FRESHWATER MICROBIALITES OF PAVILION LAKE, BRITISH COLUMBIA, CANADA – A LIMNOLOGICAL INVESTIGATION.

D. S. S. Lim[1], C. P. McKay[1], B. Laval[2], J. Bird and S. Cady[3], [1]NASA Ames Research Center, Building 245, Mail-Stop 245-3, Moffett Field, CA, USA 94035 (dlim@mail.arc.nasa.gov), [2]Department of Civil Engineering, University of British Columbia, 2324 Main Mall, Vancouver, BC, Canada V6T 1Z4, 3Department of Geology, Portland State University, 1721 SW Broadway, 17 Cramer Hall, Portland, Oregon, 97201.

Introduction & Background: Pavillion Lake is 5.7km long and an average of 0.8 km in width, and is located in Marble Canyon in the interior of British Columbia, Canada (Fig. 1). It is a slightly alkaline, freshwater lake with a maximum-recorded depth of 65m. The basin walls of Pavilion Lake are lined with microbialite structures that are oriented perpendicularly to the shoreline, and which are found from depths of 5 meters to the bottom of the photic zone (light levels 1% of ambient; approximately 30m depth). These structures are speculated to have begun formation nearly 11,000 years ago, after the glacial retreat of the Cordilleran Ice Sheet. They are likely a distinctive assemblage of freshwater calcite microbialites, which display micromorphologies possibly related to the ancient *Epiphyton* and *Girvanella* classes of calcareous organosedimentary structures [1].

The beautiful clear blue waters (Secchi depths of more than 15m) and microbialite structures of Pavilion Lake have made it a popular destination for recreational and commercial divers particularly over the months of May-October. Furthermore, the Pavilion First Nations Indian Band holds special heritage and spiritual connection to this lake and its surrounding land. As such, the lake was added to the Marble Canyon B.C. Provincial Park system on April 18, 2001 as a means of conserving and managing this biologically and historically important site.

Laval et al. [1] have classified the differing microbialite structures into four depth categories: those found at shallow to intermediate, intermediate, intermediate to deep, and deep facies. The microbial mounds found in the shallow to upper intermediate depths (5-10m) range from several centimeters to a few decimeters in height, and were noted to be covered by photosynthetic microbial communities and their calcified remains [1]. At the intermediate depth of approximately 20m, microbialite domes approximately decimeters to meters in diameter, and up to 3m in height were documented, and are likely the largest structures in the lake. At the lower intermediate to deeper depths of 20-30m, Laval et al. [1] state that the morphology of the microbialites can be described as a combination of “cone-shaped and leaf-life”. These structures are denser than those at the shallower depths and are typically 20-30cm in height, and decimeters to meters in diameter. The deepest characterized microbialites were found at depths of >30m. These structures were dense, centimeters to diameters in diameter, and at times capped by smaller cones that reached 5-10cm in height.

There is a variation of the mechanical strength of the structures with depth as well, which may reflect a change in the relative role of biotic and non-biotic precipitation with lowering light levels.

Description of Planned Study: Here we present our planned study of Pavilion Lake, which will comprise a combination of hypothesis and exploration driven research to study the lake’s unusual freshwater microbialite structures. The foundation for this proposed study is the seminal work by Laval et al. [1], which provides an overview of the morphological characteristics of the microbialites, and explores the physical limnology of Pavilion Lake. Several key hypotheses and questions related to the role of biology in the formation of the microbialites, and the effect of varying light levels on the microbialite morphologies have since resulted from Laval et al. [1], but to date remain untested and unanswered. Our plan is to revisit Pavilion Lake, and to conduct focused experiments to test two core hypotheses concerning the geobiological factors affecting the microbialite formation, and to collect further exploration data related to understanding the lake’s structure and development. In particular, we intend to (1) investigate the hypothesized biological origins of the microbialites, (2) investigate the hypothesized relationship between light attenuation and microbialite morphology in the lake and (3) further explore the physical, chemical and biological limnological properties of the lake, especially as these characteristics pertain to microbialite formation. Specifically, we will first investigate the hypothesis that photoautrophic algae are responsible for generating the carbonate structures in Pavilion Lake. Unpublished data from Dr. Imre Friedmann has shown that some of the microbialites from Pavilion Lake contain novel filamentous algae that appear to be intertwined with the carbonate at and below the surface of the structures. This algae was not identified in the initial assessment of the Pavilion Lake microbialites by Laval et al. [1], and is hypothesized to be a calcifying algae, which the control mechanisms triggering the carbonate precipitation, and ultimately driving the formation of the freshwater microbialite structures. Riding [2] lists trapped coarse grains, calcified cyanobacteria and subordinate skeletal encrusting eukaryotes as typically being the most recognizable components of a microbialite formation that could help elucidate the organisms and processes involved in their formation. We propose test our hypothesis by way of microscopy (light and scanning electron (SEM)) investigations, cell cultures and carbon isotopic analyses.

