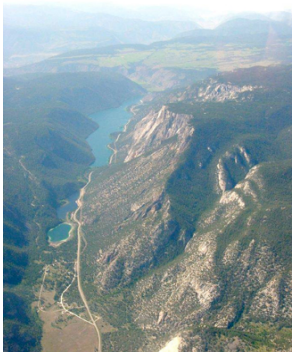
PLRP DEEPWORKER DEPLOYMENT 2008 – SCIENCE PLAN

PROJECT EXECUTIVE SUMMARY: The deployment of DeepWorker submersibles into Pavilion Lake, Canada (50°51'57"N, 121°44'20"W), presents a unique opportunity to advance the long-term objective of human exploration of the Moon and Mars. By combining rigorous scientific research on life in extreme environments with high fidelity training in an underwater, remote field setting, this will serve to inform the knowledge base, tools and techniques of future human missions to the Moon, Mars and beyond.

2008 FIELD DATES
June 21-July 11, 2008
(DeepWorker deployment from June 23-July 3)

NASA Field Participants
Darlene Lim - NASA ARC/SETI
Chris McKay - NASA ARC
Michael Gernhardt - NASA JSC
Alfonso Davila - NASA ARC/SETI
Patricia Montgomery - NASA ARC



Pavilion Lake, BC, Canada

DEEPWORKER SCIENCE PLANS:

Justification for use of DeepWorkers to meet PLRP science goals:

- SONAR suggests lake bottom is covered in microbialites, however, ground-truthing of sonar imaging data from Pavilion Lake has not been accomplished, as such, the extent and variability of deepwater microbialites is not yet known.
- Further, the inability to directly access deepwater microbialites means that very limited information has been obtained on their morphology, relationship to environmental factors (e.g. temperature, light, water geochemistry) and chemical/isotopic characteristics. Understanding these variations is fundamental to understanding the mechanisms and timing of microbialite formation.
- The deep regions of Pavilion Lake are too large and deep to explore and sample efficiently and safely using conventional SCUBA, and remote (SONAR) data provide limited interpretation.
- Solution:

  DeepWorker submersibles will help PLRP members reach our science goals by using an exploration mechanism consistent with the following requirements for exploring pristine, vulnerable, astrobiologically relevant environments:

  1. Safety
  2. Environmental Stewardship
  3. Relevant Science
  4. Advancing Human Exploration

PLRP Science Objectives:

The PLRP is a NASA-UBC led multi-disciplinary initiative (see http://supercritical.civil.ubc.ca/~pavilion/ for more information). Project members have been conducting science and exploration activities in the Pavilion Lake region since 2004. The primary funding for this project comes from the Canadian Space Agency, with additional financial contributions from NASA, the National Geographic Society, McMaster University and Nuytco Research.

The overarching goal of the PLRP is to understand the mechanisms of formation of the unique microbialites in Pavilion Lake and the potential for associated biosignatures. This understanding will contribute to astrobiology research by providing the basis for interpretation of similar organo-sedimentary structures either on early earth (e.g. stromatolites) or potentially on other planets.

The following is a list of the on-going PLRP science objectives:

1. General Limnology of Pavilion Lake and surrounding water bodies
   - Chemical and Physical characteristics
   - Stable Isotopic (C, O, H) characterization; carbon-sources; groundwater-provenance
   - Water budget and balance
2. Microbial influence on carbonate formation
   - Isotopic tracers of inorganic and organic carbon sources
   - Microscopy and molecular characterization
3. Microbialite mapping
   - Lateral and Vertical variability
   - Correlation with environmental factors (e.g. groundwater inputs, light)
4. Contextual comparison to other microbialite/carbonate rich lakes.
5. Determine the spectral (visible to thermal infrared) and erosional properties of the carbonates.

DeepWorker deployment in Pavilion Lake will directly support PLRP Science Objectives 2 and 3.

Summer 2008 Field Activities - DeepWorker Submersibles: Analog Science Missions
Dates: June 21-July 11, 2008. We will be

NASA Field Participants

Dr. Darlene Lim - NASA ARC/SETI (PLRP PI)
Dr. Chris McKay - NASA ARC (PLRP Science Advisor)

Dr. Michael Gernhardt - NASA JSC
Dr. Alfonso Davila - NASA ARC/SETI
Patricia Montgomery - NASA ARC (PLRP E/PO Lead)

DeepWorker 2008 Science Plans:

Contribution to Microbialite Mapping - Science Objective 3

To address our mapping goals, we will carry out the following science plan during the 10-day excursion to Pavilion Lake from June 23-July4, 2008:

1. Contour Mapping:
   To understand the spatial coverage and variability of microbialites in Pavilion Lake, DeepWorker transects at set contour depths will be carried out. Still and digital photographic data, and GPS data will be compiled. Transect coverage will be by 10m intervals (i.e. 5 m, 15 m, etc… Note: these are nominal depths – actual operating depths are to be determined based on SONAR data), and grouped as follows for the purposes of designating teams to each task:
   - Shallow contours – 5 and 15 m
   - Intermediate contours – 25 and 35 m
   - Deep contours – 45 and 55 m

