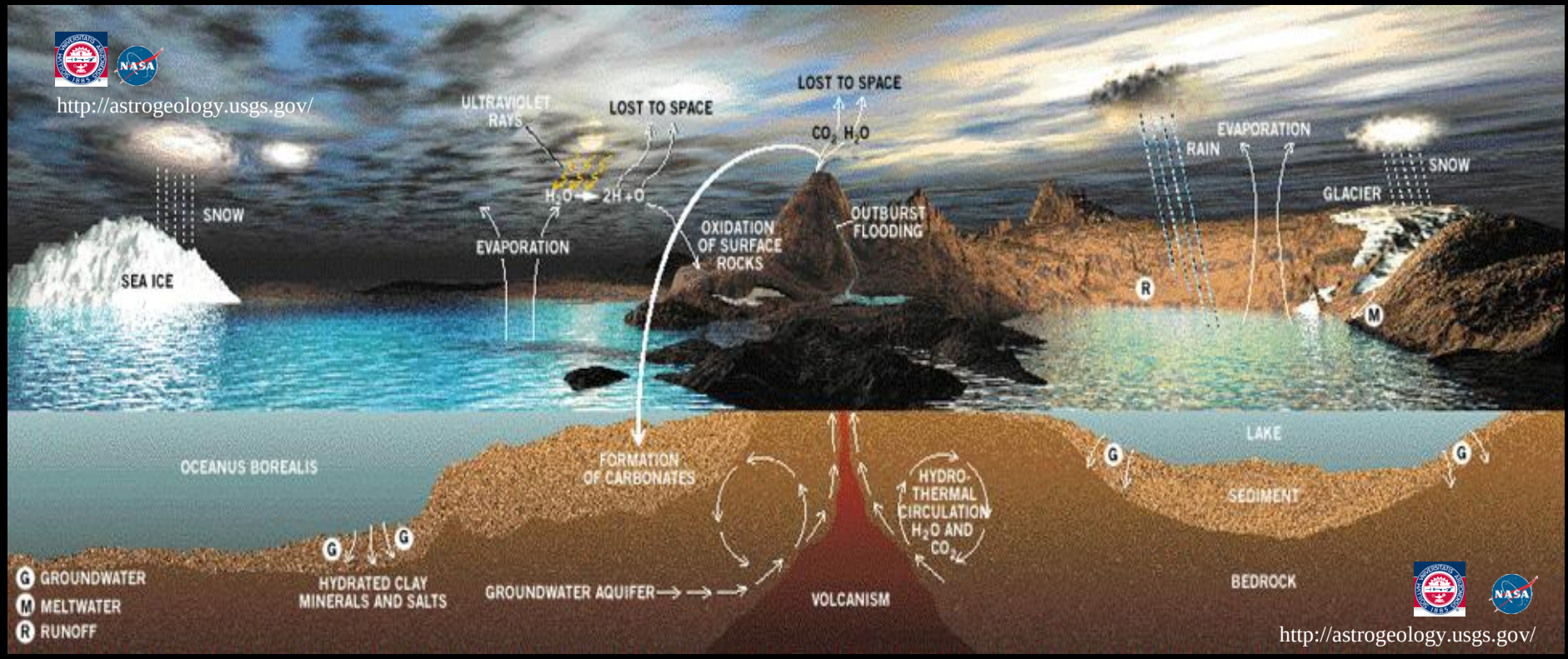
Hydrothermalism (Jaroso) and Evaporites (Salinity crisis) in SE Spain: Implications for Mars exploration

J. Martínez-Frías*

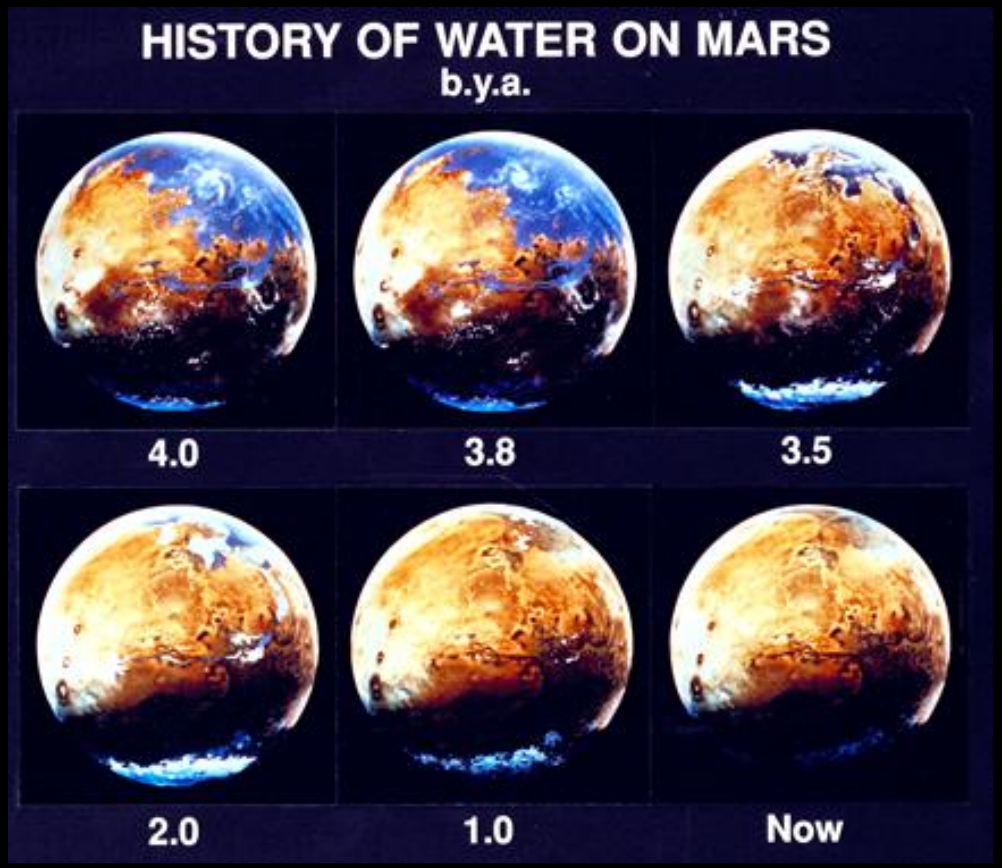
**Instituto de Geociencias, IGEO (CSIC-UCM), Madrid (SPAIN) and Spanish Planetology and Astrobiology Network (REDESPA)*
j.m.frias@igeo.ucm-csic.es

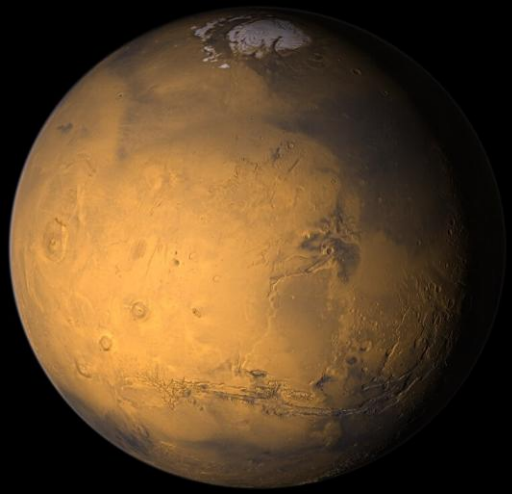


➢ Mars' surface shows many geomorphological and mineralogical features which are indicative of a wetter past, with the presence of surface and sub-surface water, as well as an ancient higher "*geological vitality*".

