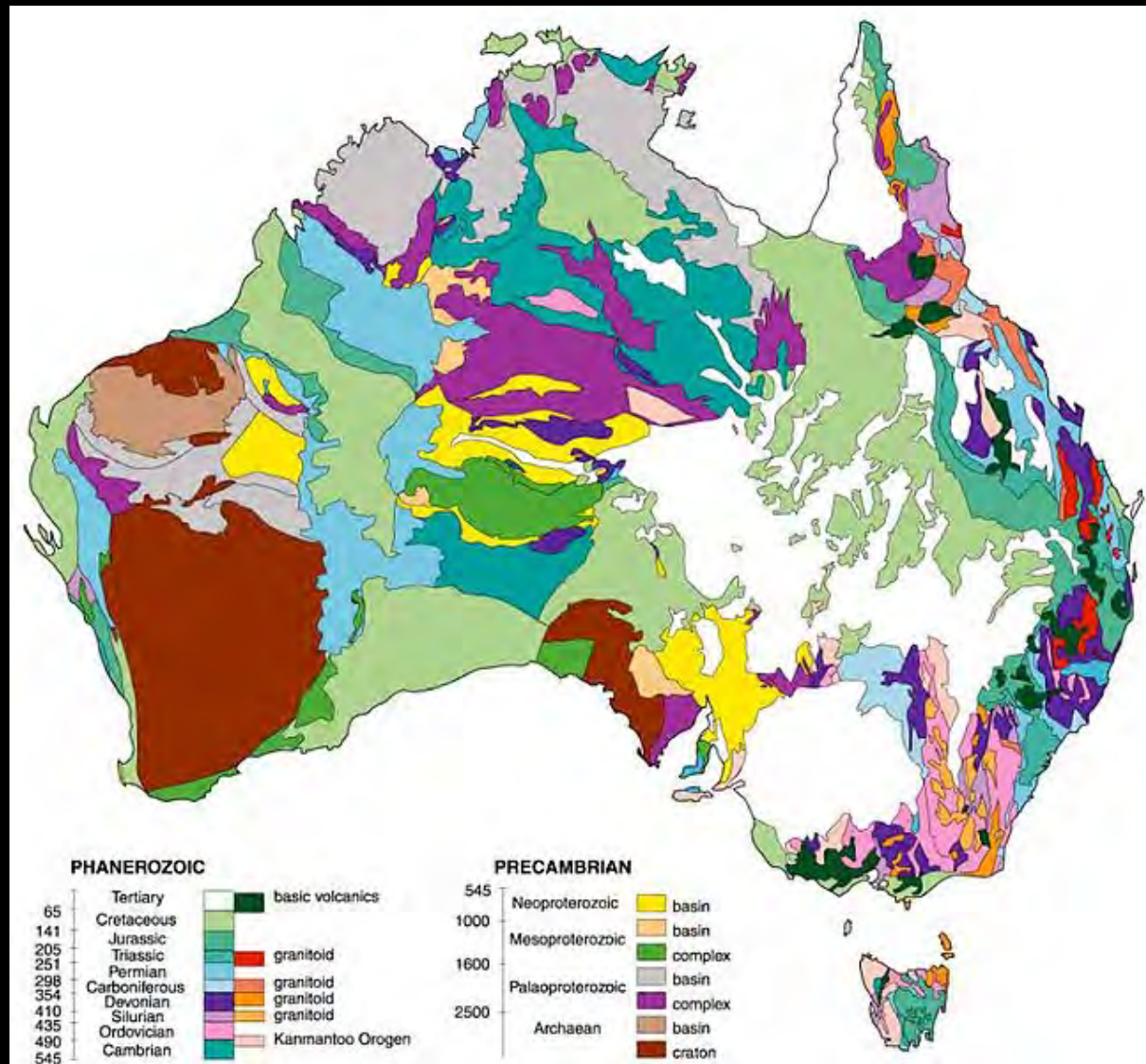


An aerial photograph of a Mars analog acid salt lake. The landscape is characterized by a complex, fractal-like pattern of mineral deposits in various shades of brown, tan, and dark grey. The patterns resemble intricate, branching structures, possibly formed by the evaporation and crystallization of salts. The overall appearance is highly textured and detailed, typical of a hypersaline environment.

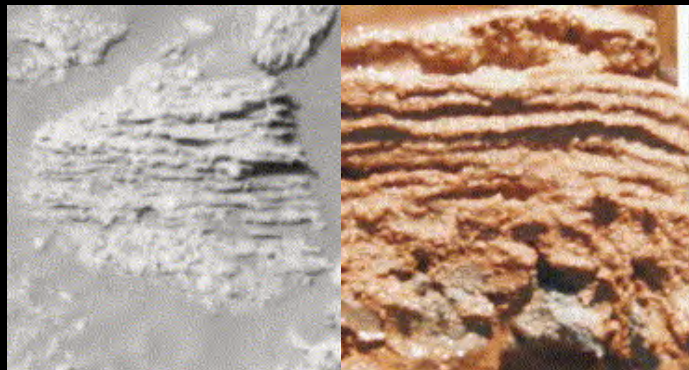
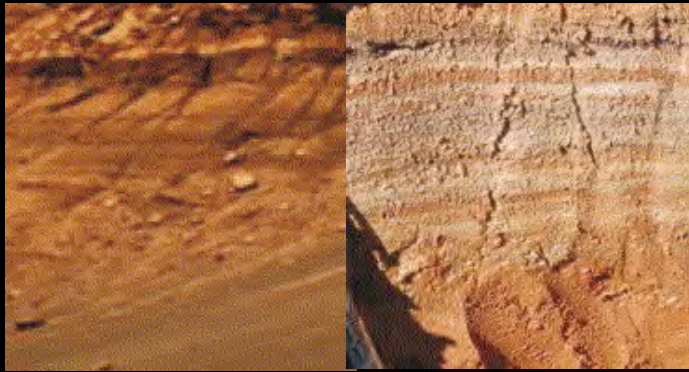
Biosignatures in Mars Analog Acid Salt Lakes

S. S. Johnson, M. L. Soni, D. J. Collins, K. C. Benison,
M. R. Mormile, M. G. Chevrette, and B. L. Ehlmann

Yilgarn Craton



Sedimentary Similarities to Mars



Geologic Setting

- Redbeds hosting ephemeral sulfuric acid saline lakes m² - km² in size
- Sulfates (gypsum, alunite, jarosite), iron oxides (hematite and goethite), phyllosilicates (kaolinite, smectite, palygorskite-sepiolite), halite, etc.
- pHs as low as 1.4
- Salinities as high as 32% TDS



High-throughput Methods

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A.....T.....

