



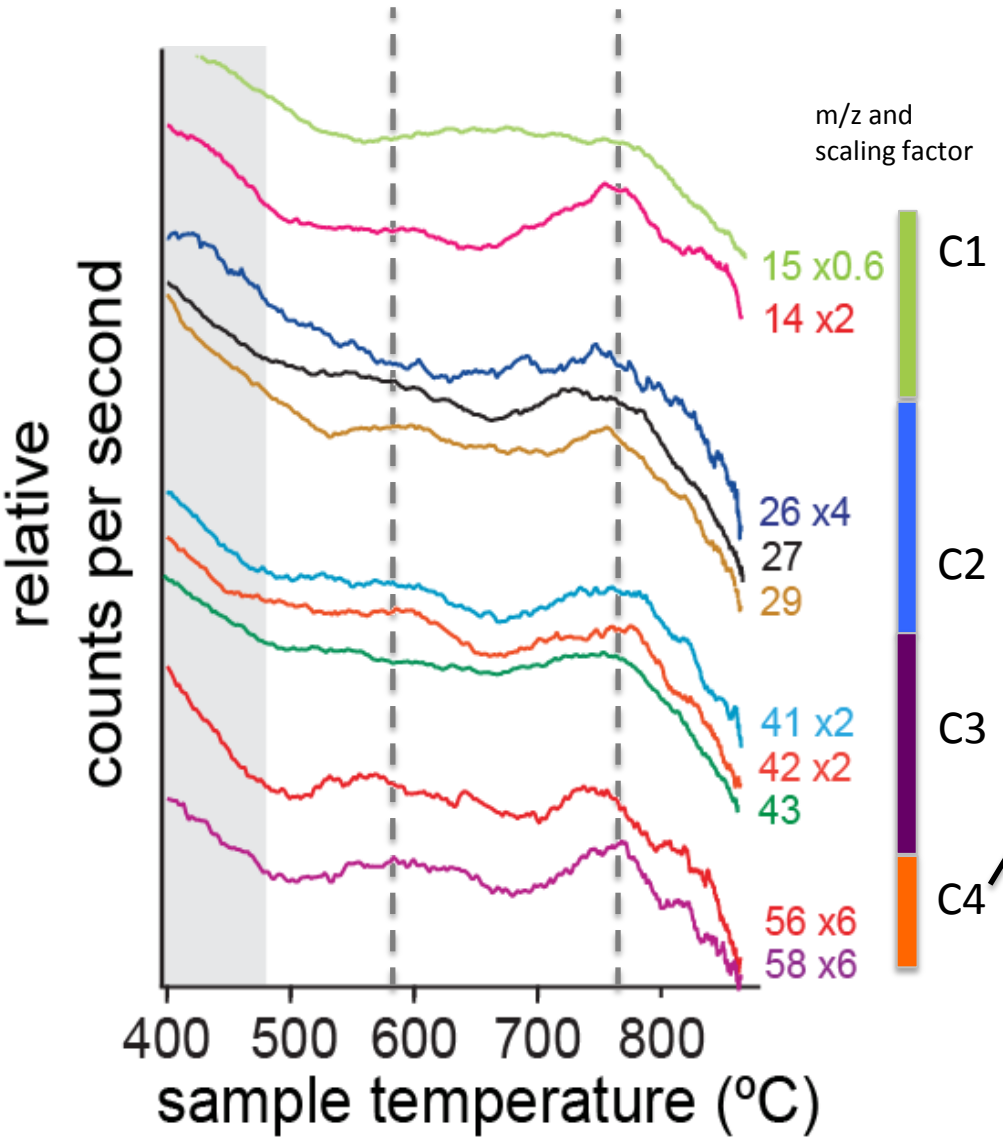


Relatively weak signals

Eigenbrode et al, AGU, 2015
Eigenbrode et al., in prep

SAM EGA of Cumberland

C1-C4 Alkyl Hydrocarbons

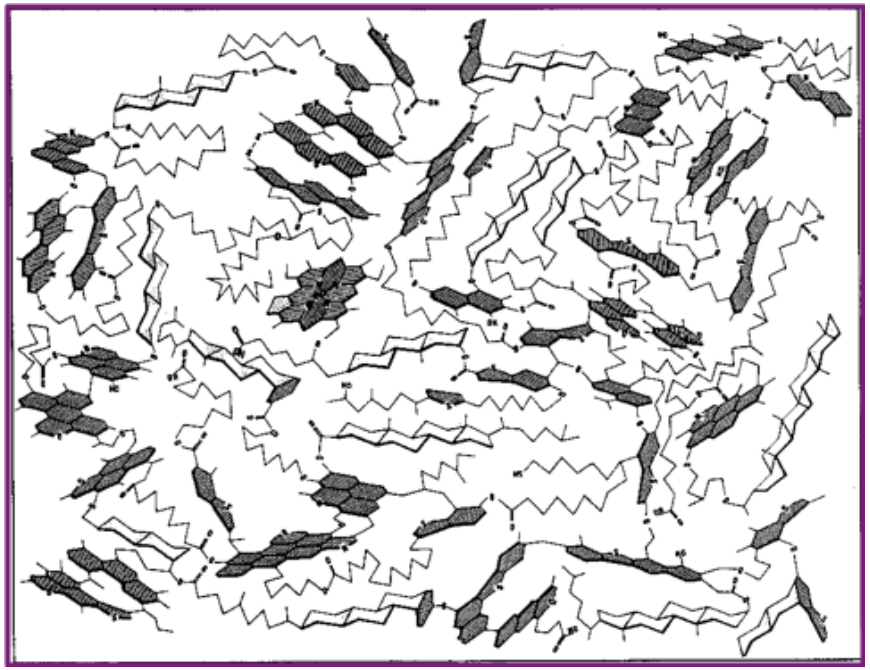


Example carbon chain