➢ The likely dominance of a volcanic lithosphere on Mars suggests that hydrothermal fluids and their associated primary and secondary mineral parageneses should be enriched in Fe, Mg, Si and Ca, with surficial deposits being dominated by lower temperature, mixed iron oxy-hydroxide, opal, clays and sulfate (and carbonate) mineralogies.

Mars lost its energy and also suffered a major climate change





Jaroso and Sorbas areas, SE Spain

- Volcanism, Hydrotermalism, Mineralization, Extremely interesting mineral paragénesis
  Jarosite World type locality

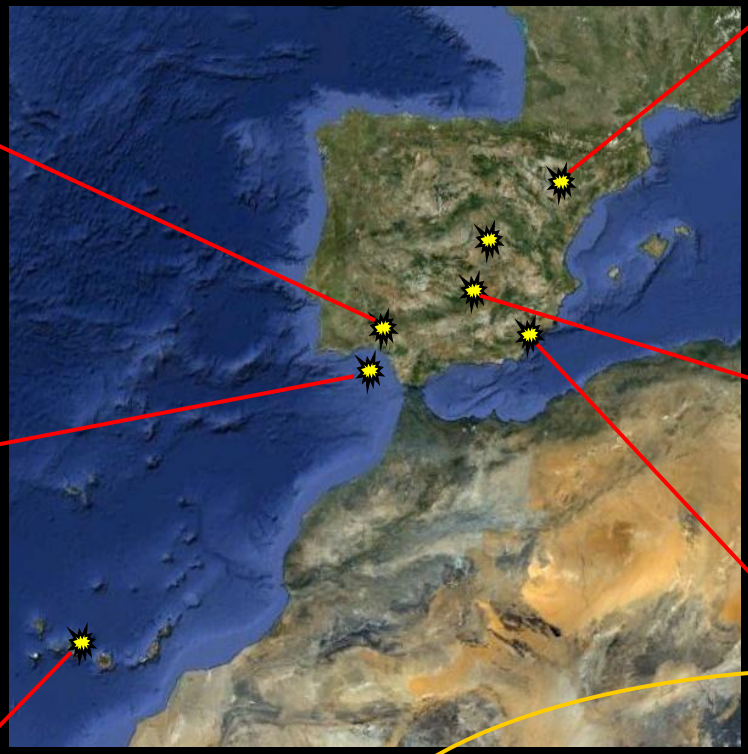
- Evaporites (Messinian Desiccation/ Salinity Crisis)

Scientific context
Mars Analogs

Scientific context
Geodiversity →
Mars analogs, Spain

Río Tinto

Bujaraloz, Monegros



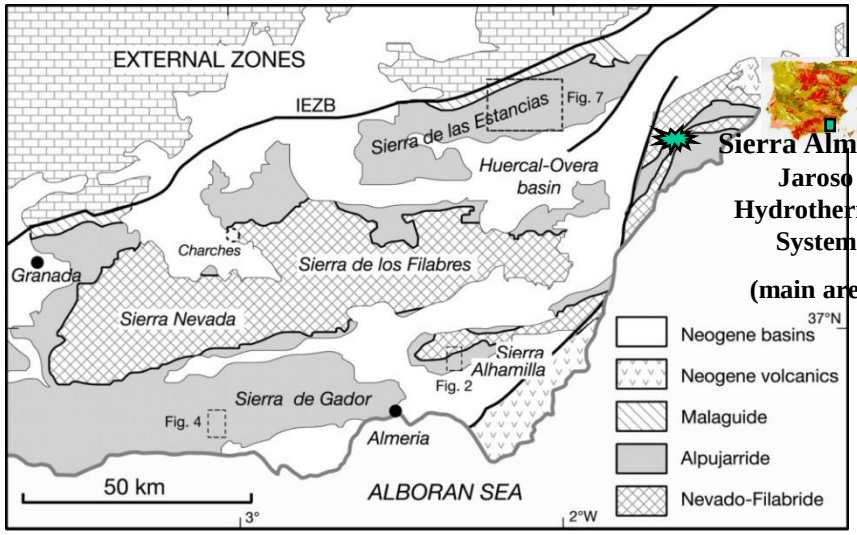
Gulf of Cádiz

Campos de Calatrava

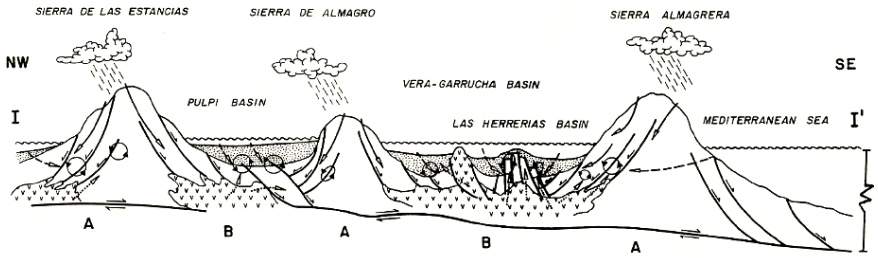
Canary Islands
Tenerife, Lanzarote…

Jaroso-Sorbas-Cabo de Gata (Almería)

Jarosite
Jaroso Hydrothermal System



▪ The SE Mediterranean margin of the Iberian Peninsula is an extremely interesting area of synchronous interaction of tectonic, volcanic, evaporitic and mineralizing hydrothermal processes during the Upper Miocene.



