# SEARCHING FOR LIFE UNDERGROUND: AN ANALYSIS OF REMOTE SENSING OBSERVATIONS OF A DRILL CORE FROM RIO TINTO, SPAIN FOR MINERALOGICAL INDICATIONS OF BIOLOGICAL ACTIVITY.

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**Background:** Water is unstable on the surface of Mars, and therefore the Martian surface is not likely to support life. It is possible, however, that liquid water exists beneath the surface of Mars, and thus life might also be found in the subsurface. Subsurface life would most likely be microbial, anaerobic, and chemoautotrophic; these types of biospheres on Earth are rare, and not well understood. Finding water and life are high priorities for Mars exploration, and therefore it is important that we learn to explore the subsurface robotically, by drilling. The Mars Analog Rio Tinto Experiment (MARTE), has searched successfully for a subsurface biosphere at Rio Tinto, Spain [1,2,3,4]. The Rio Tinto study site was selected to search for a subsurface biosphere because the extremely low pH and high concentrations of elements such as iron and copper in the Tinto River suggest the presence of a chemoautotrophic biosphere in the subsurface beneath the river. The Rio Tinto has been recognized as an important mineralogical analog to the Sinus Meridiani site on Mars [5].

**Methods:** In 2003, drilling was performed at Rio Tinto that recovered 165 m of 78mm core. Cores were extracted from the ground in 3m sections, and then cut into 1 m sections for detailed analysis. The cores were subject to aseptic subsampling of each 1 m interval of core and biological analysis of the subsamples has been performed [1,2,3,4]. Data was obtained on the recovered core using remote sensing instruments analogous to those that might be included on a robotic drilling mission. This data set included color macroscopic imaging of each 1 m section of core, microscopic images (6 micron per pixel resolution) at 25 cm intervals along the core, and Visible-Near infrared spectral observations of the cores using an Ocean Optics S2000 Visible-Near Infrared spectrometer obtained at 25 cm intervals.

As a Research Associate with the 2004 NASA Astrobiology Academy at Ames, the first author (Battler) analyzed the core logging data to determine whether or not this suite of remote sensing tools is necessary or sufficient to identify life underground. The goals of this study were to identify lithology, mineralogy, and biosignatures based on the remote sensing data alone, and to select a set of cores most likely to contain life. After the selections were made, remote observations were compared with "ground truth" –that is – geological and mineralogical observations made by geologists who logged the cores in the field. The selections of cores thought to have biological activity were compared with the locations where biological activity had been found by detailed biological and analytical techniques.

For each core, various criteria were used to interpret the data and identify lithology and mineralogy as shown in Table 1. Several different alteration minerals, which form under the influence of ground water, were identified. Alteration minerals forming along fractures and joints were of particular interest, as these areas could be ideal microhabitats. See Figure 1 for an example of alteration minerals which indicate the past presence of water, and thus suggest the possibility of the presence of life.

In the study, the lithology was correctly identified as predominantly andesite hosted volcanogenic massive sulphide deposits. Major minerals, such as pyrite, were successfully identified, as well as alteration minerals, such as jarosite and goethite. While the success rate for identifying geological parameters was quite high, the success at correctly identifying locations where microbial growth was detected was much lower. Still, 30% of the samples selected using remote sensing alone were found to correspond to microbial growth.

| Lithology | Mineralogy | Biosignature | Textures | Mineral Colour and Luster | Grain Size and Shape |
|---|---|---|---|---|---|
| Rhyolite with layered black and yellow ore mineralization, and zones of massive sulphide ore mineralization | 30% quartz, 22% un-identified black ore, 20% pyrite, 5% chalcopyrite, 10% sericite, 8% jarosite or goethite, 5% hematite | Very strong; strange brown and black feature cross-cuts flow texture (or foliation) at 94.65m; also, abundant red staining (hematite?) at 95.15m | Aphanitic, porphyritic; yellow ore minerals are concentrated in clumps;<br>alteration minerals: pyrite altering to jarosite | Leucoccratic; mainly white, with light yellow minerals; metallic luster | Fine-grained ore minerals; 0.1-0.25mm, aphanitic matrix; anhedral to subhedral grains |

**Table 1.** An example of core logging criteria used for analysis of remote data. This table shows observations for core segment 4.39B.

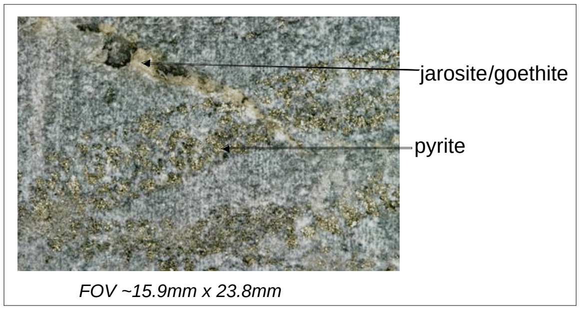

**Figure 1.** Microscopic image featuring the alteration minerals jarosite and/or goethite; a potential biosignature.

**Conclusions:** Life underground is not uniformly distributed. Furthermore, robotic missions have a major limitation when searching for subsurface life: only a limited number of samples can be analyzed. Sample analysis for biology involves grinding up a powdered sample and subjecting it to a suite of analytical techniques. Random samples are unlikely to find subsurface biology even if it is present, unless a large number of random samples can be analyzed. This study helps to gain insight into the use of remote sensing observations of cores to select the best samples to search for subsurface life. While the suite of remote sensing tools used provides sufficient data to determine lithology and mineralogy of a geologic core, more information is likely to be needed in order to correctly identify life in the subsurface. Further work is needed to determine how best to search for life (either on the surface of subsurface) robotically.

**References:** [1] Stoker, C. et al. (2004) *LPSC XXXV*, Abstract # 2025. [2] Remolar, F. et al. (2004) *LPSC XXXV*, Abstract # 1766. [3] Stoker et al. (2005) *LPSC XXXVI*, Abstract. [4] Stevens et al. (2005) *in preparation*. [5] Sogin, M. et al. (2003) *NAI Research Proposal.*