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Metagenomics

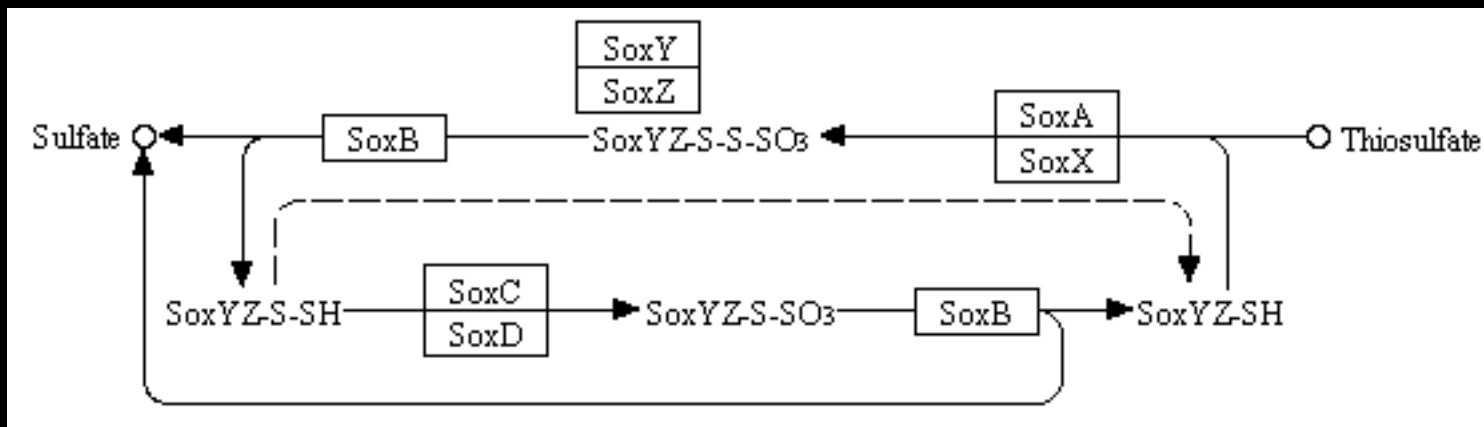
Johnson et al., 2015, *PLoS ONE*

Sequences associated with sulfur metabolism.

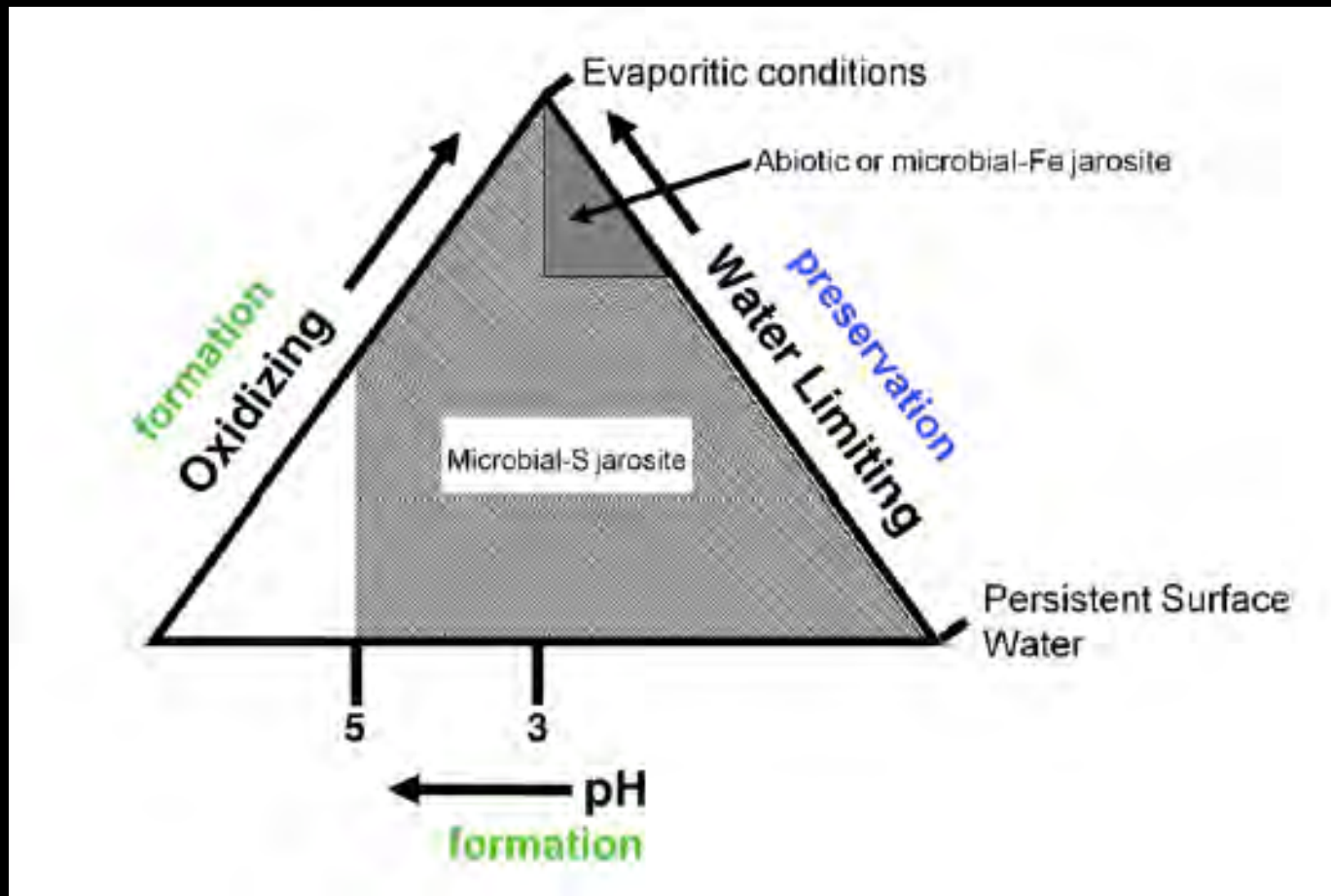
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1,536	6	BLAST, nr*	K00958	Sulfate adenylyltransferase	<i>sat</i>	<i>Acidithiobacillus</i>	<i>Acidithiobacillia</i>
						<i>Prokaryotae</i>	<i>Unclassified</i>
						<i>Halobacteriaceae</i>	<i>Halobacteria</i>
						<i>Leifsonia</i>	<i>Actinobacteria</i>
						<i>Sphingobium</i>	<i>Alphaproteobacteria</i>
						<i>Mycobacterium</i>	<i>Actinobacteria</i>
763	4	BLAST, nr	K00303	Sulfur oxidation protein soxB	<i>soxB</i>	<i>Bacillus</i>	<i>Bacilli</i>
						<i>Actinomycetes</i>	<i>Actinobacteria</i>
						<i>Rhizobium</i>	<i>Alphaproteobacteria</i>
						<i>Burkholderia</i>	<i>Betaproteobacteria</i>
761	7	BLAST, nr	K17230	Fumarate reductase flavoprotein subunit	<i>fccA</i>	<i>Purple photosynthetic bacteria</i>	<i>Gammaproteobacteria</i>
						<i>Prokaryotae</i>	<i>Unclassified</i>
						<i>Halobacteriaceae</i>	<i>Halobacteria</i>