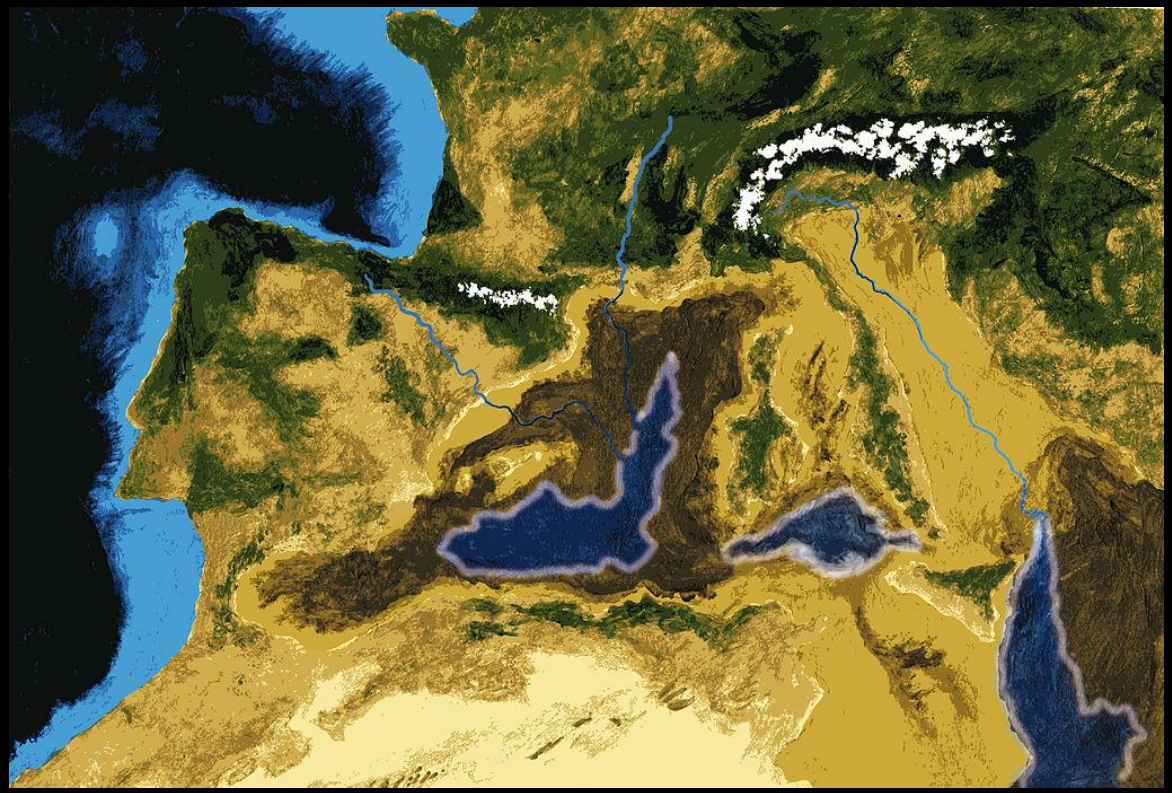
▪ The JHS is genetically linked with the late episodes of the Upper Miocene volcanism of the area.

▪All mineral deposits originated make up a metallogenetic belt of hydrothermal mineralizations which extends roughly 50 km SW-NE (Martínez-Frías et al. 2004).

▪The JHS includes oxy-hydroxides, gold and silver, Hg-Sb, and base-metal sulfides and different types of sulfosalts (mainly rich in Ag and Sb).

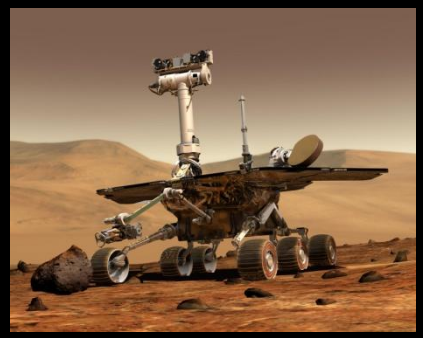
▪ Hydrothermal processes and weathering of the ores has generated huge amounts of oxide and sulfate minerals (jarosite, barite, gypsum) of which **jarosite is the most abundant (in particular in the Sierra Almagrera range → Jaroso ravine → World Type Locality) and clay minerals (mainly at the Cabo de gata area).**

The Messinian Salinity Crisis (MSC), also referred to as the *Messinian Desiccation or Messinian Event*, and in its latest stage as the Lago Mare event, was a geological event during which the Mediterranean Sea went into a cycle of nearly complete desiccation throughout the latter part of the Messinian age of the Miocene epoch, from 5.96 to 5.33 Ma (million years ago).



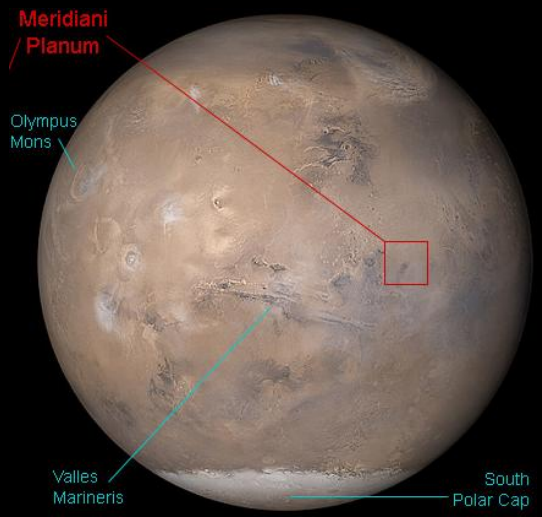
This event, the Messinian Salinity Crisis (MSC), is recorded in a sequence comprising thick gypsum and halite evaporites. Cyclic evaporite deposition is almost entirely related to circum-Mediterranean climate changes.

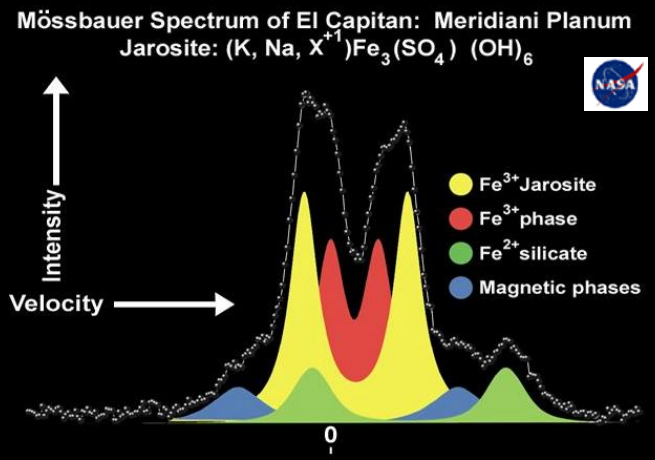
The section in this area of SE Spain, has been proposed to be a world parastratotype for the Messinian Stage.



Jarosite/Mars/El Capitán

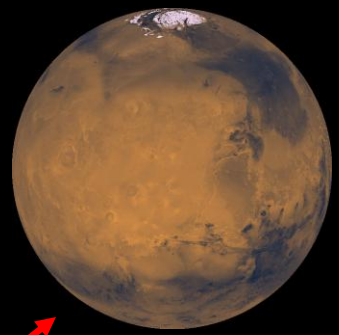
Jarosite is a hydrated sulfate of iron and potassium ($KFe_3(SO_4)_2(OH)_6$), which was identified, in 2004, at Mars' Meridiani Planum by the Opportunity rover





Squyres et al (2004) Science 306, 1709

Jarosite
Jaroso Hydrothermal System



CAB, MiniSymposium, Torrejón de Ardoz, Madrid, Spain (2001)

HYDROTHERMAL MINERALIZATION IN SE SPAIN AS POSSIBLE VOLCANICS-RELATED METALLOGENETIC MODEL FOR THE EARLY MARS

J. Martínez-Frías[(1)], R. Lunar[(2)] & J. A. Rodríguez Losada[(3)]

[(1)] Centro de Astrobiología, (CSIC/INTA) Instituto Nacional de Técnica Aeroespacial. Ctra de Torrejón a Ajalvir, km 4 28850 Torrejón de Ardoz, Madrid (España) e-mail: martinezfrias@mncn.csic.es
[(2)] Facultad de Ciencias Geológicas, Univ. Complutense de Madrid, 28040 Madrid (España) e-mail: lunar@eucmax.sim.ucm.es
[(3)] Unidad de Geología, Facultad de Ciencias, Univ. La Laguna, Avenida Astrofísico Francisco Sánchez, s/n 38206 La LagunaTenerife (Es

Hydrothermal systems are a common, r
faulting, rifting) processes in permeabl
predominance of basaltic crust on M
deposits should be enriched in Fe, Mg
lower temperature, mixed iron oxide
Spectrometer (TES) instrument on the
accumulation of the coarse-grained he
five hundred kilometers (~300 miles)
amounts of hot water move through iro
in solution.