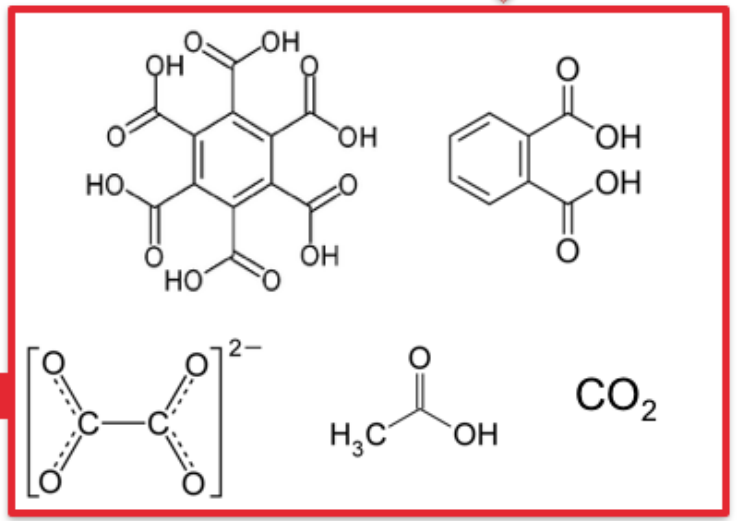
Relatively weak signals

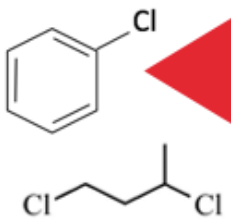
Eigenbrode et al, AGU, 2015
Eigenbrode et al., in prep

From refractory organic matter to chlorohydrocarbons proposed mechanism: Fenton-like reactions