e.g. the SOX Pathway

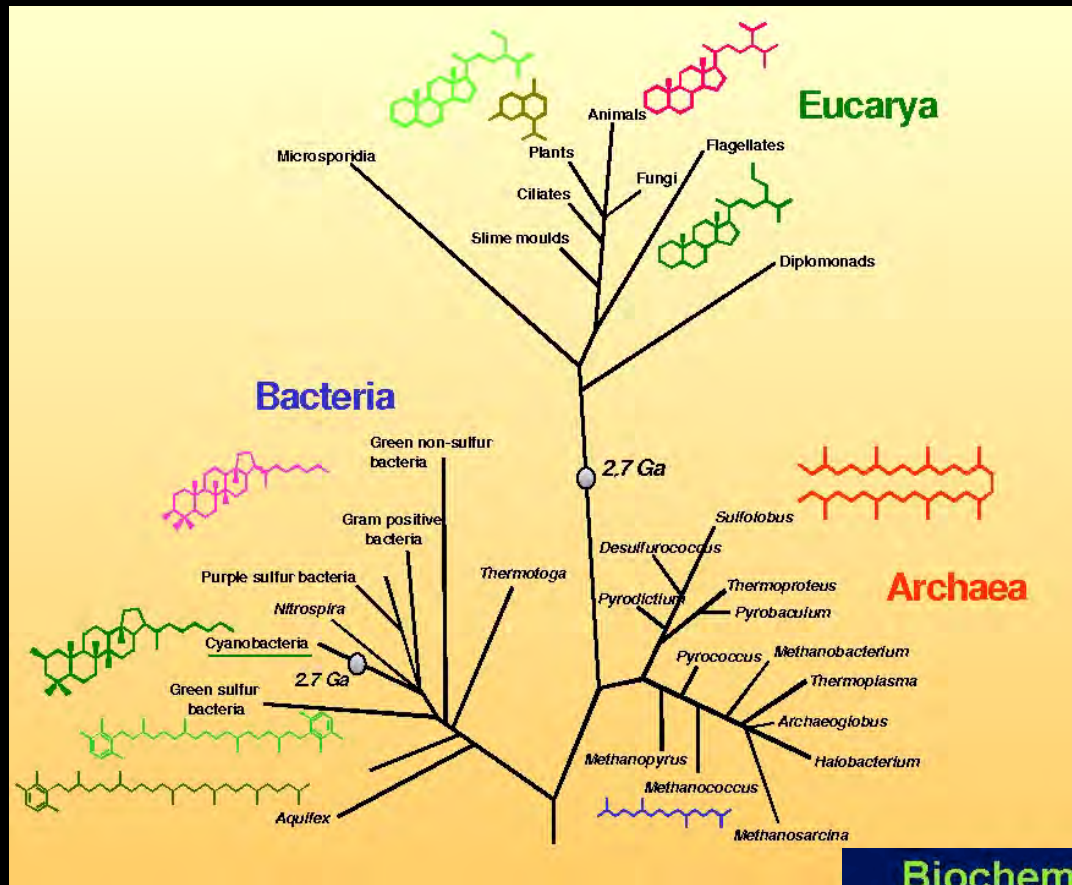
- Sulfur oxidation pathway found in both photosynthetic and non-photosynthetic sulfur-oxidizing bacteria, thiosulfate oxidized to sulfate via a series of sox genes
- Microbial activity generating acidity, affecting local geochemical conditions



