Siderophilic cyanobacteria for the development of extraterrestrial photoautotrophic biotechnologies.

I.I. Brown and D.S. McKay

In-situ production of consumables (mainly oxygen) using local resources (In-Situ Resource Utilization-ISRU) will significantly facilitate current plans for human exploration and settlement of the solar system, starting with the Moon.

With few exceptions, nearly all technologies developed to date have employed an approach based on inorganic chemistry. None of these technologies include concepts for integrating the ISRU system with a bioregenerative life support system and a food production system.
Therefore, a new concept based on the cultivation of cyanobacteria (CB) in semi-closed biogeoreactor, linking ISRU, a biological life support system, and food production, has been proposed. The key feature of the biogeoreactor is to use lithotrophic CB to extract many needed elements such as Fe directly from the dissolved regolith and direct them to any technological loop at an extraterrestrial outpost. Our studies showed that siderophilic (Fe-loving) CB are capable to corrode lunar regolith stimulants because they secrete chelating agents and can tolerate [Fe] up to 1 mM.

However, lunar and Martian environments are very hostile (very high UV and γ-radiation, extreme temperatures, deficit of water). Thus, the selection of CB species with high potential for extraterrestrial biotechnologies that may be utilized in 15 years must be sponsored by NASA as soon as possible. The study of the genomes of candidate CB species and the metagenomes of the terrestrial environments which they inhabit is critical to make this decision.

Here we provide preliminary results about peculiarities of the genomes of siderophilic CB revealed by analyzing the genome of siderophilic cyanobacterium JSC-1 and the metagenome of iron depositing hot spring (IDHS) Chocolate Pots (Yellowstone National Park, Wyoming, USA).

It has been found that IDHS are richer with ferrous iron than the majority of hot springs around the world. Fe^{2+} is known to increase the magnitude of oxidative stress in prokaryotes through so called Fenton reaction. It is not surprising therefore that the CB inhabiting IDHS have larger sets of the proteins involved in the maintenance of Fe homeostasis and oxidative stress protection than non-siderophilic CB. This finding combined with our earlier results about the ability of some siderophilic CB to utilize chemical elements released from analogs of lunar and Martian regolith make them the most advanced candidates to be employed in advanced extraterrestrial biotechnologies.