Besides the well known iron deposit
(Almería), a significant characteristic
temporal relationship with Fe-Mn, Hg
mineralization. The stratabound-type m
of sea-floor, hydrothermal mineralizatio
(pipes and crusts), barite, jasper, and na

EVAPORITIC AND HYDROTHERMAL GYPSUM FROM SE IBERIA: GEOLOGY, GEOCHEMISTRY, AND IMPLICATIONS FOR SEARCHING FOR LIFE ON MARS

MARTINEZ-FRIAS, Jesus[1], LUNAR, Rosario[2], MANGAS, José[3], DELGADO, Antonio[4], BARRAGÁN, Guillermo[5], SANZ-RUBIO, Enrique[1], DÍAZ-MARTÍNEZ, Enrique[1], BENITO, Raúl[6], and BOYD, Trevor[7], (1) Centro de Astrobiologia, CSIC-INTA, Crtra. Ajalvir, km 4, Torrejon de Ardoz, Madrid, 28850, Spain, sanzre@inta.es, (2) Depto. Cristalografía y Mineralogía, Fac. Ciencias Geológicas, Univ. Complutense de Madrid, Madrid, 28040, Spain, (3) Departamento de Física, Fac. Ciencias del Mar, Univ. Las Palmas de Gran Canaria, Campus de Tafira. Apartado 550, Las Palmas, 35080, Spain, (4) Depto. Ciencias de la Tierra y Química Ambiental, Estacion Experimental del Zaidin, Prof. Albareda, 1, Granada, 18008, Spain, (5) Depto. Estratigrafía y Paleontología, Fac. Ciencias, Univ. Granada, Campus Fuentenueva, Granada, 18003, Spain, (6) Depto. Geología, MNCN, CSIC, José Gutiérrez Abascal, 2, Madrid, 28006, Spain, (7) Scotiabank Marine Geology Research Laboratory, Department of Geology, University of Toronto, 22 Russell Street, Toronto, ON M5S 3B1, Canada

In the Mediterranean region, the Upper Miocene was a time of convergence and interaction of different geological processes including tectonism, volcanic activity, hydrothermalism and desiccation of the Mediterranean Sea. The Messinian salinity crisis probably was the most outstanding geological event of the late Cenozoic. The giant evaporitic (anhydrite/gypsum) sequence is well represented in the stratigraphic record and consists of several crises that fit the context of catastrophic modeling of a Mediterranean "saline giant".

The Cuevas del Almanzora (CA) geological section (Vera b
terminal Miocene events. Likewise, the CA area hosts a vo
by the largest exhalite deposit in Spain (alternating beds of
found cutting the volcanic rocks.

Gypsum occurs in some Martian meteorites (e.g. Governad
existed in crater-basins during Mars' early (Noachian) epoc
upon evaporation, if the initial SO42-:Ca2+ ratio is high and
geological and even biological processes that could event
as a habitat for primitive life.

The comparison of the geology and geochemistry of these
astrobiological exploration of Mars.

GSA Annual Meeting, November 5-8, 2001
General Information for this Meeting

Session No. 100--Booth# 2
Geochemistry (Posters)
Hynes Convention Center: Hall D
8:00 AM-12:00 PM, Wednesday, November 7, 2001

The volcanism-related multistage hydrothermal system of El Jaroso (SE Spain): Implications for the exploration of Mars

J. Martinez-Frías[1], R. Lunar[2], J. A. Rodríguez-Losada[3], A. Delgado[4], and F. Rull[1,5]

[1]*Centro de Astrobiología (CSIC-INTA), associated to the NASA Astrobiology Institute, Ctra de Ajalvir, km 4, 28850 Torrejon de Ardoz, Madrid, Spain*
[2]*Departamento de Cristalografía y Mineralogía, Facultad de Ciencias Geológicas, Avda. Paraninfo s/n Universidad Complutense de Madrid, 28040 Madrid, Spain*
[3]*Departamento de Edafología y Geología, Facultad de Biología, Universidad de La Laguna, 38206 La Laguna, Tenerife, Canary Islands, Spain*
[4]*Estación Experimental del Zaidín, CSIC, Prof. Albareda 1 18008 Granada, Spain*
[5]*Cristalografía y Mineralogía and Unidad Asociada CSIC-Univ. Valladolid, 47006-Valladolid, Spain*

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The SE Mediterranean margin of Spain is an extremely interesting area of synchronous interaction of tectonic, volcanic, evaporitic and mineralizing hydrothermal processes. This works tackles the multiple relations among these processes by the study of a specific and representative case: the 'Jaroso Hydrothermal System'. The hydrothermal fluids were genetically linked with the late episodes of the Upper Miocene calc-alkaline and shoshonitic volcanism of the area. The ascent of the fluids was mainly controlled by the Palomares fault in Sierra Almagrera. In the shallow-marine basin of Las Herrerias, the movement of the acid solutions was controlled by both NNE-SSW and N150E normal faults and WNW-ESE wrench reverse faults. At least three mineralising stages were identified, although the particular formation of jarosite could be associated with both hypogenic and supergenic processes. We suggest that the multistage hydrothermal system of El Jaroso (Sierra Almagrera, Almería province, SE Spain), which is responsible for both the Jaroso ores (especially rich in jarosite) and the Las Herrerias sulfate-rich, shallow-marine laminites, could be exploited as a potential model with important implications for the exploration of Mars.
Key words: Jarosite, hydrothermal, shallow-marine, analog, Mars.