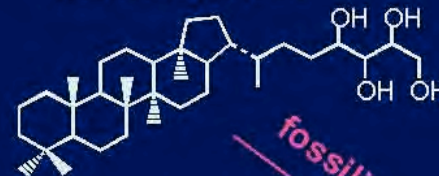
Microbially Precipitated Sulfates



Molecular Fossilization

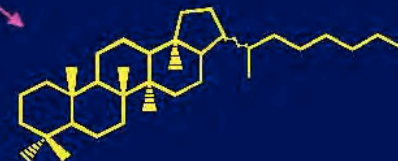


Biochemical

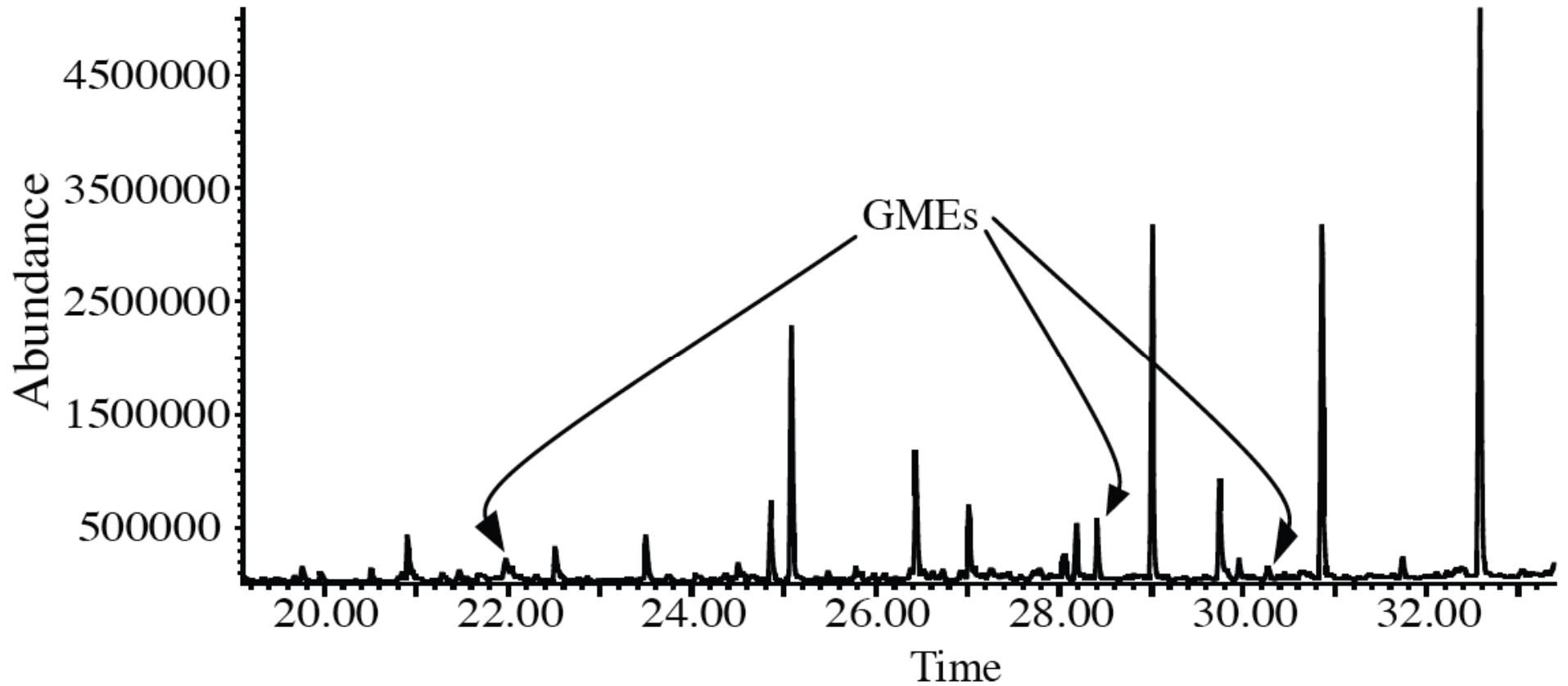


fossilisation

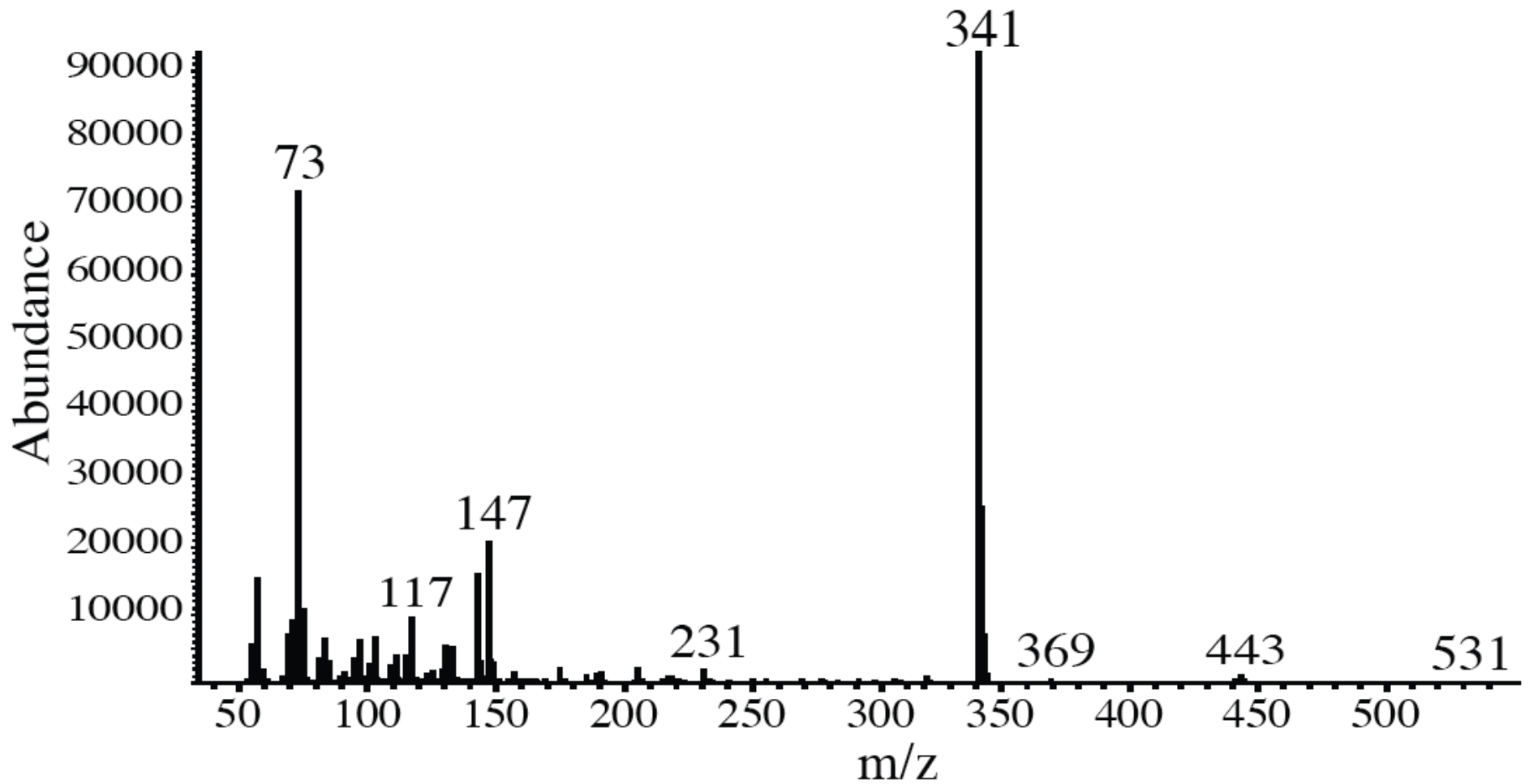
