FINAL DRAFT

Life in Extreme Environments

(Origin and Evolution of Life on Earth and Elsewhere)

Yellowstone National Park

4-7 August 2005

Science Themes

1. **Chemistry of Life**
   - **Chemosynthetic mode of life**
   - **Energy fluxes required to support life**
   - **Thermodynamic requirements of cells and their components**
   - **Prebiotic ingredients necessary for life**
2. **Microbial Ecology**
   - **Limits of life: Temperature, alkalinity and acidity**
   - **Ecosystems in Yellowstone**
   - **How we study the diversity of life: 'extremophiles' and in the deep biosphere**
3. **The Origin of Life in Hydrothermal and Subsurface Environments**
   - **Thermodynamics of hydrothermal systems: Why is it an attractive lunchbox?**
   - **Organismal adaptation (behavioural and physiological) to hydrothermal and subsurface systems**
4. **Life-Supporting Environments Elsewhere**
   - **Exploring organic chemistry in our solar system (Mars, Europa, Titan, comets, meteorites),**
   - **Sources of prebiotic ingredients in our Solar System**
   - **Evaluating the potential for environments to support life on other planets and moons**
   - **Astrobiology missions concepts (MRO launch is next August --currently slated for August 5)**

Science Personnel:
Tom McCollom (CU)
Norm Pace (CU)
Corien Bakermans (MSU)
Dave Des Marais (NASA Ames)
Ken Nealson (JPL)
Steve D'Hondt (URI-GSO)
Anna-Louise Reisenbach (Portland State University)

Other Personnel:
Emily CoBabe-Ammann (CU)
Kate Becker (CU)
Catherine Tsairides (NASA Ames)

Preliminary Agenda

Thursday, August 4th (West Yellowstone)

- Participants and scientists arrive into Bozeman Airport with shuttled down to West Yellowstone
- Rendezvous at the Days Inn, West Yellowstone
- Dinner on your own
- ***Welcome and Evening Talk (7:30): Mud volcanoes, sulfur springs and geyser basins: Why do we want to see, touch and smell life here? (Emily CoBabe-Ammann)[Starlight Room, Days Inn]***

Friday, August 5th (Yellowstone National Park)

- 7:00 Breakfast at the Days Inn
- 8:30-10:00: ***What is life? And what is the Chemistry of Life in an Extreme Environments? [Starlight Room, Days Inn]***
  - **What is life? (David Des Marais)**
  - **The thermodynamics of chemosynthetic life (Ken Nealson)**
  - **The effects of temperature on life (Corien Bakermans)**
  - **The interchange between life and its geochemical environment (Steve D'Hondt)**
- 10:15: Leave hotel and head into YNP
- West Yellowstone to Norris (1 hour) MILE 0.0
- 11:15: **Norris Junction** (2.5 hours) MILE 26.5
  - **Field Talks (30 minutes)**
    - **Diversity of Life (Norm Pace)**
    - **Metabolism and thermodynamics of hot spring living (Anna-Louise Reysenbach)**
    - **Geochemistry of Yellowstone hot springs (Tom McCollom)**
  - **Field sights: steams pools, run-off channels, geysers (1 hour)**
    - **Group Leads: 1) Anna-Louise Reysenbach and Tom McCollom, 2) Norm Pace and Steve D'Hondt, 3) Dave Des Marais and Ken Nealson**
  - Field lunch
- 1:45: Leave Norris
- Norris to Grand View (30 minutes) MILE 40.1
- 2:15: **Grand View** (1 hour)
  - **Field Sights: Cross-section of the subsurface exposed (opportunity to see what's below the surface of hot springs).**
  - Head to the Vista (15 minutes)
  - **Field Talk: Fluid-rock interactions and origin of hot spring fluids (D'Hondt) (20 minutes)**
  - Head down to the Falls and meet up with vans at the end of the trail. (25 minutes)
- 3:15: Leave Grand View
- Grand View to Mud Volcano (15 minutes) MILE 49.6
- 3:30: **Mud Volcano** (1 hour)
  - **Field sights: Sulfur-rich pools, substantially different than those at Old Faithful, Grand Prismatic** (Saturday)

    - **Field Talk: The diversity of chemistry and microbial life in Yellowstone hot springs (Pace) (20 minutes), followed by The diversity of cold-adapted organisms (Bakermans)**
- 4:30: Leave Mud Volcano for Lake Area (10 minutes) MILE 56.9
- 5:00: Arrive Lake Village – Check-in, Get keys
- Dinner at 5:15 at Lake Yellowstone Hotel Dining Room
- ***Evening Talk (8:00)[Lake Conference Room at the Lake Yellowstone Hotel]***
    - ***How to Search for and identify life (Ken Nealson)***
    - ***Mars Ecosystems and Evaluating Life-Supporting Supporting Environments Elsewhere (Dave Des Marais)***

Important Note: Vans will be available to take you from the Hotel to the cabin area after the talks. If you stay to have a drink at the bar, make sure that you come back in groups to avoid a run in with the bison!

Saturday, August 6th (Yellowstone National Park)

- Breakfast at the Lake Lodge Cafeteria
- 8:00-10:00: ***The Origin of Life in Hydrothermal and Subsurface Environments [Lake Conference Room, Lake Yellowstone Hotel]***
  - **Nealson [What phylogeny tells us about the origin of life?? Hydrothermal/subsurface environments on the early Earth??]**
  - **D'Hondt [Life in the deep subsurface]**
  - **Hydrothermal systems as a possible site for the origin of life (McCollom)**

- 10:15: Leave Lake Yellowstone Hotel
- Lake Village to Lower Geyser **(Sentinel Meadows)** (1.5 hours) MILE 117.6
- 11:45: **Lower Geyser Basin (Sentinel Meadows)** (4 hours)
  - Field lunch
  - **Lunch Talk:**
    - **Chemical gradients & life (Ken Nealson)(20 minutes)**
    - **Geochemical control of community composition (Norm Pace and Anna-Louise Reysenbach) (40 minutes)**
  - Hike out to initial stop
  - **Field Sights: Close look at hot springs at several sights during hike (Tom McCollom)**

- 3:45: Leave Lower Geyser Basin
- Lower Geyser Basin to Grand Prismatic (15 minutes) MILE 123.6
- 4:00: **Grand Prismatic**
  - Walking tour (30 minutes)
- 4:30: Leave Grand Prismatic
- Grand Prismatic to Old Faithful (15 minutes) MILE 131.0
- 4:45: **Old Faithful**
  - Free time to see Old Faithful, walk the board walk, shop, etc.
  - ***Dinner at Old Faithful Inn (Dinner at 5:30) (9 tables of 4)***
- 8:30: Vans leave Old Faithful for Lake Lodge cabins MILE 168.5

Sunday, August 7th (Yellowstone National Park)

- Breakfast at Lake Lodge Cafeteria on your own
- 8:00-9:30 **Wrap-Up: Life in Extreme Environments and the Search for Life in the Solar System (McCollom, Des Marais et al) [Lake Conference Room, Lake Yellowstone Hotel]**
  - **Summary of Key Points**
  - **Discussion on the potential for hydrothermal/subsurface habitats on the early Earth, Mars, Europa, and Titan**
- 9:30-11:00 **What stories aren't we telling? (Yulsman, CoBabe-Ammann)**
  - **What should the next workshops be?**
- Workshop ends at 11:00.
- 12:00: Transportation to Bozeman for those leaving
- 12:00 – through afternoon: **Optional Field Trip: Geology of the Yellowstone Caldera [see separate itinerary]**
- 6:00: Arrive in West Yellowstone, Dinner on the town….