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# Astrobiological interest of deep subsurface geomicrobiology

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## Abstract

If we want to detect signs of life on Mars, either extant or extinct, drilling missions to gain access to the subsurface are indispensable since life on the surface is virtually impossible due to the extreme doses of UV radiation, lack of liquid water, low temperatures and high oxidant conditions. But selecting the appropriate technologies for life-sign detection in the subsurface poses an important challenge since current knowledge of the dark biosphere is still very scarce.

## Introduction

Economic and technical constraints have limited the amount of information obtained from devoted geomicrobiological drilling studies. Most of the continental subsurface data has been obtained using pre-exisiting subterranean "windows" (artesian wells, springs, deep mines, underground locations for waste disposal and underground research facilities) all of them with important limitations.

The picture that is emerging from the available data shows a variable number of cells in the subsurface, probably related to the geology and hydrology of each studied system. In general, the number and diversity of microorganisms decreases with depth and Bacteria outnumber Archaea. Within Bacteria the most common detected phyla correspond to Proteobacteria, Actinobacteria, Bacteroidetes and Firmicutes. Within the Archaea, methanogens are recurrently detected in most analyzed subsurfaces together with sulfate reducing activities.

In the study of subsurface environments, one of the most controversial topics is whether the available energy source is endogenous or partially dependent on products generated in the surface. However H2, which can be generated abiotically, seems to be among the most widely used electron donors, although other lithotrophic metabolisms that make use of reduced iron, sulfur and nitrogen have also been detected in the subsurface. More information at a better depth resolution will build up the repertoire of subsurface electron acceptors and donors biologically available in the deep subsurface. Several studies reported the presence of viruses in subterranean environments, but only a more systematic evaluation can accurately assess their role in horizontal gene transfer among microbial populations. Similarly, a thorough analysis is needed to verify the reported presence of fungi as members of the dark biosphere.

Even though drilling and contamination control methodologies are well established, procedures for taxonomic, functional and metabolic analysis are rather diverse and reflect the rapid evolution of this field of study. In any case, the use of complementary techniques is strongly advisable because it helps sort out the most important elements in the system. Of the many techniques used for sample analysis, those based on fluorescence in situ hybridization are of particular interest because they allow a resolution at the micro-niche scale, which cannot be obtained by most of the other currently available methodologies due to the large volumes of sample they require, consequence of the low cell numbers existing in deep low porous rocks.

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