LIFE ON MARS?

Río Tinto as a terrestrial analogue of the Red Planet

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Introduction

Search for life beyond Earth has been a major scientific and philosophical issue for decades, and our neighbor planet Mars is considered one of the main candidates to host some kind of extraterrestrial life. One of the most relevant terrestrial analogs of the Red Planet is a very peculiar river, located in a small region in the south of the Iberian Peninsula, the province of Huelva (Spain). This river, "Río Tinto", has been studied for years because its unique ecosystem, where true extreme conditions (acidity, toxic heavy metals) are present; and at the same time it hosts an unexpectedly high microbial diversity, both Eukaryotic and Prokaryotic .

Fig. 1: Río Tinto location

Relevant findings on Mars

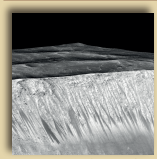


Fig. 2: Evidence of liquid water on Mars[1]

Liquid water evidence

Evidence of liquid water flowing on Mars is indispensable to consider any biological form of life in the Red Planet. In 2016 [1], NASA's Mars Reconnaissance Orbiter (MRO), using an imaging spectrometer, provided the strongest evidence of water flowing on Mars surface yet.

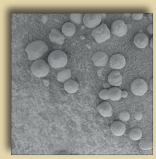


Fig. 3: Hematite at "Meridiani Planum"[2]

Hematite and Jarosite

The discovery of these two iron minerals in the "Meridiani Planum" area supposed a major advance in the search for past or present Martian life, as liquid water and acidic conditions are needed for their formation. Also, these minerals can be found in the Río Tinto basin, produced by chemolithotrophic microorganisms[3].

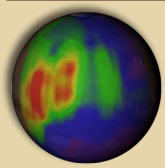
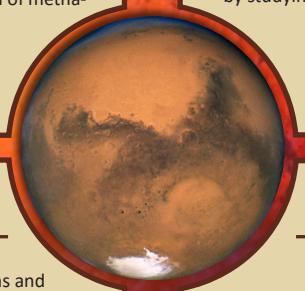


Fig. 4: Methane detection on Mars[4]

Methane on Mars

In summer 2003, Mumma et al.[5] performed a study where the main objective was the detection of methane gas on the Red Planet.

High methane levels were detected, and the authors suggested that an active source of methane must exist in Mars nowadays.



Project M.A.R.T.E.

Mars Astrobiology Research and Technology Experiment

Although mining activities are recorded in the area since more than 4500 years ago, previous studies determined that extreme acidic conditions in the river are not a product of these mining activities, but the consequence of a bioreactor, still operating nowadays in the groundwater near the area.

To test this hypothesis, a drilling project was performed in Río Tinto: the M.A.R.T.E. project, a collaboration between NASA and CAB ("Centro de Astrobiología"). Its objective was to search for subsurface microbial activity, focusing in Río Tinto basin groundwater[6].

Fig. 5: M.A.R.T.E. drilling site at "Peña del Hierro"

One of the main findings of this study was that the unique mineralogical characteristics of Río Tinto groundwater (like the high presence of iron oxyhydroxides and sulfates), are a product of the alteration of the sulfide deposits in the IPB by chemolithotrophic microorganisms. The authors concluded this by studying SEM and CARD-FISH analyses performed on drilling samples.

Contrary to previous opinons, they also reported the presence of methanogenic microorganisms in subsurface microhabitats, despite extreme acidic and oxidative conditions of the environment.

Eukaryotic and prokaryotic diversity

Eukaryotes

In an extreme environment like Río Tinto, where acidic conditions and high metal concentrations are present, it could be thought that eukaryotic growth and diversity would be very limited. However, Eukaryotic algae represent 60 % of the river biomass, with clorophytes *Chlorella*, *Dunaliella* and *Chlamydomonas* being the most abundant genera[7].

Fungal species have a strong presence all along the river: phylum Ascomycetes is the most abundant, and one species related to *Hobsonia* genus is found forming charachteristic macrofilamentous structures.

Fig. 6: Eukaryotic algae in Río Tinto

Protists are also well represented, with photoautotrophic flagellates (*Euglena*, *Bodo* and *Ochromonas*), ciliates (order Hypotrichida), pennated diatoms (mostly *Pinnularia* genus), amoebas (*Vahlkampfia* genus) and heliozoa (*Actinophyris* genus), all being reported in the river.

Prokaryotes

Eigthy percent of the prokaryotic diversity was identified as bacteria belonging to only three genera: *Leptospirillum*, *Acidiphilium* and *Acidithiobacillus,* all described members of the iron cycle. *Acidithiobacillus ferrooxidans* is the most remarkable species, as it is involved in several biogeochemical processes (showed at **Fig. 7**).

Iron and Sulfur cycles in Río Tinto

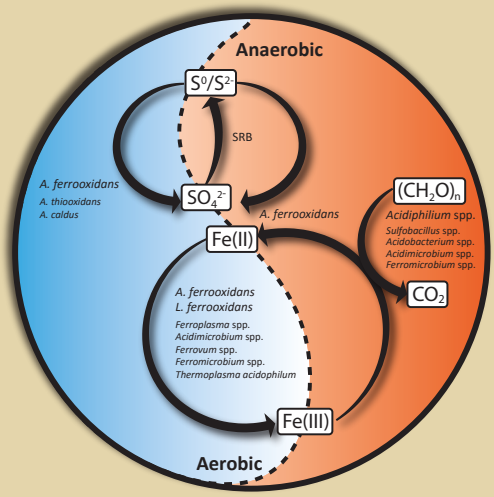


Fig. 7: Simplified model for the iron and sulfur cycles in Río Tinto.
Font: Prepared by the author on the basis of models purposed by Sánchez-Andrea et al.[8] and Amils et al.[9].

Conclusions

Several studies have been performed in recent years in this peculiar river, achieving different goals: the hypothesis of microbial activity as the origin of extreme acidic conditions has been tested and proved, with obtained results being consistent with previous work. Microorganisms responsible for these conditions have been isolated and identified, and a great eukaryotic and prokaryotic diversity has been found. Iron and sulfur cycles sustain the ecosystem, and *A. ferrooxidans* is the most relevant species regarding these cycles. Also, it has been proven that methanogens can live in extremely unfriendly conditions, thanks to the creation of suitable microhabitats. Despite the obvious differences, (oxygen, temperature, water abundance), Río Tinto is useful as a terrestrial analog of Mars, as it study allows researchers to extrapolate different possible biogeochemical processes on the Red Planet surface or subsoil.

Fig. 8: Río Tinto landscape

References:

(1) **[Image credit: NASA/JPL/University of Arizona].** NASA, (2016). NASA Confirms Evidence That Liquid Water Flows on Today's Mars. [online] Available at: http://www.nasa.gov/press-release/nasa-confirms-evidence-that-liquid-water-flows-on-today-s-mars [24 Feb. 2016].
(2) **[Image credit: NASA/JPL/Cornell/USGS].** JPL, N. (2016). Mars Exploration Rover. [online] Mars.nasa.gov. Available at: http://mars.nasa.gov/mer/gallery/all/1/m/046/1M132266947EFF05AMP2987M2M1.HTML [21 May 2016].
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