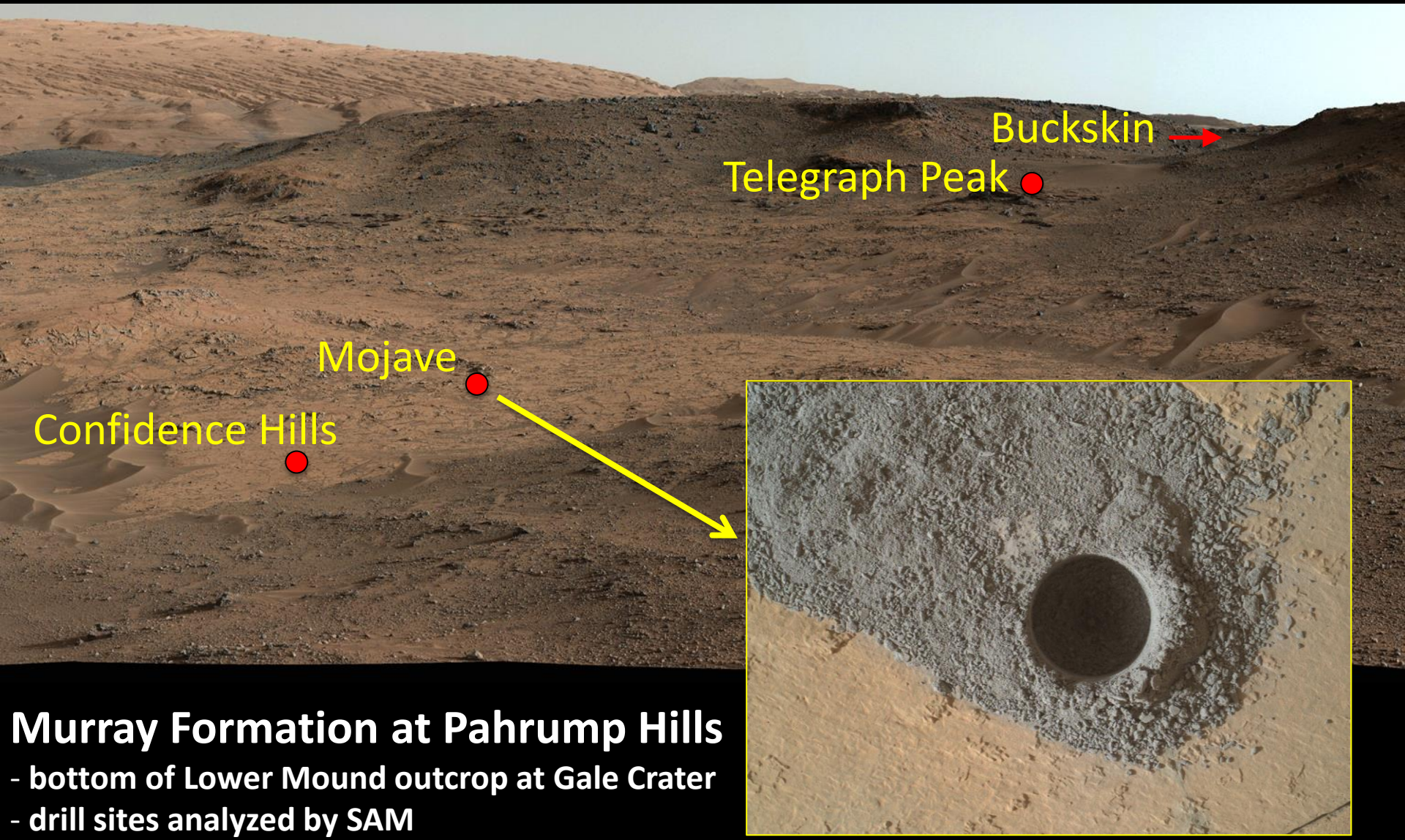
Ionizing radiation +
Organics + Metal catalysts





Low temperature evolution of chloro-hydrocabons may be an indication of radiolytic weathering