Secondly, we will test the hypothesis that microbialite morphological variation in Pavilion Lake is controlled by the increase of photosynthetically active radiation (PAR) attenuation with depth. Prior to the Fall seasonal turnover of Pavilion Lake, Laval et al. [1] recorded a decrease of PAR by approximately one order of magnitude per 10m increase in depth. Observational data indicate that the changes in microbialite morphology with depth seem to track these variations in light attenuation (McKay pers. comm..). If the carbonate formations are driven by oxygenic photoautotrophic activity, then it is likely that the attenuating light would result in a decrease of metabolic activity in the algal communities with depth. Hence slower carbonate precipitation and microbialite development in the deeper facies could result in microbialite morphologies different than those in the shallower photic regions of Pavilion Lake. Zooplanktonic grazing activity may also be affecting microbialite structural development, however their prevalence is likely constrained to the warmer, more productive shallows of the lake, and probably declines rapidly with increasing depth, and decreasing light and temperature.

We will be measuring annual fluctuations in light and temperature at the distinct depth classifications of the lake, and collecting observational ecological data (e.g. prevalence of grazing populations around microbialites). We will relate these data to variations in lake consortium populations.

Finally, to better understand the geochemical influence of the lake water on the development and preservation of the microbialites, we intend to conduct exploratory activities to further characterize the physical, chemical and biological characteristics of Pavilion Lake. We propose the following approach: (1) thoroughly mapping the extent and morphology of the microbialites with Pavilion Lake; and (2) describing the Pavilion Lake basin-scale environment in which the formations are found using conventional limnological techniques.

Collecting and analyzing interferometric sonar data will produce a bathymetric map of Pavilion Lake. From this map, identification and characterization of microbialite structures will be possible with respect to both depth, and distribution. This will also help to pinpoint areas of interest for further investigation, as the accuracy to which multi-angle swath bathymetry sonar can establish position of the microbialites is very high.

Sonar research conducted during the study at Pavilion Lake will focus not only on establishing the acoustic diversity of the microbialite structures themselves, but will include analysis of their surrounding bottom conditions. The goal of the bottom classification will be to determine any influences of environmental factors such as algae ground coverage and proximity to water seeps on the pattern of distribution and morphology of the microbialite structures. Through continued monitoring of the lake, long term impact on the bottom due to activities on the lake, such as anchoring boats, diving or troll fishing, as well as the impact of rubble from slides, will be quantitatively assessed.

Preliminary results from our first reconnaissance and sample collection trip to Pavilion Lake in August 2004 will also be discussed in our poster presentation.

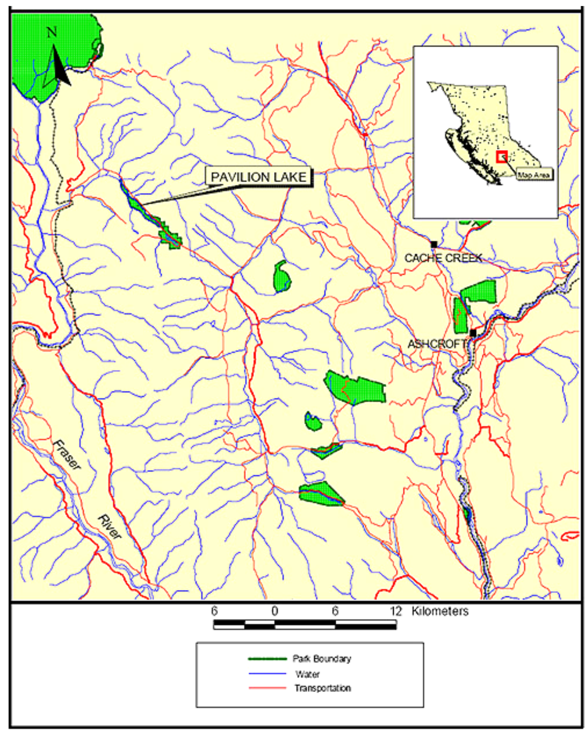

Figure 1. Map showing location of Pavilion Lake in the province of British Columbia, Canada. (Modified from BC Parks Management Direction Statement [3])

References: [1] Laval, B., S.L. Cady, J.C. Pollack, C.P. McKay, J.S. Bird, J.P. Grotzinger, D.C. Ford, and H.R. Bohm, 2000. *Nature*, 407, 626-629, [2] Riding, R., 2000. *Sedimentology*, 47: 179-214, [3] Management Direction Statement for Pavilion lake, Marble Canyon Park, March 2003,http://wlapwww.gov.bc.ca/bcparks/planning/mgmtplns/marble_cyn/pavilion_mds.pdf