Biomarker



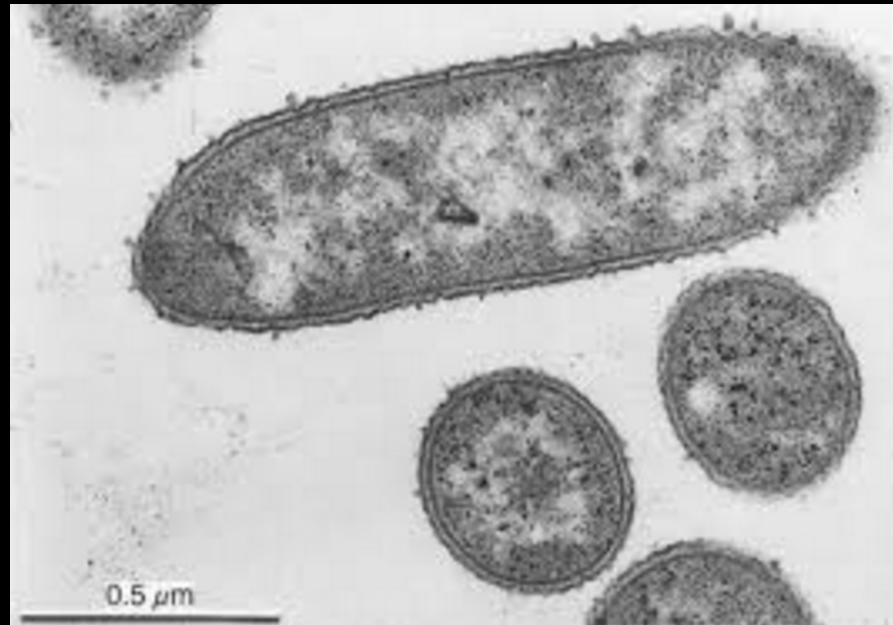
Bacterial glycerol monoethers



1-O-alkylglycerol

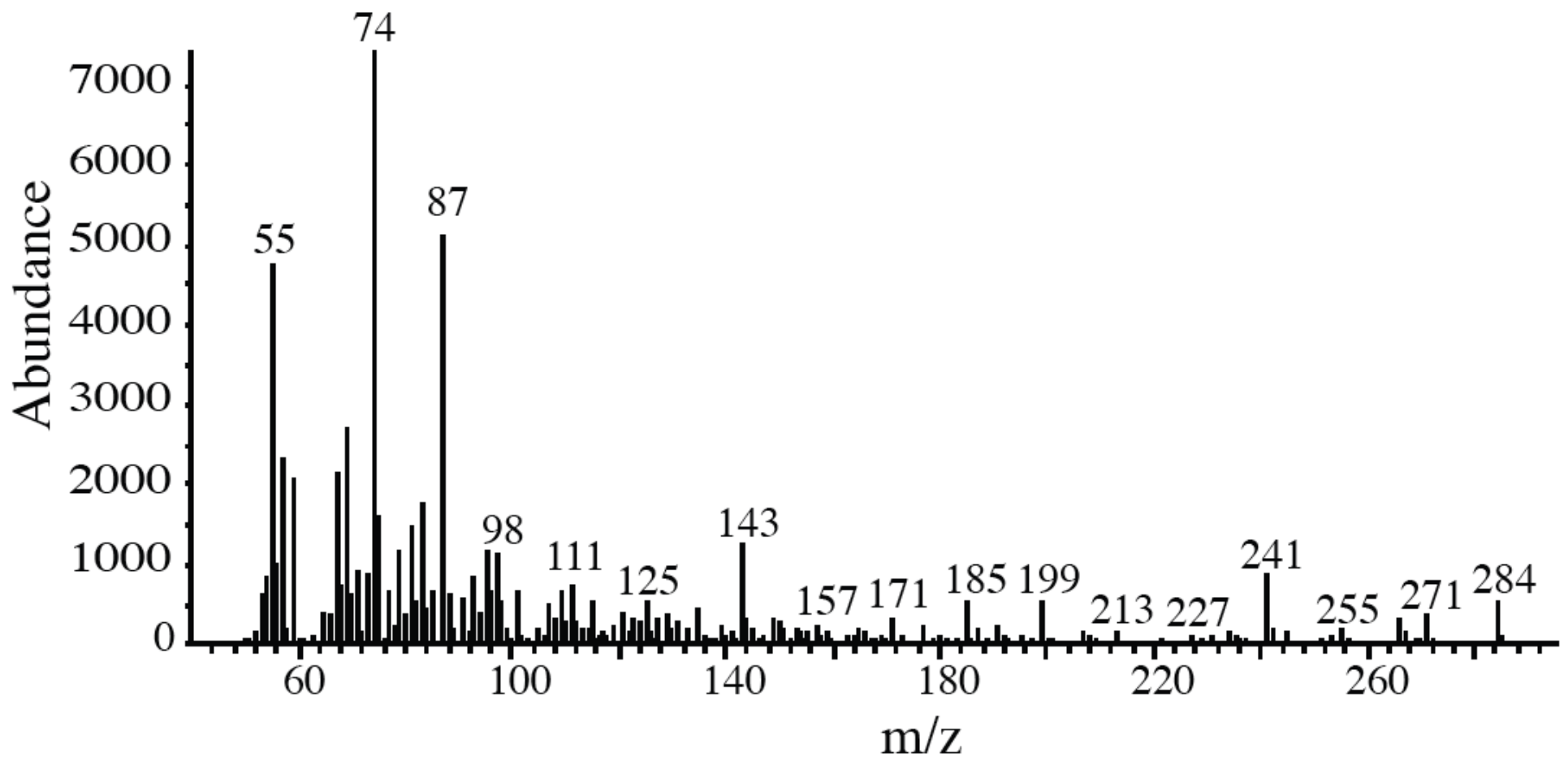


Diagnostic of Microbes



Aquifex, *Ammonifex*, *Thermodesulfobacteria* and certain extremophilic δ -proteobacteria