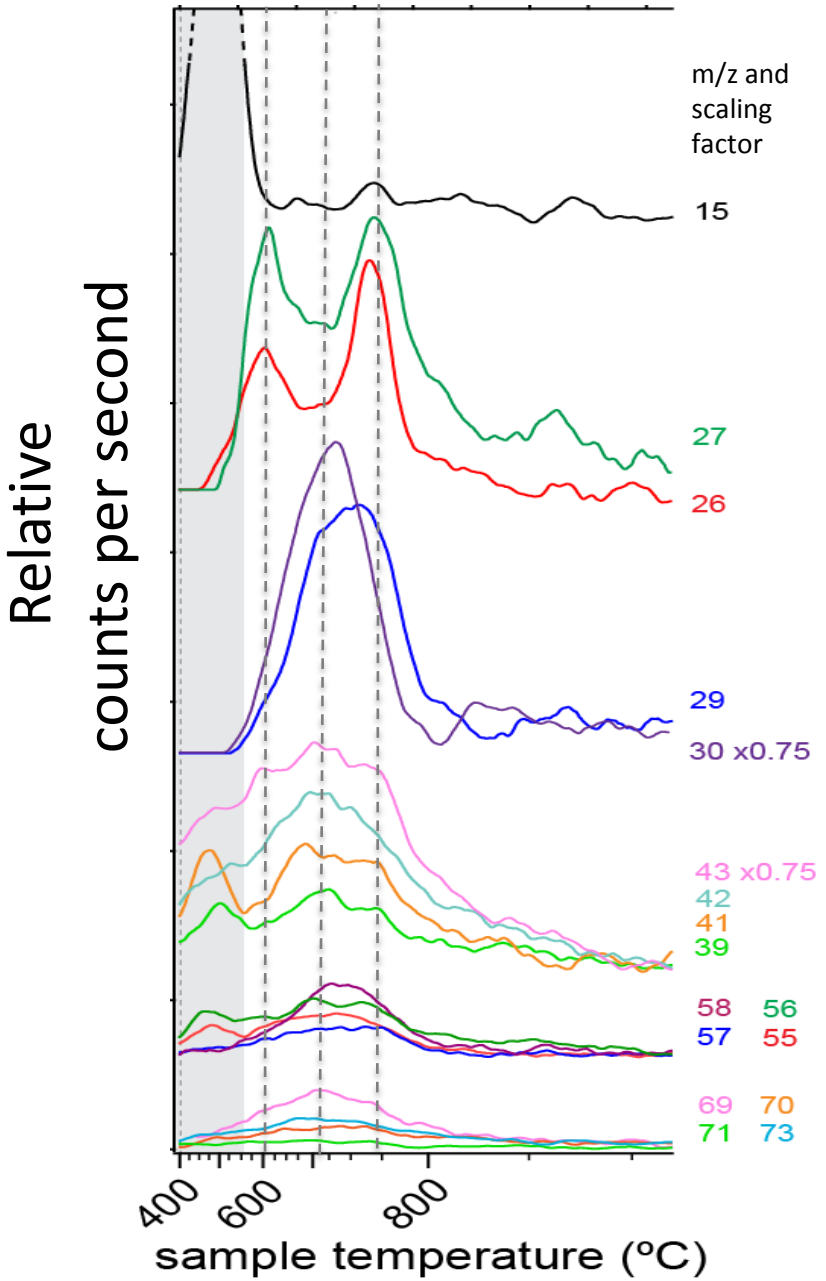
Benner et al., 2000, PNAS (via UV)



Murray Formation at Pahrump Hills

- bottom of Lower Mound outcrop at Gale Crater
- drill sites analyzed by SAM
- lake deposit (Grotzinger et al., 2015, Science)

