Letter of Interest

Title: Impact of subsurface microbial activity on the corrosion and deterioration of metallic mine infrastructure and secondary support systems.

Investigator: T.C. Onstott

Collaborators: TNTC

T.J. Phelps
G. Southam
T.C. Hazen
And others

Science Goals:
The maintenance of ventilation ducts, water lines, secondary support structures and metal screening attached to rock bolts can cost a mine tens of millions of dollars a year. Corrosion is apparent in all mines where moist warm air is present. The role of microorganisms in this corrosion process is not well understood but it is reasonable to assume that they accelerate the rate of corrosion. By understanding the microbial oxidation mechanisms responsible for the corrosion and the species involved from the initial stages of colonization to the climax biofilm community, it may be possible to fabricate alloys or coatings that would retard the corrosion process. Metallic components proposed for DUSEL that will be outside of a controlled environment should also be tested for corrosion in situ. Such test could lead to substantial savings in the long term for DUSEL.

Research objectives:

- Obtain samples of each class of materials used in Homestake mine that exhibits corrosion to various degrees.
    - Set up an air temperature and humidity data logger at each site noted for corrosion.
    - Collect air and water samples (if pipeline corrosion) and characterize their chemistry (pH, salinity, major cations and anions).
    - Characterize the microbial community with 16S rDNA and 16S rRNA of the air and water samples and the corroded materials. Use these results to construct a DNA microarray.
    - Characterize the biofilm and metal surfaces by environmental SEM and regular SEM.
- Deposit multiple metal coupon arrays of each alloy at sites noted for corrosion.
    - Monitor air temperature and humidity data logger at each site noted for corrosion.
    - Sequentially sample coupons over the course of a few years to determine the rates of deposition and corrosion.
    - Determine key microbial species and limiting nutrients in the corrosion process.
- Reproduce environment on bench top in lab below ground where the environmental conditions, i.e. temperature and moisture, can be controlled and its influence on the corrosion rate could be examined.
    - Test a variety of alloys not used at Homestake and proposed to be used for DUSEL.

Methods:
The microbial characterization would include determination of the abundance of "living" cells and their phylogenetic diversity by extracting and amplifying both 16S rDNA and rRNA. The chemical properties would include geochemical analyses of the water in the pipes, condensed from the air and present on the surface of the metal components and coupons. Oxidized/reduced aqueous species in the metal surfaces could be characterized by XAFS at LBNL. FISH and SEM analyses will be used to characterize the biofilms.

Integration with E&O:
Experiments can be designed in collaboration with local school groups who could use simple microscopy to look at the coupons and come up with their own approaches for coating metals with compounds to inhibit corrosion.

Infrastructure Requirements and Impact on Other Users:
No infrastructure requirements at all. One small cubicle at a corrosion site will be required where temperature and humidity of coupons could be controlled while permitting air deposition to occur.

Readiness for Deployment of the Technology:
All the technology is available.

Readiness of Effort and Funding:
The experiment can begin as soon as reentry into Homestake occurs. The results of this experiment could introduce potential cost savings for DUSEL in the long run.

Budget:
~$150,000 per year will be required for 5 years to support graduate students performing analyses of the water samples and coupons.

ES&H Issues:
None