C₁₅ and C₁₇ iso- and anteiso-branched fatty acids

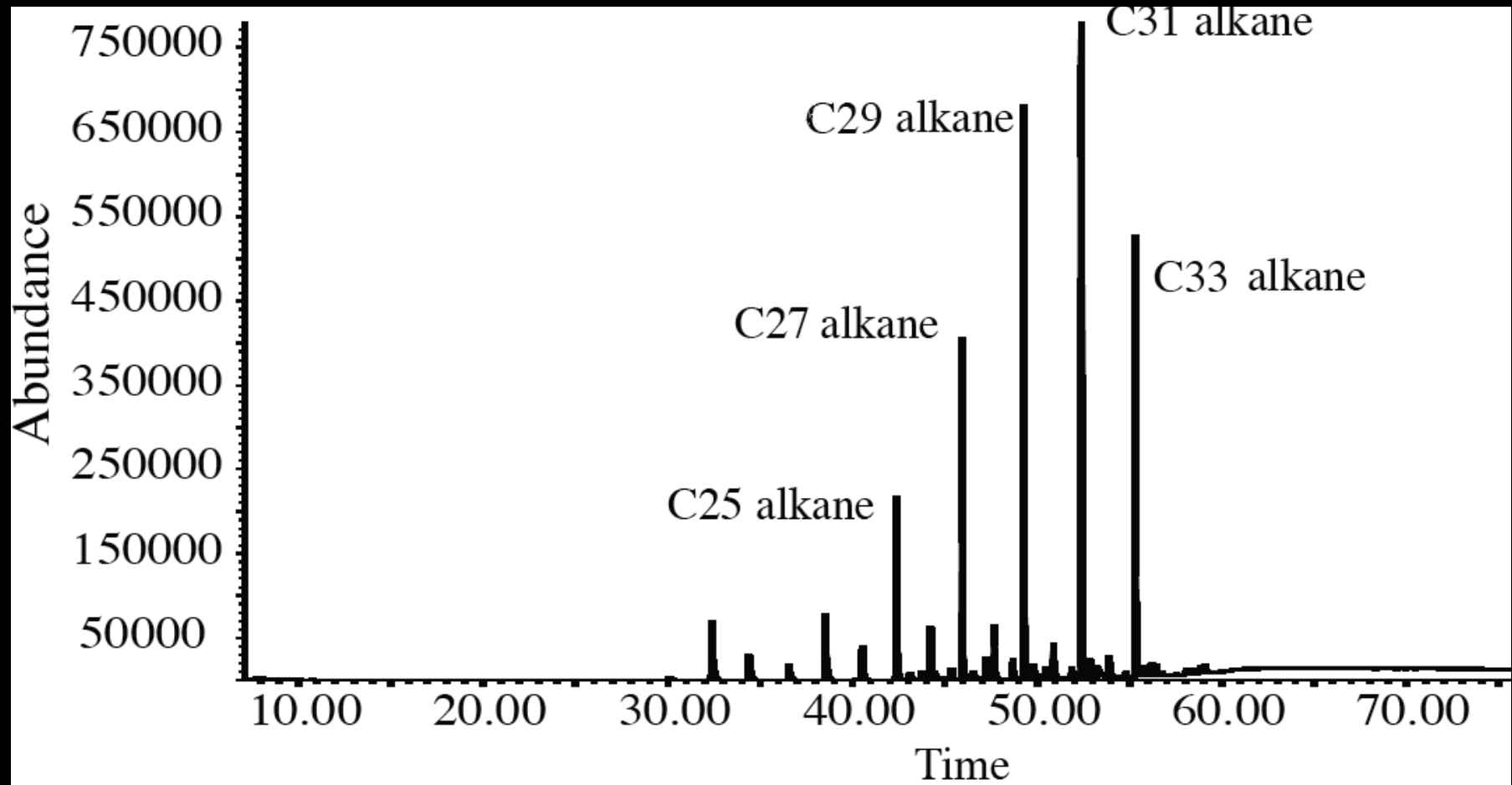


Sulfate-reducing bacteria, sulfur oxidizing bacteria



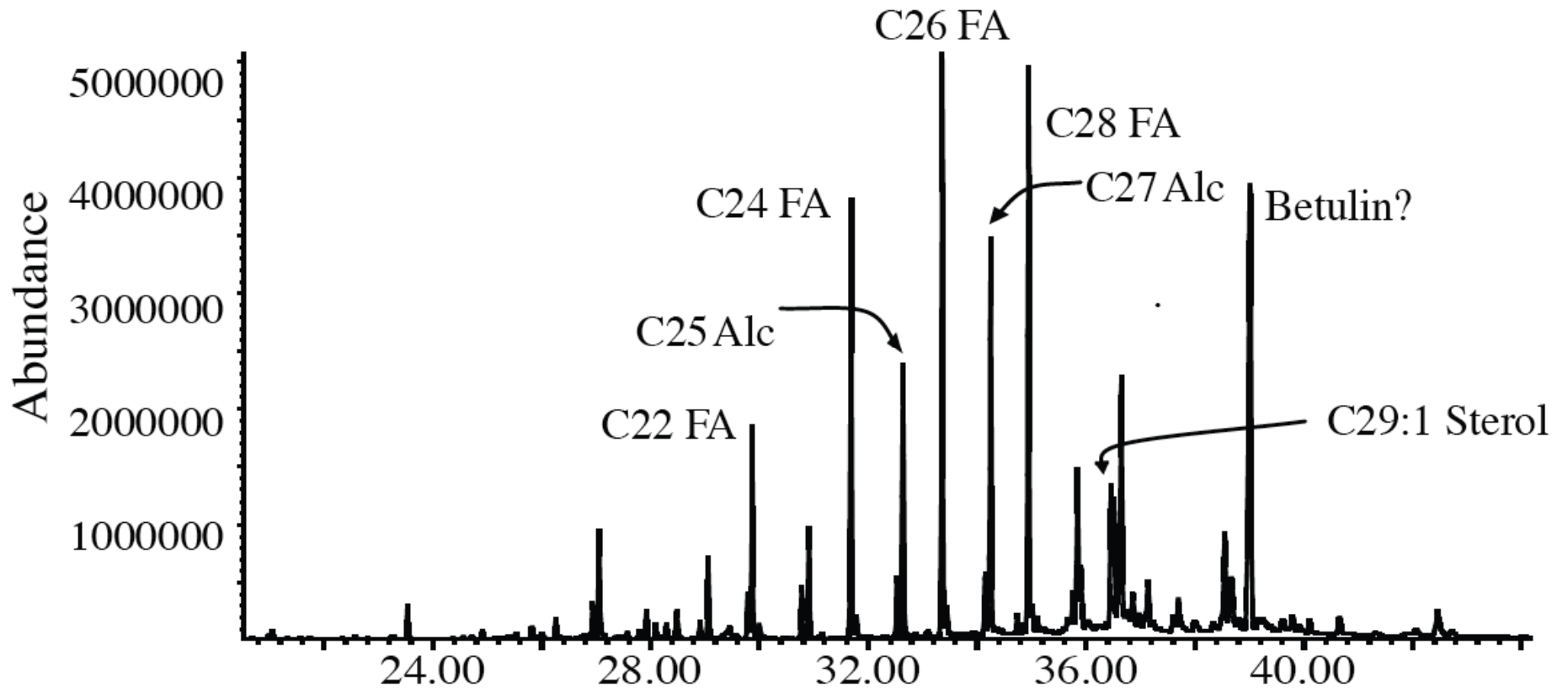
Images: lbl.gov, opencourses.uoa.gr

Long chain *n*-alkanes



Terrigenous origin, cuticular waxes?