SAM EGA of Mojave2



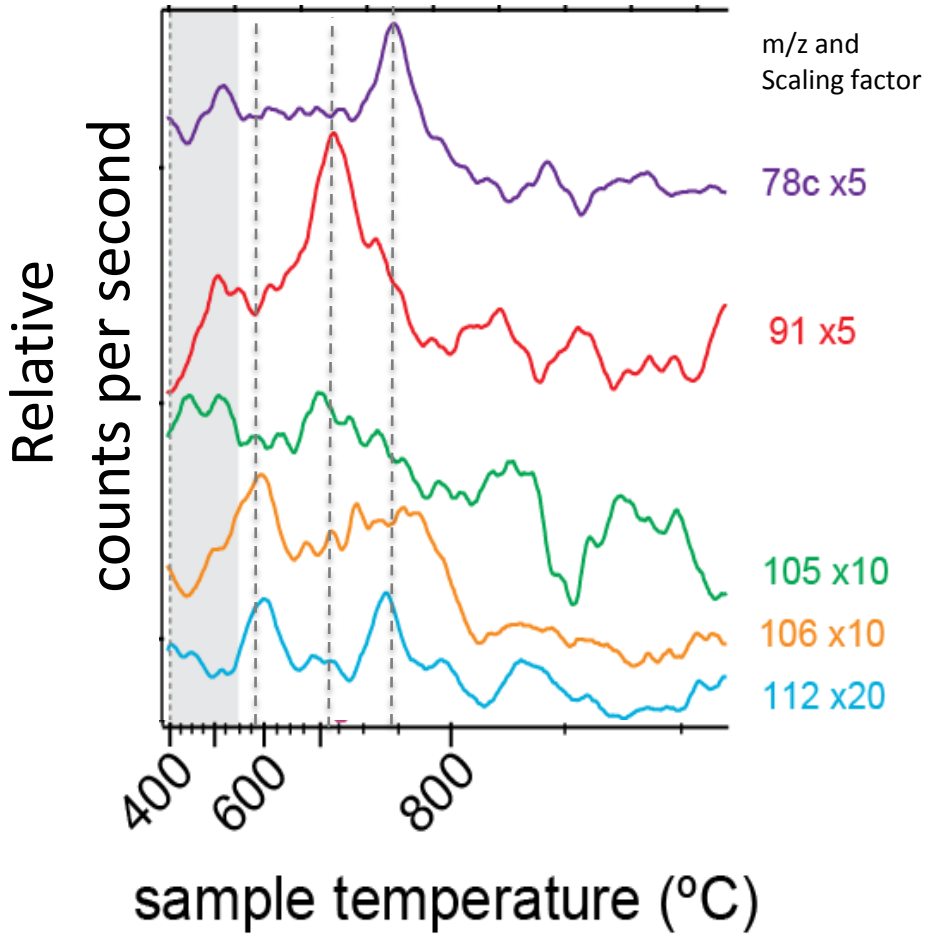
C1-C5? Alkyl Hydrocarbons

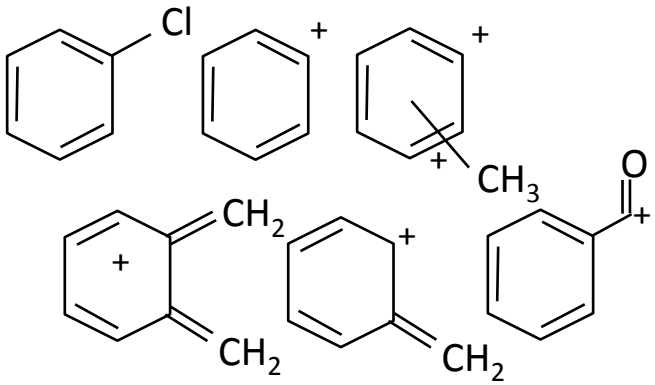
Example carbon chain

Eigenbrode et al, AGU, 2015
Eigenbrode et al., in prep

SAM EGA of Mojave2

Single-Ring Aromatic Hydrocarbons

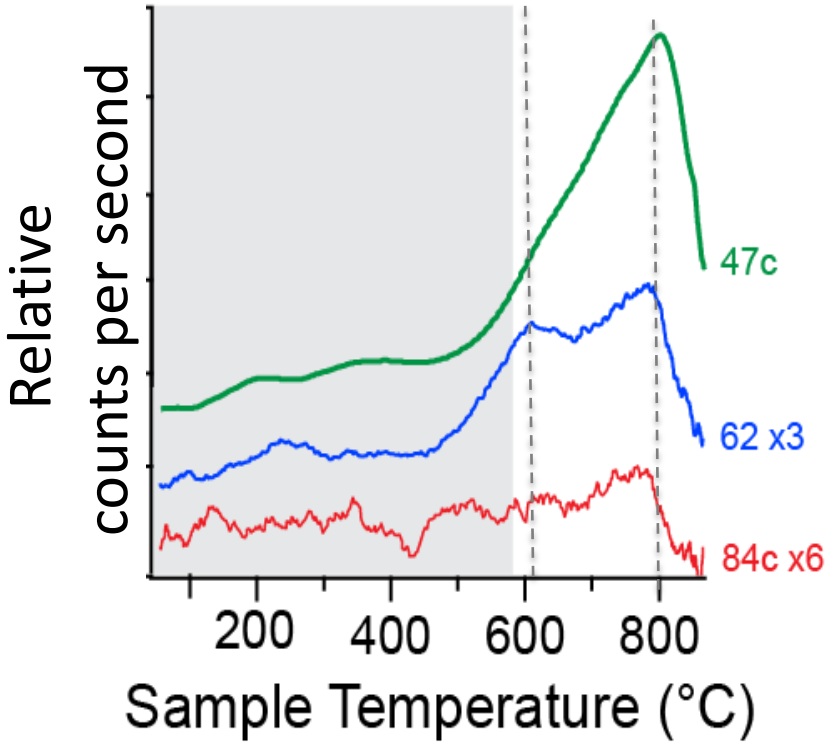


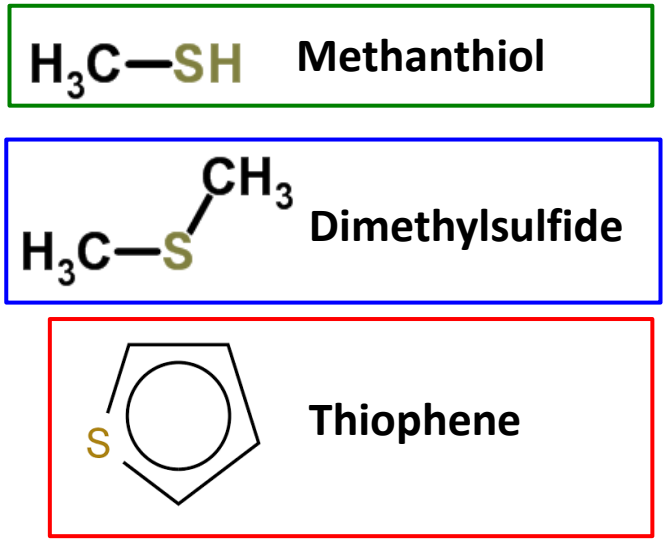


Eigenbrode et al, AGU, 2015
Eigenbrode et al., in prep

SAM EGA of Mojave2