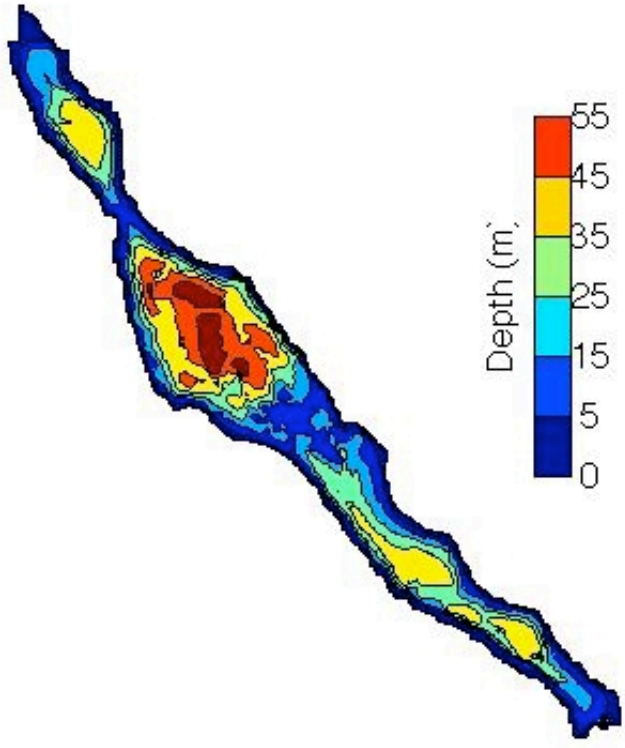


Figure 1. Pavilion Lake with contours at 5, 10, 15, 25, 35, 45, and 55 m.

2. Basin Mapping:
    - The deepest regions of Central (40-60m), North (30-40m), South basin (30-40m) will be photographed, and mapped for unusual and interesting features

3. 'Bioherm' Mapping:
Bioherms have been identified in several portions of the lake. This includes the large bioherms visible from the surface in the Central basin, and smaller bioherms identified through SONAR and drop camera data at 35 - 55 m depths in the Central and North Basins of Pavilion Lake. Other potential bioherms have been identified through SONAR data throughout the lake.

Using DeepWorkers, we will:
    - Visually document, and map the known bioherms through top-to-bottom contours,
    - Ground truth SONAR data of potential bioherms,
    - Similarly map any newly discovered bioherms,
    - Ensure that groundwater inputs, faults, etc are documented and mapped

4. Groundwater Inputs:
Any identified groundwater inputs will be carefully visually documented and GPS coordinates will be recorded for these important features.
    - Detection of groundwater inputs via temperature and chemical differences identified via a CTD installed on the DeepWorker and operated during mapping exercises
    - Combine investigation of these identified sites with the UBC GAVIA AUV to further interpret GAVIA results
    - Provide indicators of groundwater inputs that may be further investigated using GAVIA

5. Photography of any visible salinity and thermal boundaries

6. Mapping of rock debris flows throughout lake

7. Vertical transects along identified regions of interest:
    - Vertical transitions are likely going to be important in attempting to link macro-scale morphology with environment.

Contribution to Microbial Influences on Carbonate Formation – Science Objective 2

Distinguishing between mechanisms (abiotic versus biotic) of microbialite formation is crucial to the interpretation of biosignatures that may be preserved in similar structures on the early earth or other planets such as Mars.

Results of natural abundance isotope analysis (^{13}C, ^{14}C) of currently accessible (< 35 m deep) microbialites indicate the potential for input of carbon from regional groundwater to Pavilion Lake dissolved inorganic carbon (DIC) as well as to the microbialites themselves. The results obtained for the single, small deepwater sample obtained (> 35 m) indicates that the proportion of old carbon is greater for this sample. This suggests variability in the carbon inputs to the deep portions of the lake or differences in the time of microbialite formation within the lake.

DeepWorkers will enable:

1. Direct sampling of deep microbialites (40 + m), which will allow for the:
    A. Characterization of microbial community structure and isotopic indicators of metabolic activity at these depths
    B. Identification of isotopic constraints on carbon sources for the microbial communities and microbialite carbonate
    C. Correlation of isotopic samples to mapping of geochemical and light conditions
    D. Ultimately, constraint of the growth mechanisms and rates of microbialite structures

2. The photo and video documentation, and mapping of sites of interest for future detailed sampling. Data gathered about microbialite morphology variability and distribution will be most useful to the science community if it can be clearly linked with internal morphology, and local and lake-wide geochemistry.

Images from May 2008 PLRP DeepWorker Training Session in Vancouver

NASA Astronaut Dr. Michael Gernhardt preparing for launch in DeepWorker submersible (May 2008; photo credit: L.Stang)

Dr. Darlene Lim preparing for launch in DeepWorker submersible (May 2008; photo credit: L.Stang)

(May 2008; photo credit: L.Stang)