C₂₉ Sterols

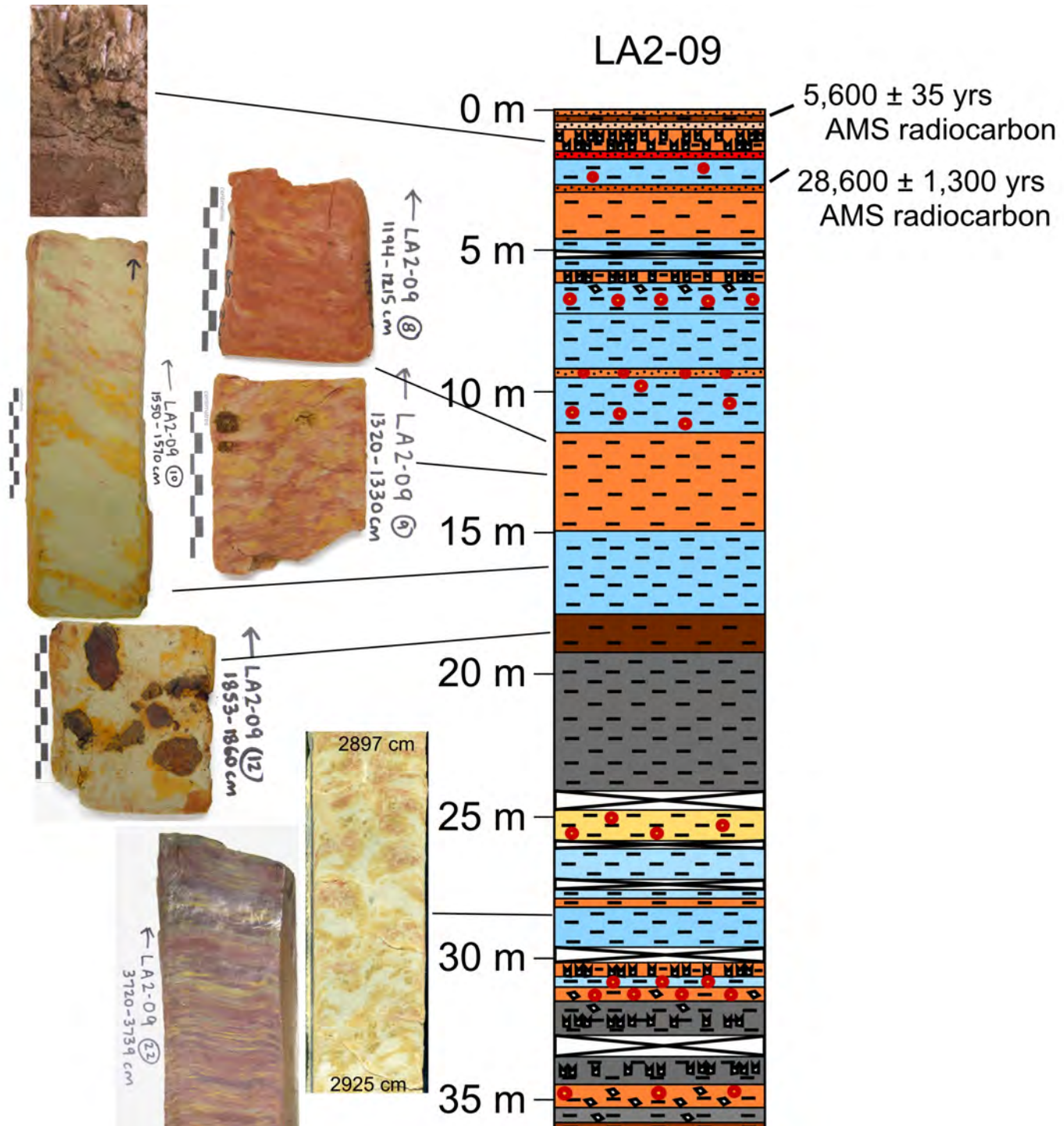


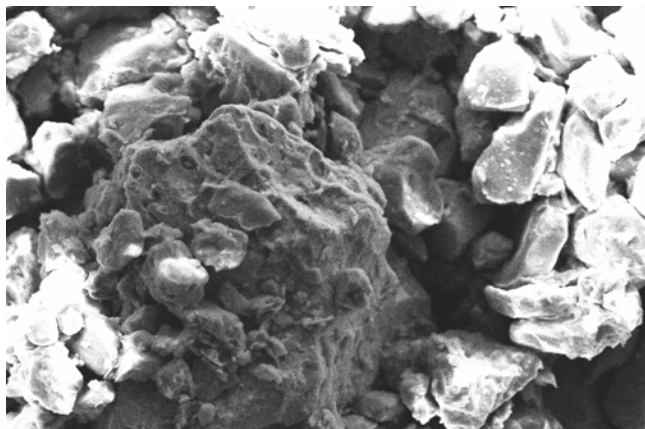
Also oleanic acid, betulin, higher plant leaf waxes?

What's happening through time?

