MICROBIAL Fe(II) OXIDATION AND MINERALIZATION IN SEDIMENTS OF AN ACIDIC, HYPERSALINE LAKE (LAKE TYRELL, VICTORIA, AUSTRALIA). E. E. Roden[1,2], M. Blöthe[1,2], and E. S. Shelobolina[1], [1]Department of Geoscience, University of Wisconsin, Madison WI 53706, USA, eroden@geology.wisc.edu, [2]NASA Astrobiology Institute.

Introduction: Lake Tyrrell (see Fig. 1) is a variably acidic, hypersaline, Fe-rich lake located in Victoria, Australia [1-3]. Terrestrial acid saline lakes like Lake Tyrrell may be analogs for ancient Martian surface environments [4], as well as possible extant subsurface environments. The saline, Fe-rich groundwater-fed sediments of Lake Tyrell are analogous to what might have formed on Mars during times of standing water, e.g. conditions that were originally (incorrectly) thought to have been present at Gusev Crater [5, 6], and that recent evidence suggests could have been present at other locations (e.g. intercrater plains north of Holden Crater) on ancient Mars [7]. Although the basis for potential microbial life in such environments is of course not known, one possibility is upward transport of Fe(II)-rich fluids derived from acid-promoted mobilization ("bleaching") of primary basalt minerals [8, 9]. In this conceptual model, which draws upon discussion in Chan et al. [10], Ormo et al. [9], and other sources, acidic, Fe(II)-rich hydrothermal fluids are envisioned to travel toward the planet surface, coming in contact with cooler, oxidant (e.g. O_2) containing surface fluids. Oxidation of Fe(II) and precipitation of ferric oxides in the vicinity of the redox front, combined with burial and diagenesis, could ultimately lead to accumulation of crystalline Fe(III) oxide phases in layered plains units of high Fe content similar to those that are forming in Lake Tyrell, Subsequent weathering of the plains units may expose hematite deposits, and continued flow could lead to formation of variably-sized hematite concretions [9] analogous to those that are present on the Martian surface [6, 11]. The key implication of this for astrobiology is that the interface at which acidic, Fe(II)-rich anoxic fluids contact oxidizing conditions would have represented an ideal environment for proliferation of lithotrophic Fe(II)-oxidizing microorganisms.

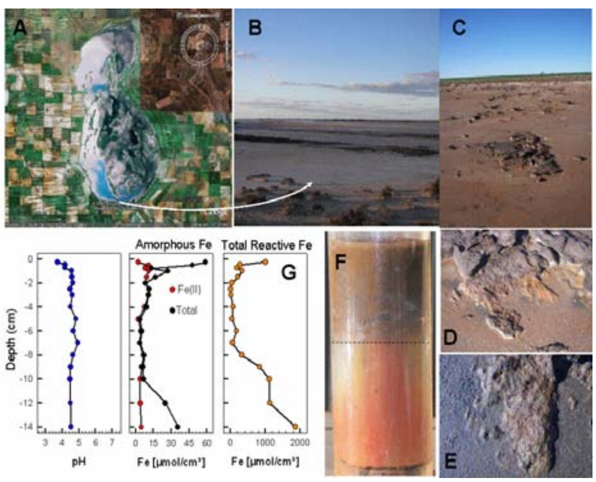

Figure 1. Lake Tyrell, Victoria, Australia. The lake is ca. 10 km wide and 30 km long, and is fed entirely with saline groundwater of varying pH and chemical composition [1, 2]. The southern and western sides of the lake receive inputs of low-pH (2-3), Fe-rich (ca. 1 mM) groundwater [3]. Panel B shows an image taken from the southern end of the lake, where large Fe concretions are present, some of which protrude from the surface of the sediment (panels C, D, and E). High concentrations of Fe(III) oxide phases are present starting at ca. 8 cm depth in the sediment (panels F and G).

To investigate the potential for microbial Fe cycling under acidic conditions and high salt concentration, we collected groundwater and sediment core samples during three field trips between 2006 and 2008 from the southern, acidic edge of the lake. Materials from the cores were used for chemical and mineralogical analyses, as well as for molecular (16S rRNA genes) and culture-based microbiological studies.

Results: Near-surface (< 1 m depth) pore fluids contained low but detectable dissolved oxygen (ca. 50 uM), significant dissolved Fe(II) (ca. 500 uM), and nearly constant pH of around 4 – conditions conducive to enzymatic Fe(II) oxidation. High concentrations of Fe(III) oxides begin accumulate at a depth of ca. 10 cm (see Fig. 1G), and may reflect the starting point for formation of massive iron concretions that are evident at and beneath the sediment surface (Fig. 1B-F). XRD and SEM-EDS revealed that the consolidated sediments and concretions were composed primary of Fe(III) oxides (goethite and hematite), halite, and quartz. MPN analyses revealed low (10-100 cells/mL) but detectable populations of aerobic, halophilic Fe(II)-oxidizing organisms on the sediment surface and in the near-surface ground water. With culture-dependent methods at least three different halotolerant lithoautotrophic cultures growing on Fe(II), thiosulfate, or tetrathionate from different acidic sites were obtained. Analysis of 16S rRNA gene sequences revealed that these organisms are similar to previous described gamma proteobacteria *Thiobacillus prosperus* (95%), *Halothiobacillus kellyi* (99%), *Salinisphaera shabanense* (95%) and a *Marinobacter* species. (98%). 16S rRNA gene pyrosequencing data from two different sites with a pH range between 3 and 4.5 revealed a dominance of gamma proteobacteria. 16S rRNA gene pyrosequencing libraries from both cores were dominated by sequences related to the *Ectothiorhodospiraceae* family, which includes the taxa corresponding to the pure culture isolates.

Conclusions: Our results suggest that microbial Fe(II) oxidation is a major biogeochemical process in the acidic and Fe-rich sediments of Lake Tyrrell, and may provide a model for how microbially-catalyzed Fe(II) oxidation under hypersaline conditions could occur in subsurface Martian environments.

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