Jaroso Hydrothermal System

Three types of fluid inclusions

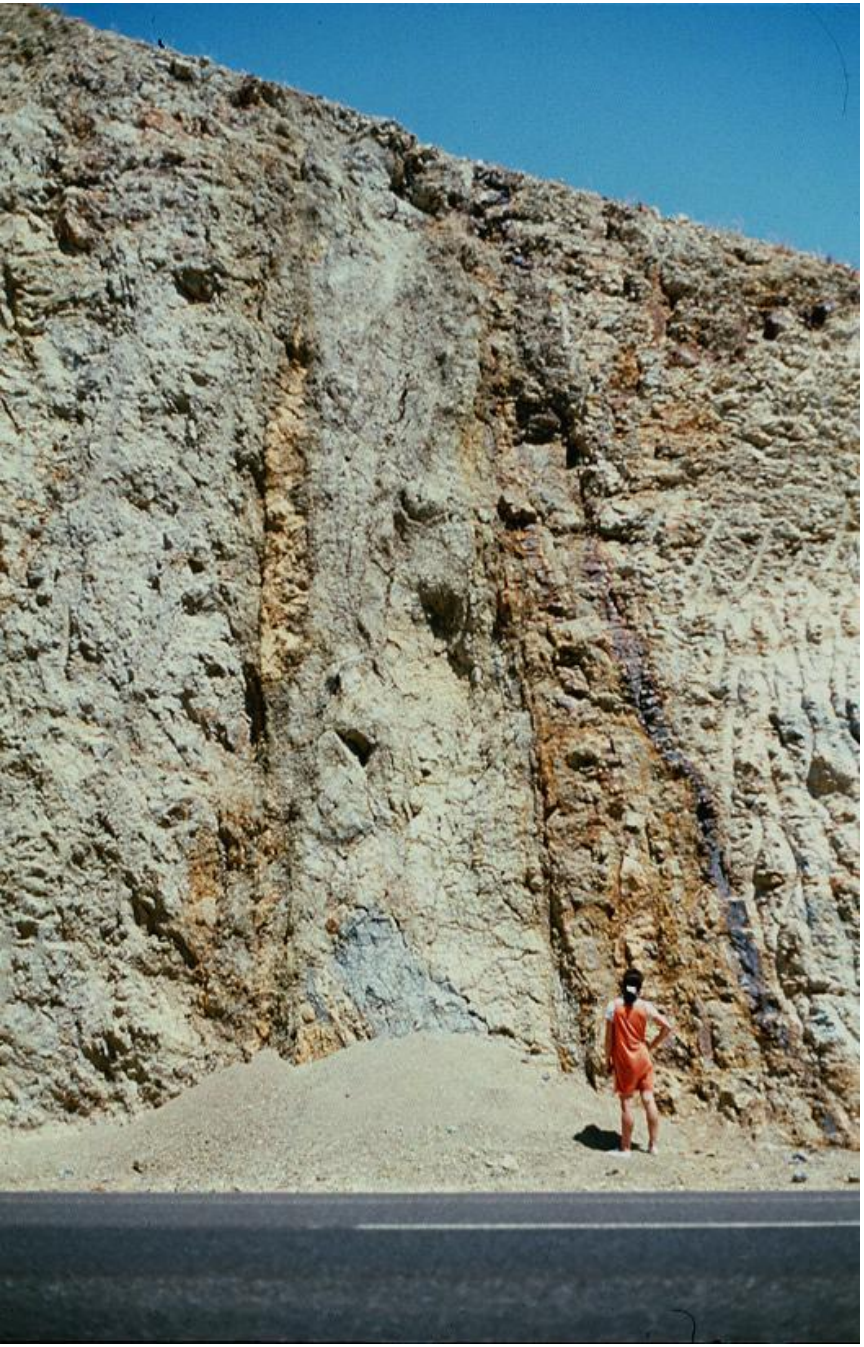
1) Two-phase (L+V) inclusions, with CO_2, in which the vapor phase occupies 50-70% of the total volume (T_H = 330-360°C);

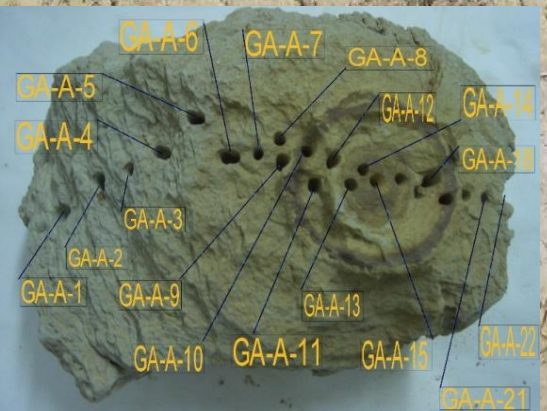
2) Aqueous, two-phase (L+V) inclusions, without CO_2, in which the vapor phase occupies 25-40% of the total volume (with the additional presence of trapped solids (KCl and haematite) (T_H = 270-350°C)), and

3) Aqueous, two-phase (L+V) or three-phase (S+L+V) inclusions (T_H = 160-260°C). In broad terms, an increase of salinity linked to a loss of vapor is the general tendency in relation with the descent of temperature.

Jaroso Hydrothermal System

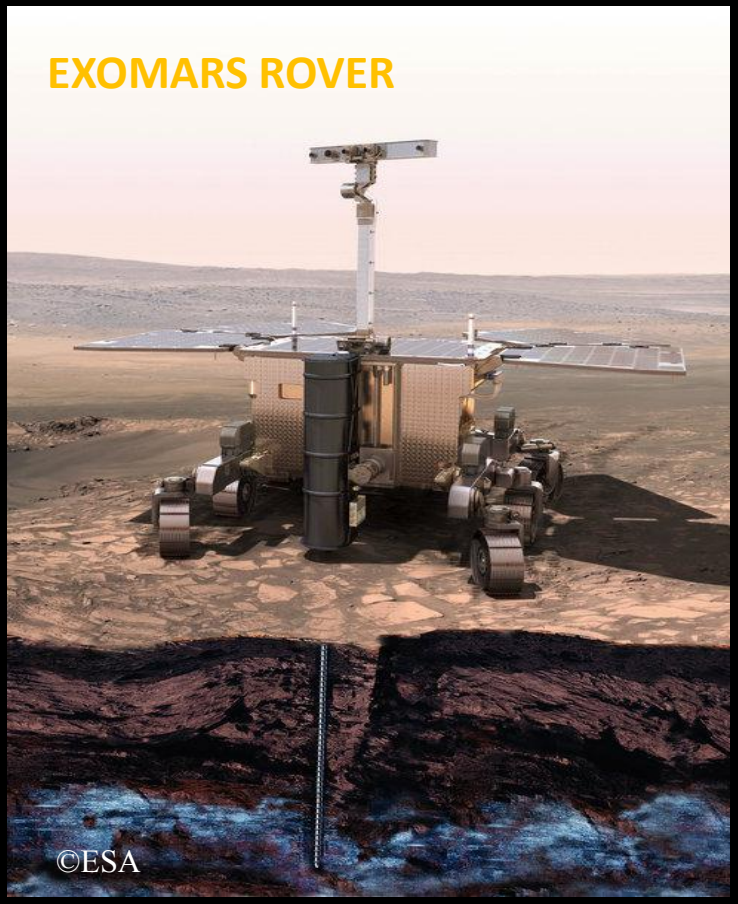
Volcanic outcrops and mineralization hydrothermal veins



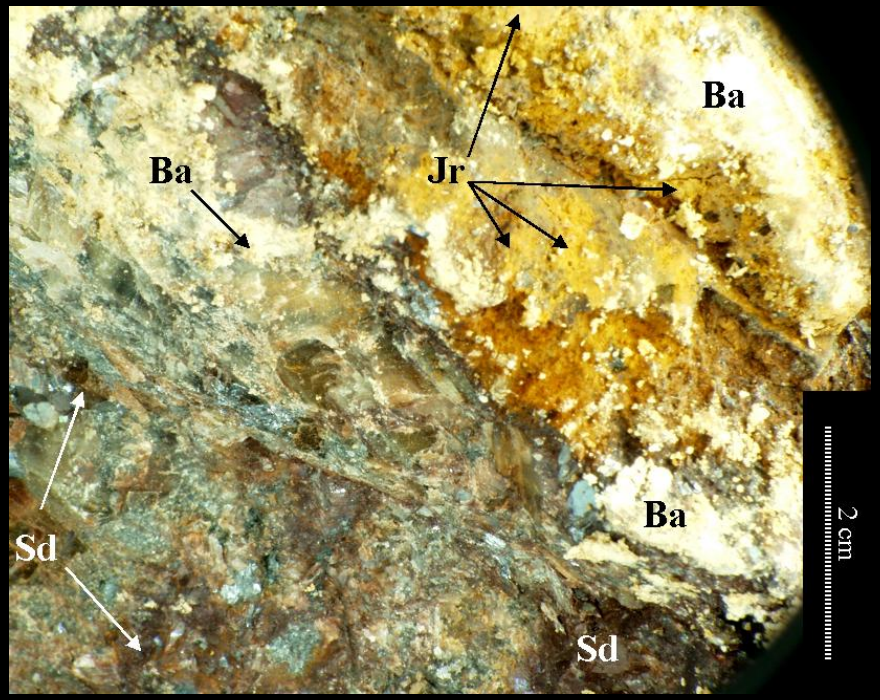


Some extinct undersea hydrothermal vent structures, which are associated with the mineralizing process of the JHS, are still preserved "in situ" and allowed to carry out a detailed isotopic analysis complementing the fluid inclusion studies (Martínez-Frías et al., 2007).

