BACTERIAL DIVERSITY AND ECOLOGY OF RÍO TINTO (SPAIN)

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INTRODUCTION

Río Tinto rises in Peña del Hierro (Huelva, Spain), on the core of **Iberian Pyrite Belt** (IPB), which is one of the largest sulphidic deposits on Earth, and reaches the Atlantic Ocean at Huelva (**Fig. 1**).

Its **red wine color** is due to the acidification of water as a result of **oxidation of pyrite** by chemolithotrophic microorganisms, producing high ferric iron and sulphate contents along the river [4, 5, 6]. At first, the acidic water was thought to be a result of human activity such as mining, but research in the area has shown that similar conditions were present for at least 10^6 years before human activity. [2]

Ferric iron plays an important role in the Río Tinto ecosystem controlling not only pH due to its buffering capacity, but also redox potential and the concentration of other ionic metals deriving from the oxidation of metal sulphides since it is the predominant oxidant in the river.

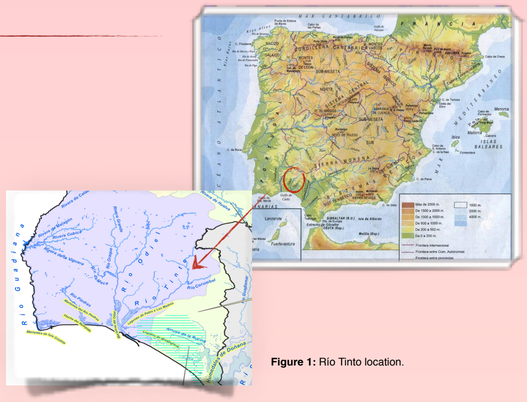


Figure 1: Rio Tinto location.

BACTERIAL DIVERSITY AND ECOLOGY [3,4,5]

Figure 2: *Acidithiobacillus* (green) and for *Acidiphilium* (red).

The main group involved is **Proteobacteria (Fig. 2)**, which oxidase ferrous iron to ferric iron:

- *Leptospirillum* spp. → Fix C using ferrous iron as electron donor and oxygen as electron acceptor. They are found forming a pink biofilm which floats on the surface of water.

$4 Fe^{2+} + 4 H^+ + O_2 \rightarrow 4 Fe^{3+} + 2 H_2O$

↓ Energy

+ Quantities iron for growing

DIVERSITY: Iron reducers · Hydrogen producers · Nitrate reducers · Sulphate reducers · Methano-gens

The hydrogen produced serves as electron donor for:

Denitrification | SO_4^{2-} reduction | Methanogenesis

while avoiding the toxicity of organic acids at low pHs.

- *Syntrophobcter* spp. → Produces H_2 degrading **propionate** (unfavourable) and only occurs in presence of *Methanospirillum*.
- *Clostridium butyricum* → H_2 production is more stable in **anoxic** environment like sediments.

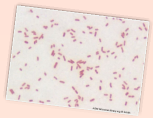
Clostridium butyricum.

The most abundant are heterotrophics and **Firmicutes** is the main group found. They reduce nitrate to N_2:

$NO_3^- \rightarrow NO_2^- \rightarrow NO \rightarrow N_2O \rightarrow N_2$

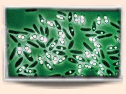
Favoured by anoxic conditions

- *Alcaligens faecalis* → Denitrification rate increase with decreasing of dissolved $[O_2]$. It is a opportunistic pathogen than only can denitrify **nitrite**.
- *Clostridrium* spp. → Reduce nitrite to **amoni** ion by a process based in the deviation of NADH electron to nitrite instead of organic compound.



Alcaligens faecalis.

They use **sulphate** (SO_4^{2-}) as the terminal electron acceptor for growth and in the degradation of OM. The result of the reduction is **sulphide** (H_2S), which can be oxidized to elemental sulphur (S°) and SO_4^{2-} by others sulphur bacteria.

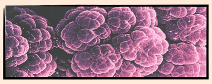


Desulfotomaculum spp.

- Variable in O_2 → Sporeformers dominate (*Desulfotomaculum* spp.).
- Permanently anoxic → Non-sporeformers dominate.

In sediments

They are Archaea, not Bacteria. Methanogenesis is usually believed to be inhibited at low pH, but the ability of ***Methanosarcina*** to tolerate mildly low pH conditions make it possible.



Methanosarcina spp.

RÍO TINTO: AN ECOSYSTEM CLOSE TO MARS [1,2,6]

The similar extreme conditions between Mars and Río Tinto elicited the interest of **NASA** and **Astrobiology Centre** (CSIC-INTA) to launch two projects with different aims:

M.A.R.T.E. (Mars Astrobiology Research and Technology Experiment) ▶ Develop the **toolkit** for detecting biomarkers and a **robotic drill** with remote control (**Fig.3**).

IPBSL (Iberian Pyrite Belt Subsurface Life) ▶ Estimate the **diversity** and **metabolism** of microorganisms in deep subsoil of Río Tinto.

Figure 3: A photograph of the M.A.R.T.E. drill mounted on the lander.

CONCLUSIONS

1- The extreme conditions of Río Tinto provides a **special microbiota** in its waters, which contribute to keep the river in its conditions.

2- Different **bacteria** are **related** between them in different ways due to their metabolic diversity.

3- We can take **benefit** of these bacteria: BIORREMEDATION / BIOLEACHING

4- **Microorganism** found in Río Tinto suggest that we can find them on **Mars** because there are similar conditions between the 2 environments.

5- Due to these similarities, Río Tinto provides the opportunity to prepare **future expeditions**, giving previous information.

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