"Geomicrobiology of Extreme Acidic Environments: fundamentals and applications in astrobiology"

Final Report

Hosted by: Dipartimento di Scienze Biologiche, Geologiche e Ambientali-BiGeA dell' Alma Mater Studiorum

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The course started with an introduction about the different types of extremophilic organisms including acidophile, alkaliphile, halophile, radioresistant, thermophile…etc. Refereeing to some places like Uyuni salt flat and Volcan Illimani (Bolivia), submarine hydrothermalism, Yellowstone, Russian drilling base (Vostok), themal area of Gunhuver (Iceland), with a special attention to "Iberian Pyrite Belt (IPB) subsurface", the origin of the "Río Tinto", as a case study of the methodological problems in the geomicrobiological characterization of the Dark Biosphere.

Río Tinto is a large acidic river with a high concentration of sulfate and soluble metals specially iron which can be efficiently oxidized in an anaerobic conditions by nitrate reducing bacteria. Metabolic products of nitrate reduction can also be used in the oxidation of pyrite, otherwise it can be oxidized directly by Acidovorax. Which indicate that there is subsurface microbial activities help in explaining the extreme environmental conditions of Río Tinto. Pyrite was also found to be colonized with Acidithiobacillus ferrooxidans by using CARD-FISH technique.

CARD-FISH (Catalyzed reporter deposition Fluorescence In Situ Hybridization) is a powerful methodology with a growing number of applications in the quantitative evaluation of microbial populations of complex ecosystems. CARD-FISH is very useful for the detection, identification and quantification of microorganisms involved in bioleaching processes, because it can solve two important problems in the field: signal intensity and high background fluorescence of the sample. With this methodology the identification of microorganisms attached to the

mineral substrate, a critical property in biohydrometallurgical processes, is rather simple, allowing its direct quantification without the need of a previous detachment. This technique is much more informative to understand the operation of biogeochemical cycles (C, N, S, Fe) in the subsurface than other techniques like NGS sequencing, cloning, enrichment culture, that require large amounts of samples and gives only general information of the system.

The future of mining industry using microorganisms which is called biomining has also been discussed. Biomining is a technique of extracting metals from ores and other solid materials typically using prokaryotes or fungi. These organisms secrete different organic compounds that chelate metals from the environment and bring it back to the cell where they are typically used to coordinate electrons. Biohydrometallurgy is an emerging trend in biomining in which commercial mining plants operate continuously stirred bioreactors to efficiently separate and mine these metals from water systems. The same concept can be used for bioremediation models. Bacteria can be inoculated into environments contaminated with metals, oils, or other toxic compounds. The bacteria can clean the environment by absorbing these toxic compounds to create energy in the cell. Microbes can achieve things at a chemical level that could never be done by humans. Bacteria can mine for metals, clean oil spills, purify gold, and use radioactive elements for energy.

The course also asserts certain new points such as subsurface biofilms have been detected in situ although it is considered as a high energy consuming place not recommended for oligotrophic environments like the subsurfaces. High level of biodiversity, functional activities and biogeochemical cycles has been detected in the deep subsurface of the solid matrix of IPB. The exploration and characterization of the Tinto ecosystem is important to understand the properties of microorganisms that could develop on Mars. It has been detected that on Mars there are sedimentary rocks that were formed in acidic conditions (acidic lakes or oceans) so it do not seems to be the ideal place for life development. However, life on the subsurface has much more possibilities.

This advanced course certainly improved my skills as well as updates my knowledge about current issues concerning extremophiles and their applications. This course will also be useful for my future research, teaching and other academic activities; and thus will be a part of a well-considered long-term plan.