Since 2004, numerous geological and multi-analytical (Raman, XRD, LIPS, FTIR) campaigns were carried out at the Jaroso. Most of them were organized in the framework of the future ExoMars mission (2016-2018) in which we are participating with the development of a Raman Laser Spectrometer (RLS). The RLS will be hosted in a rover which will analyze the Martian minerals, rocks and geological outcrops.

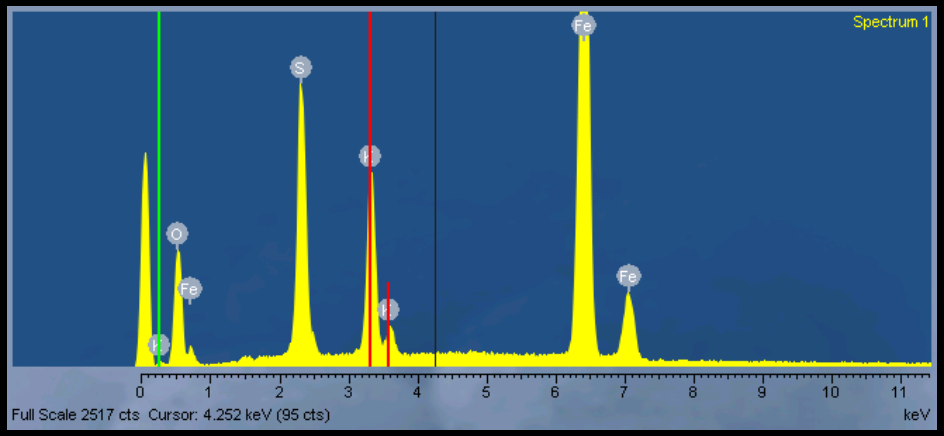


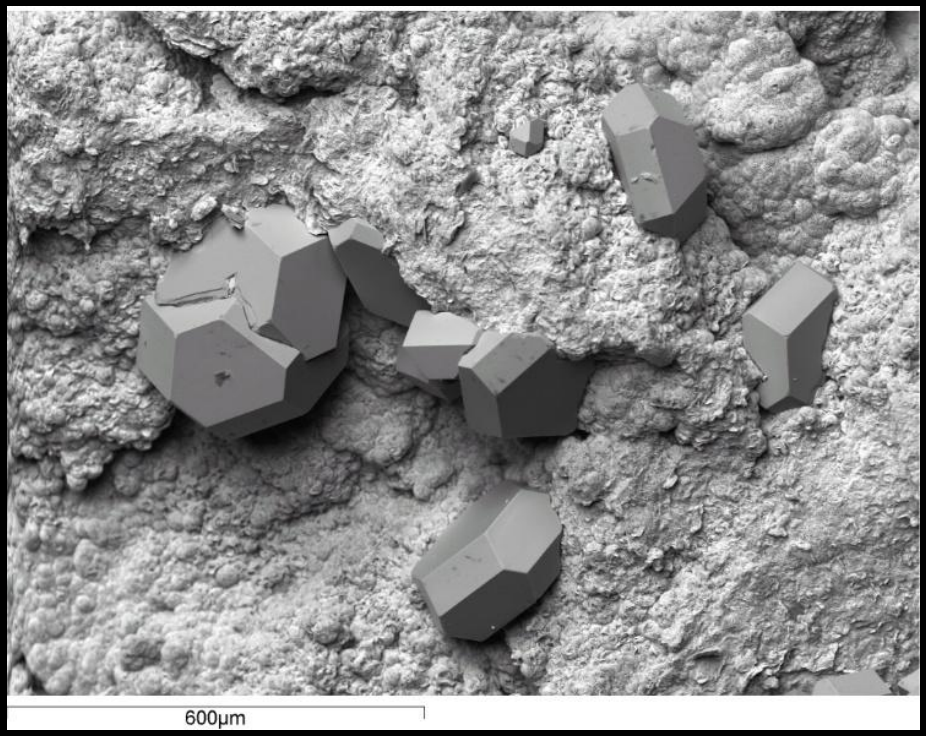
Jarosite usually occurs as efflorescences, earthy masses and films or crusts, associated to other sulfates