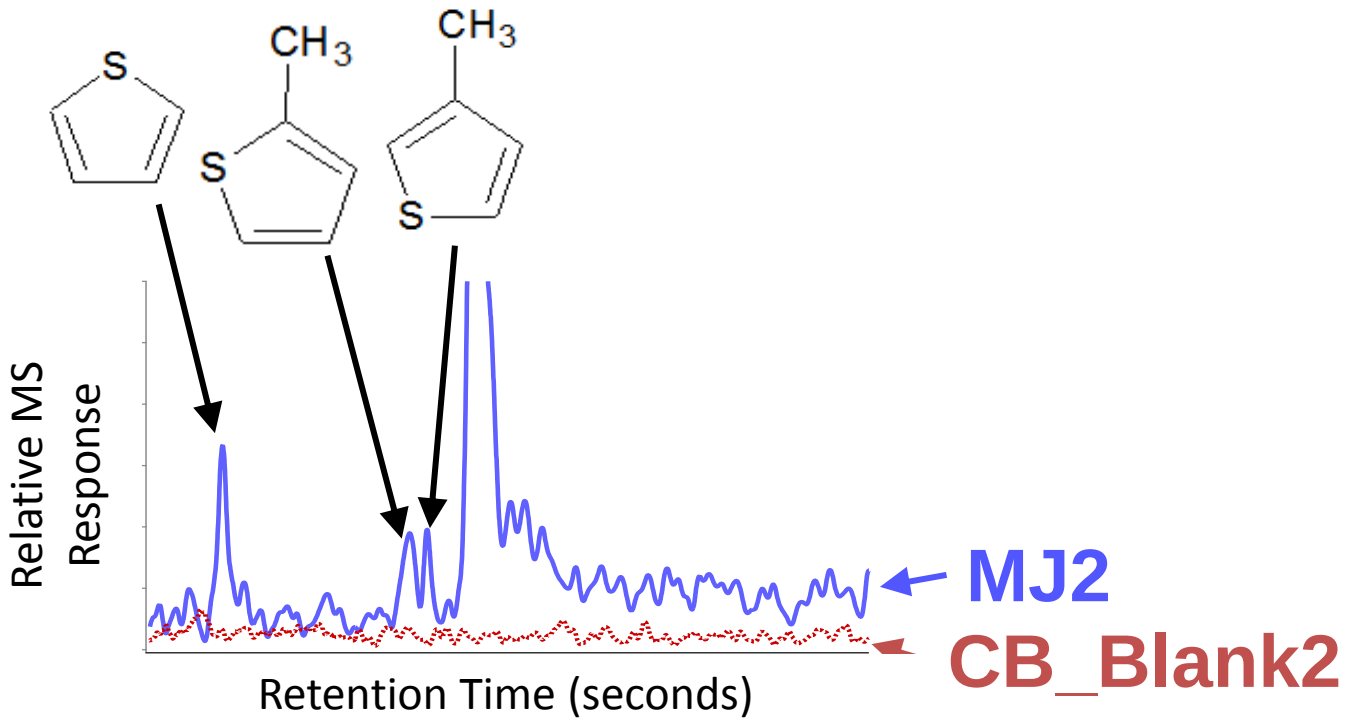
Organic sulfur volatiles



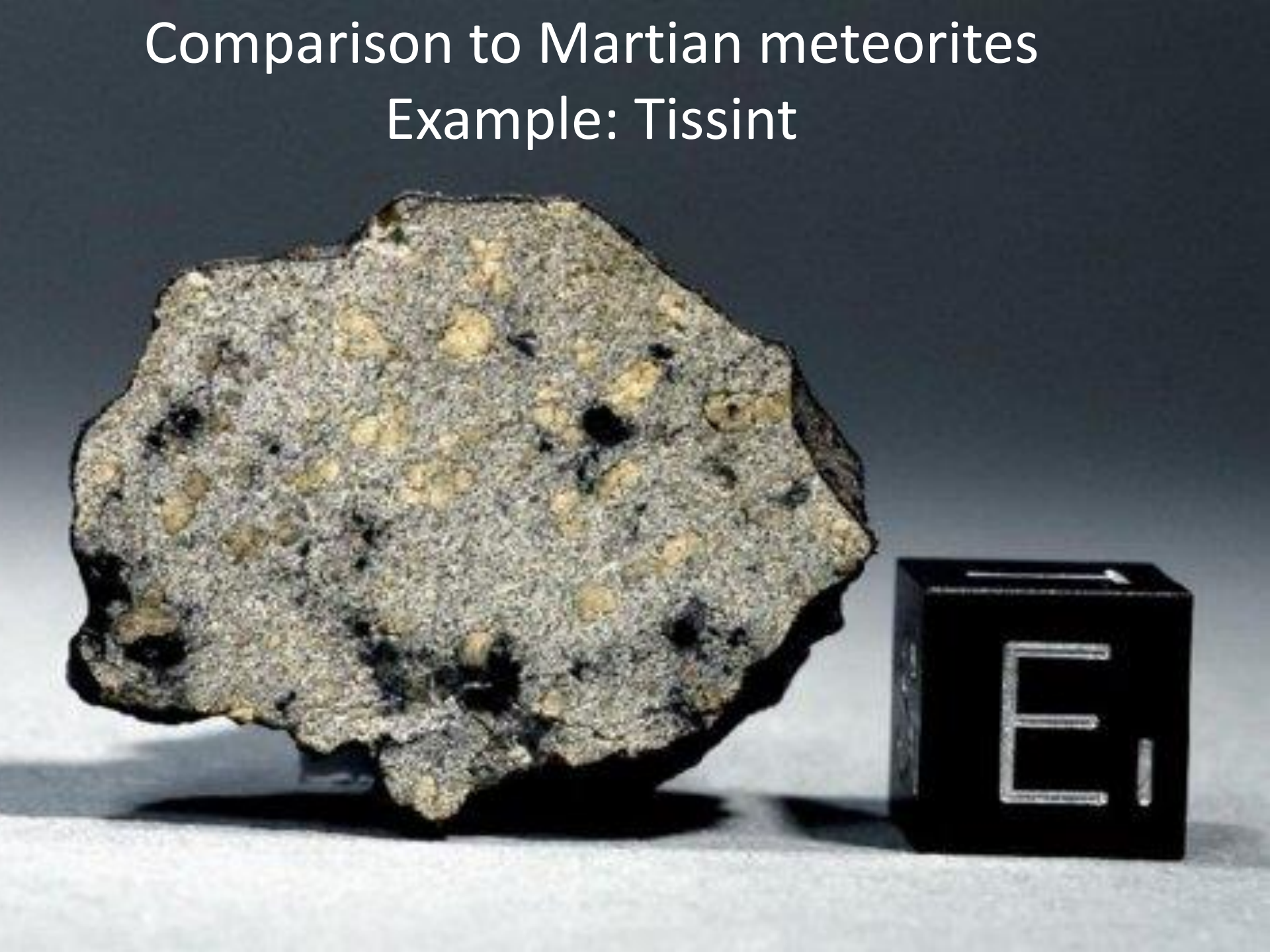


Eigenbrode et al, AGU, 2015
Eigenbrode et al., in prep

Identification of Organic Sulfur Compounds by SAM GCMS of Mojave2



Comparison to Martian meteorites
Example: Tissint

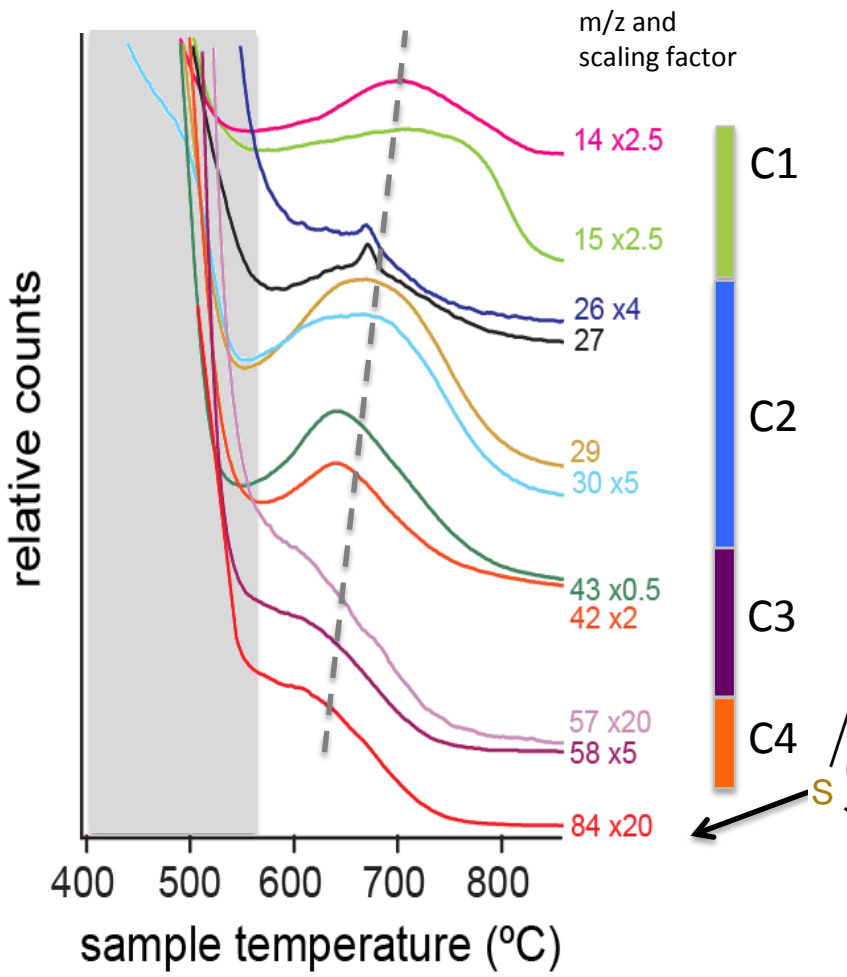


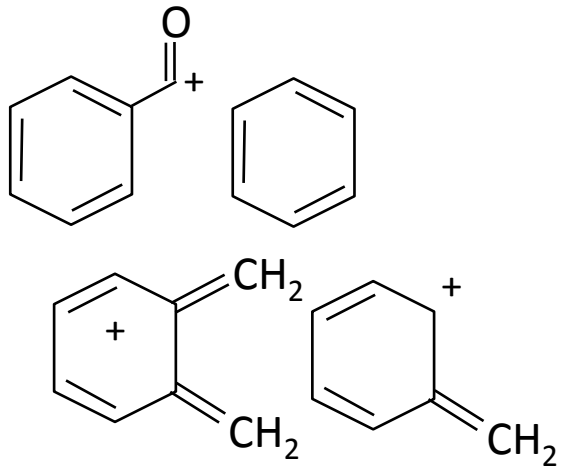
Lab EGA analysis of Tissint martian meteorite

C1-C4 Alkyl Hydrocarbons

Single-Ring Aromatic Hydrocarbons

Organic sulfur volatiles





Thiophene

Similar high temp release and composition as in situ Mars signals

Eigenbrode et al, AGU, 2015
Eigenbrode et al., in prep

Conclusions

- Refractory organic matter is present in the Rocknest eolian sediments and some lacustrine mudstones in Gale Crater

- Possible sources:
  - Abiotic igneous/hydrothermal?
  - Meteoritic?
  - Heavily processed biological?

- We don’t know the organic source. Could be a mixture.

Implications

- **Organic matter may be widely distributed over the surface and throughout the rock record of Mars**

- **Supports habitability of the ancient lake environment in Gale Crater ~3.6 billion years ago**

  → **Organic molecules = energy and C source for metabolisms**

- **Supports modern and future habitability**


Questions?