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Geomicrobiology associated with formation of Fe-rich accretions in an extreme acidic environment

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Abstract

The abandoned mine of Valdarcas (north of Portugal) includes a small effluent channel associated with a permanent strong acid mine drainage (AMD) (average pH= 3.0), where Fe-rich tubular and spherical macro concretions have been formed and can be observed in situ. Results from biological analysis demonstrate a high phylogenetic diversity within Bacteria domain and Fungi kingdom, and less diversity for the Archaea domain.

1. Introduction

The study of extremophile microorganisms provides information about the limits of life on Earth and is under the scope of interest for astrobiology as it can provide information about evolution and adaptation of life beyond Earth.

Evidence of sulfates and iron oxides was found by the two MER (Mars Exploration Rovers), by NASA. Recently, the presence of an aqueous-sulphated system was confirmed by the OMEGA (Observatoire pour la Minéralogie, l'Eau, les Glaces et l'Activité) instrument of MarsExpress, by ESA. The presence of an ancient extreme (acidic) environment on Mars was suggested by the discovery of jarosite. Thus, the study of the communities from acidic and iron rich habitats can be useful to identify Mars analog environment-specific biomarkers [1].

Fe-rich tubular and spherical macro concretions (fig. 1) can be observed*in situ* over ochre precipitates of iron(III)-bearing minerals in the streambed of a small effluent associated with a permanent strongly acid mine drainage (AMD) (average pH= 3.0) [2] from the abandoned mine of Valdarcas(north of Portugal) [2][3]. Trapping of biogenic gas can be directly associated with the formation of these accretions.

It was also observed the presence of *Euglena mutabilis*, a microeukaryoticphototroph previously reported to contribute to the formation of Fe-rich stromatolites in AMD systems [3][4][5]. According to Brake et al. [4][5] this microorganism contributes to the formation of the Fe-stromatolites (directly, from the intracellular Fe compounds released after death, or indirectly, as a result Fe(II) oxidation due toO_2production via photosynthesis, followed by inorganic precipitation of Fe(III) minerals). This raises the question whether the Fe-rich macroaccretions found at Valdarcas are: 1) biogenically-derived, 2) the result of an abiotic process, or 3) a conjugation of both processes.

We examined the microbial community composition associated with the macroscopic accretions by means of culture-independent techniques, such as polymerase chain reaction (PCR) and denaturing gradient gel electrophoresis (DGGE) analysis, in order to gain a better understanding of the mineral-microorganism interactions.

Figure 1: *In situ* image from Fe-rich macroaccretions.

2. Methods

2.1Study site

Valdarcas mine is located in the Northern Portugal, where scheelite and wolframite had been exploited between the 50's and the 80's of last century [2]. Ochre precipitates of Fe(III)-bearing minerals can be found along a nearby small streambed which is under the influence of the mine waste drainage. Mineralogical analysis of the precipitates indicates the presence of mixtures with variable composition and crystalllinity, with predominance of jarosite, schwertmannite and goethite[2].

2.2DNA Extraction

PowerSoil DNA Isolation Kit (MOBIO Laboratories, Inc.)used according to the manufacturer's instructions.

2.3Primers for 16S and 18S rDNA amplification and sequencing

Bacteria: 27f/1492r (1st set); 338f-GC/518r (2nd set); Archaea: 344f/934r (1st set); 344f-GC/518r (2nd set); Eukarya: Euk 1A/516r-GC (1st and 2nd sets); Fungi: ITS1f-GC/ITS2 (1st and 2nd sets).

2.4DGGE Fingerprinting

Denaturing gradients used for small subunit ribosomal RNA profiling: Bacteria 35-60%; Archaea 30-70%; Eukarya and Fungi 20-50%.

2.5Mineralogical Analysis

X-ray powder diffraction (XRD), using Cu-K α radiation at 40 kV and 30 mA; SEM-EDS (on C and Au coated samples), with a LEICA S360.

2.6SEM images

Field emission scanning electron microscope (FE-SEM) (JEOL JSM-630F).

3. Results

The PCR-DGGE analyses reveal the presence of microorganisms from the three domains: Bacteria, Archaea and Eukarya. The phylogenetic diversity is high within the Bacteria and Fungi kingdom. Archaea show less diversity.

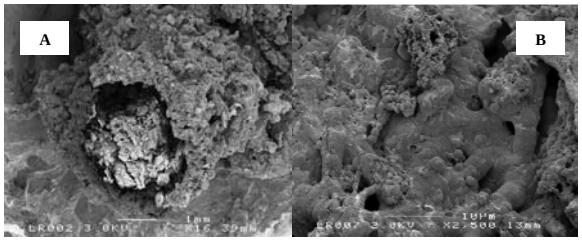

Figure 2: SEM image from a tubular macroaccretion (A).Mineralized microbial-like features and a smooth coat can be observed on the surface of the structure (B).

A significant number of microbial-specific features associated to the minerals were observed on SEM images. At specific locations, a coating can be observed over the microorganisms (fig.2B).

4. Summary and Conclusions

The results suggest that the macro concretions have associated a microbial community particularly rich in Bacteria and Fungi. A detail characterization of the dominant members is needed, in order to understand them contribution in the formation of these Fe-accretions. The relation between algae colonization and themineralogical composition of the precipitatesneeds to be investigated as well.

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