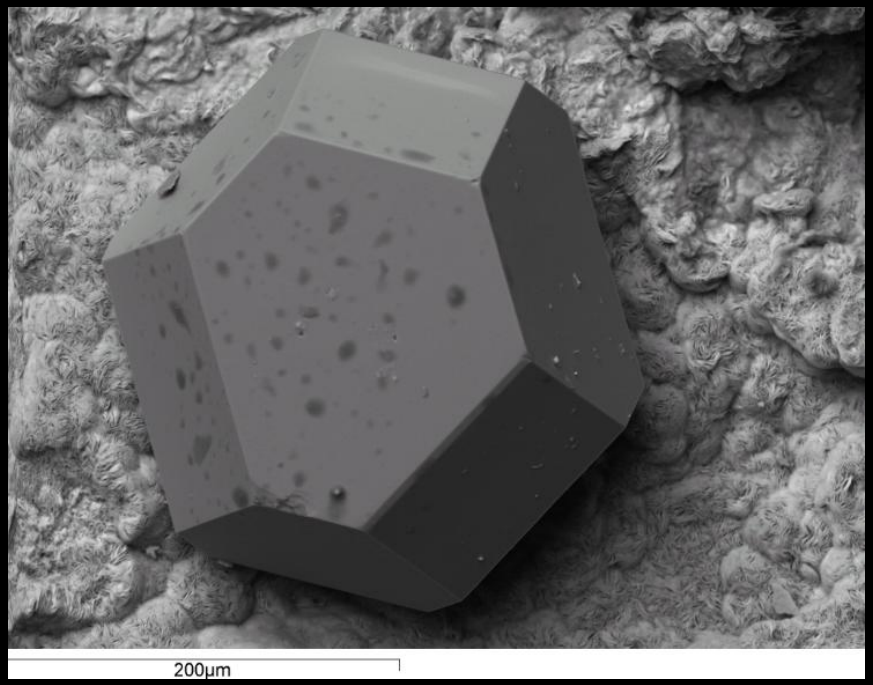


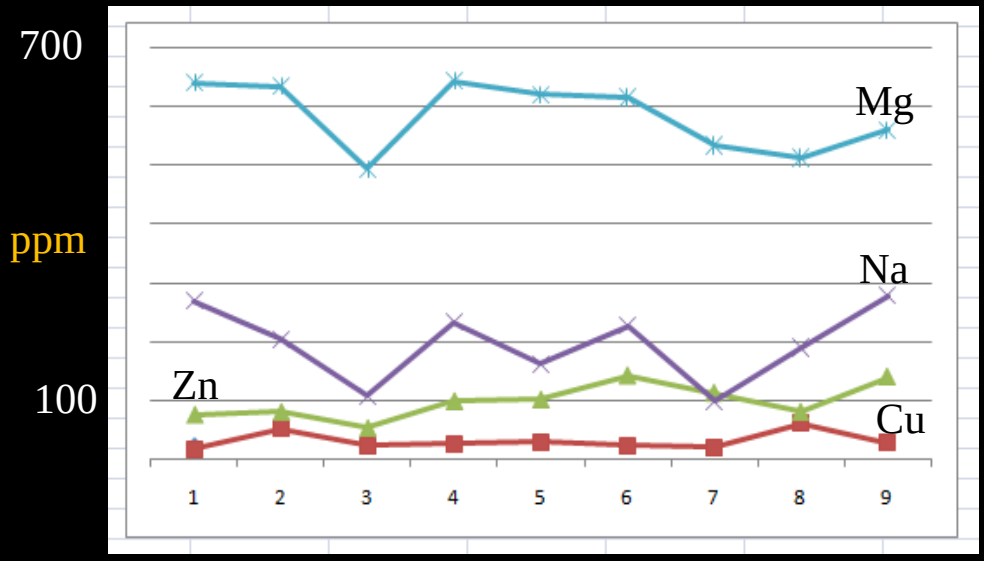
Typical mineral associations at the Jaroso ravine (JHS), Sierra Almagrera representing various paragenetic stages. Yellow crust and patches: jarosite. Brown areas: Ca-Mg-Fe carbonates. White areas: barite.

Recently (Martínez-Frías et al. 2015) we have found tiny jarosite crystals (*around 200 mm*). They are extremely scarce, and show a hexagonal outline, resulting from combinations of rhombohedra; occasionally tabular, forming hexagonal thick platelets. Rarely, the crystals may develop a pseudooctahedral habit.





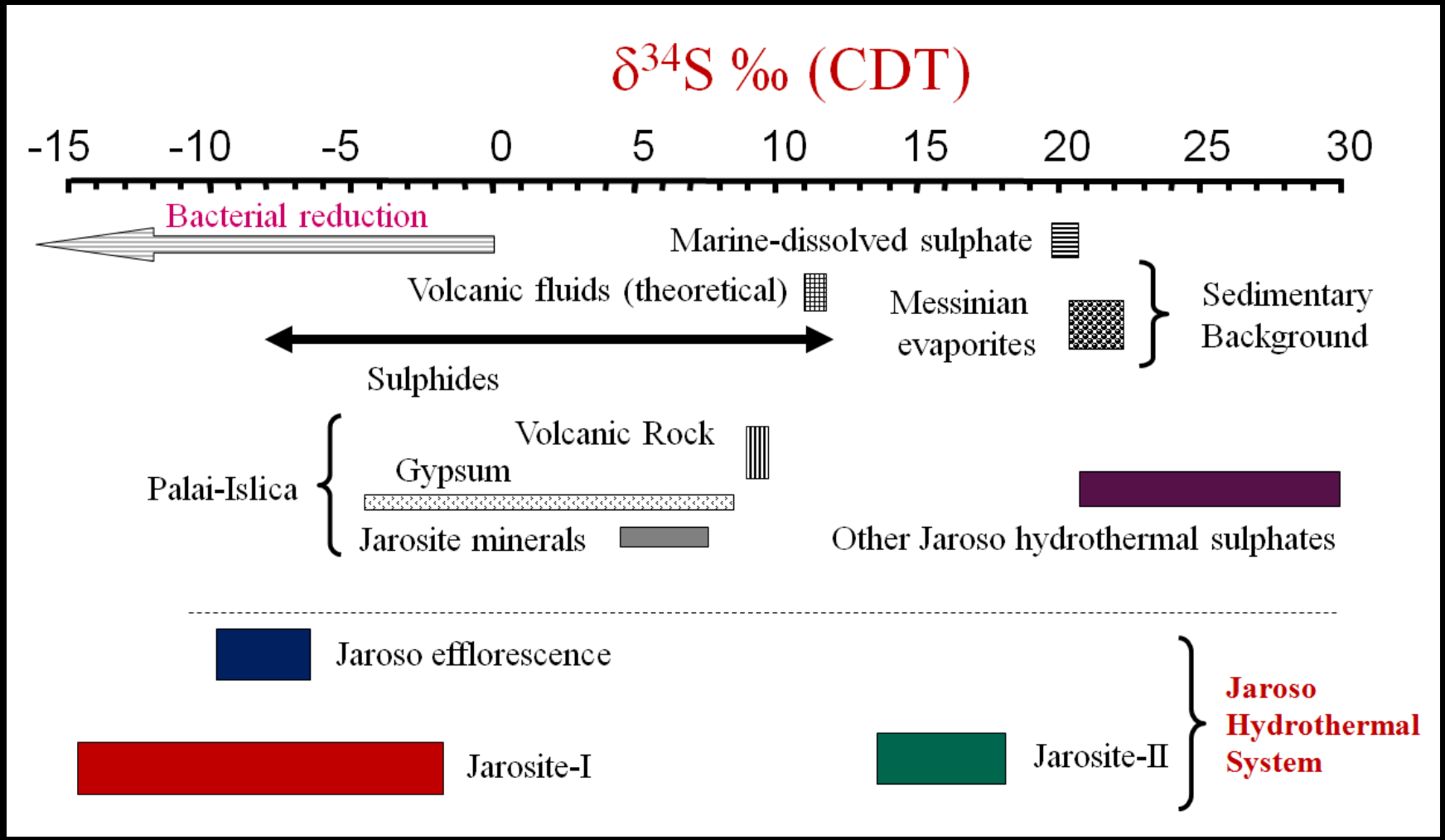




- Nine jarosite-rich outcrops have been found and characterized by different mineralogical (XRD, SEM-EDX, Raman) and geochemical (ICP-MS) techniques.

* PerkinElmer ELAN9000 quadrupole ICP-MS spectrometer (Perkin Elmer Instruments, Spain), with a Ryton™ cross-flow nebulizer, scott spray chamber and Cetac ASX-510 autosampler.

$\delta^{34}S‰$ values of jarosites and other sulphates from Jaroso Hydrothermal System in comparison with other minerals, areas and geological settings.