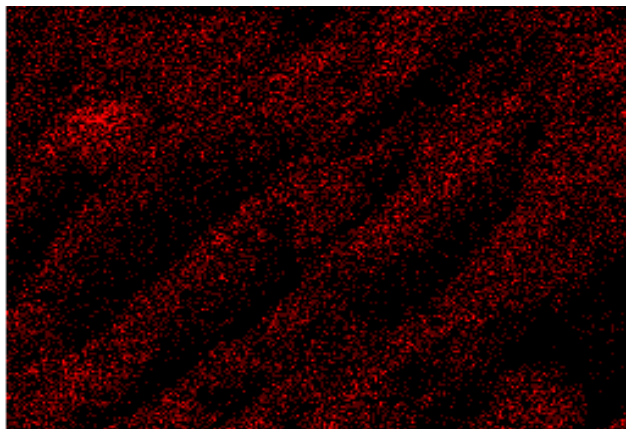


LA2-09

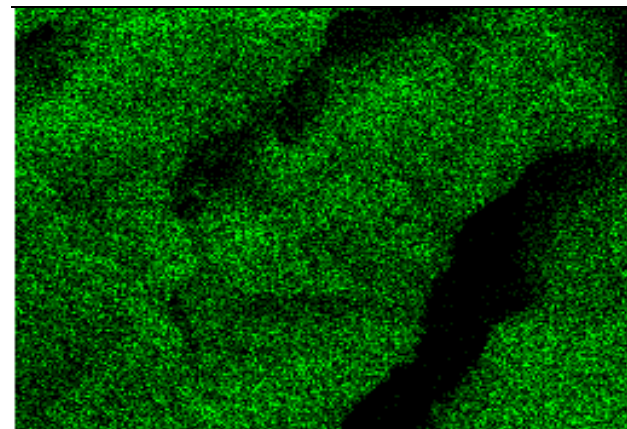




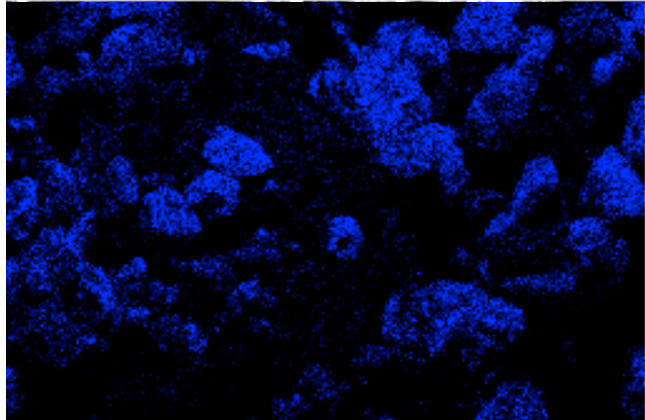
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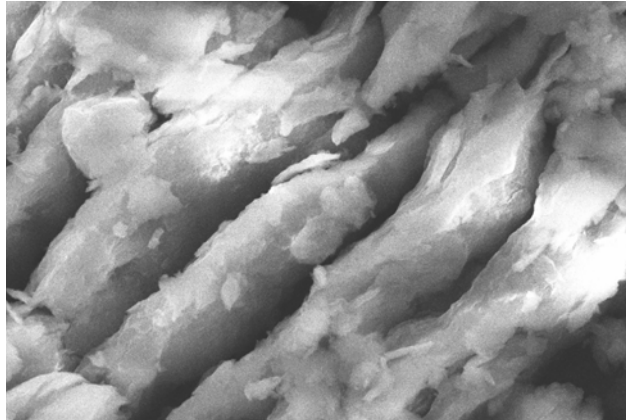
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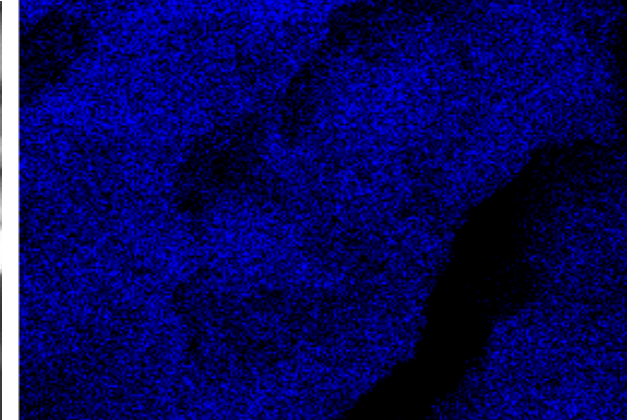
Na Ka1 2



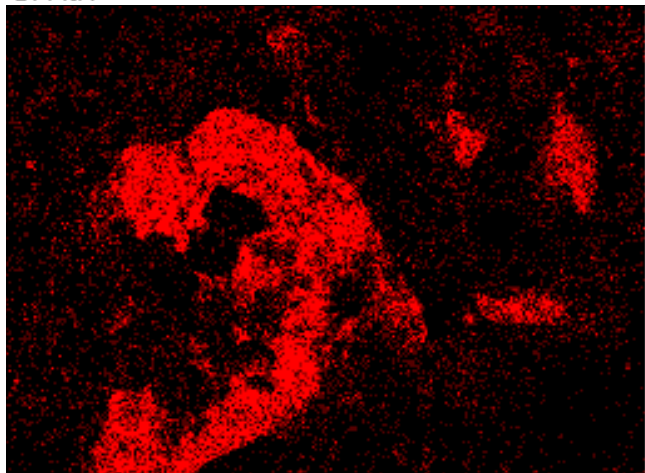
Si Ka1



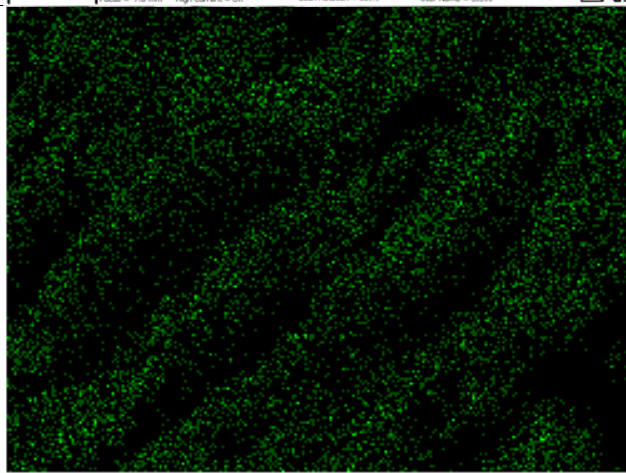
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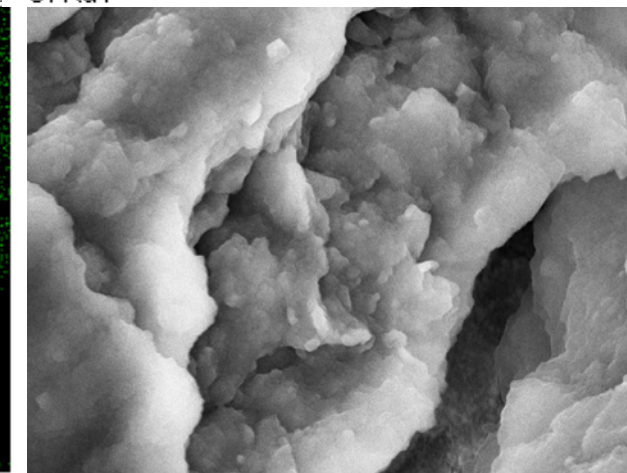
Cl Ka1



Fe Ka1



Al Ka1



2 µm
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Conclusions

- Mineral biosignatures
- Biotic mineral precipitation
 - i.e. jarosite under certain environmental conditions as a biomarker for microbial S oxidation?
- Power of sequencing
- Preservation potential of a range of mineral assemblages, not only clays
- Preservation potential of salts