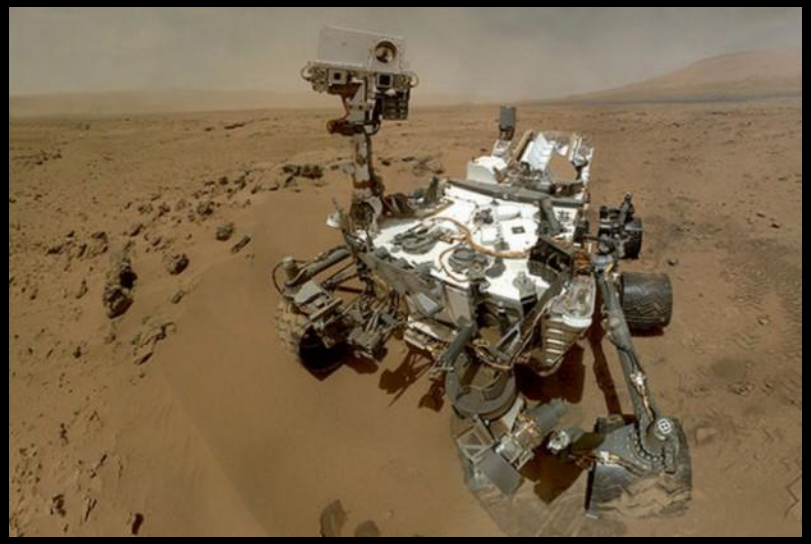



Massive gypsum layers
Sorbas area

Gypsum outcrop
Sorbas area

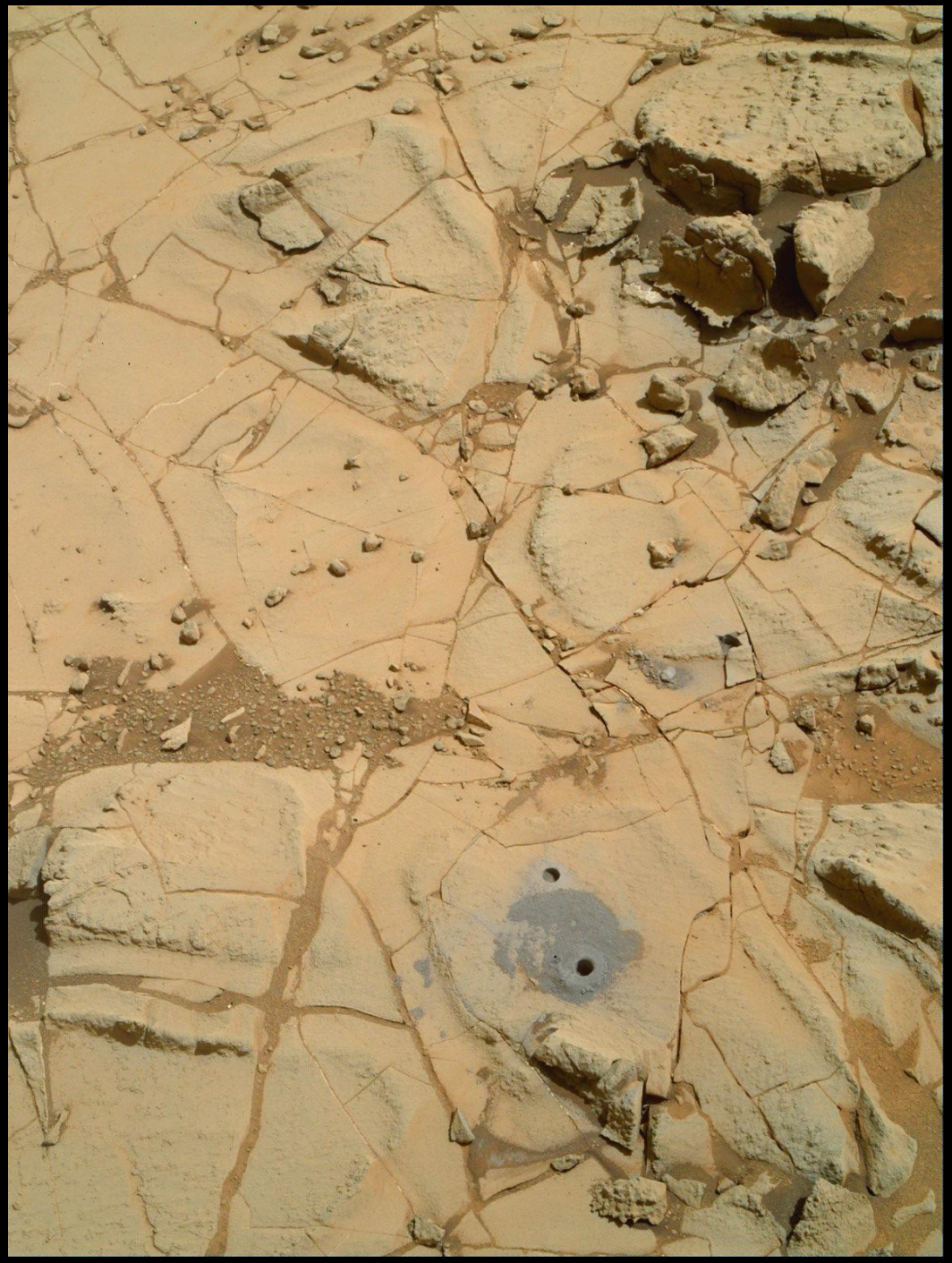
Jarosite and gypsum are two extremely important sulfate minerals for Mars, which occur in the Jaroso Hydrothermal System as part of subaerial and subterraneous settings

Giant crystals of gypsum, Pulpi giant geode, Almería (Jaroso Hydrothermal System)



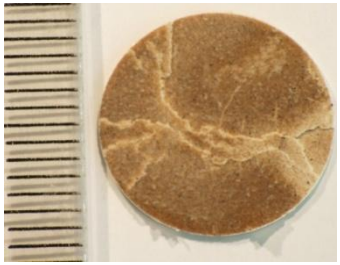
Jarosite has also been detected by the rover Curiosity (MSL) in varios areas in the interior of the crater Gale. Gray cuttings from Curiosity's drilling into a target called "Mohave 2" are visible surrounding the sample-collection hole in this Jan. 31, 2015 image from the rover's MAHLI camera. This site in the "Pahrump Hills" outcrop provided the mission's second drilled sample of Mars' Mount Sharp.

Credit: NASA/JPL-Caltech/MSSS



Credit: NASA/JPL-Caltech/MSSS

Source areas of the fabrication of Mars simulants: Mineralogy, geochemistry, astrobiology



Educational activities about Astrobiology

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ILUSTRE COLEGIO OFICIAL DE GEOLOGOS

Spanish Planetology and Astrobiology Network (REDESPA)

http://www.icog.es/redespa/

Science Centers and Institutes (e.g. CAB, IACT, IGME, IQFR, ICM)

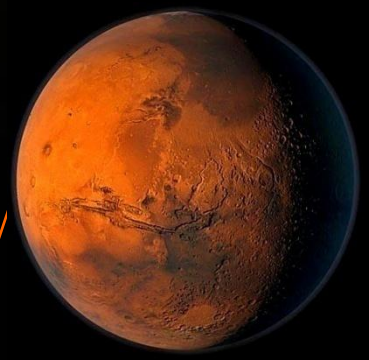
Astronomical Observatories, societies (e.g. National Astronomic Observatory)

Universities 14

Science Culture and Outreach Units

Science Museums, Planetaria and Parks (e.g. Madrid Planetarium)

Science Communication (Selected Space related blogs)



Thanks for your attention!

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