



Project Report: Delivery of Organic Materials to Planets

Focus Group Chair(s): A. D. Anbar, R. Buick, S. J. Mojzsis

Focus Group Description & Activities

The search for life beyond Earth requires some concept of the conditions under which life originates and begins to evolve, and of the environmental "fingerprints" of primitive biospheres. This concept must be informed by a solid understanding of the only planet on which life is known to exist—the Earth. Hence, study of life and the environment on the early Earth is a critical component in developing mission plans for astrobiology space missions. This is the underlying rationale of the Mission to Early Earth (MtEE) Focus Group.

Background

The further back in time one goes in examining the conditions on early Earth, the sparser the geologic record becomes. Furthermore, the quality of material easily available is not high—particularly when the interest in environmental and biological history leads to a focus on biogeochemical signatures that are vulnerable to oxidation and other alteration processes at Earth's surface. From the earliest discussions among the MtEE Focus Group members, a consensus emerged that progress in "bio-environmental reconstruction" is fundamentally sample limited. This consensus in the community led directly to the idea that the MtEE Focus Group might be most useful as a means to promote, provide justification for, and identify support for the acquisition and distribution of samples from the Precambrian, with a special emphasis on deep drilling to acquire pristine sediment samples from the near subsurface (< 1,000 m).

This activity has the potential to stimulate participation and collaboration from across the Institute, one of the benefits of the NAI focus groups as originally conceived by its director. In addition, these kinds of sampling activities can provide opportunities to test technologies that might prove useful in future Mars exploration. The projects under development by the MtEE Focus Group should, in particular, provide information useful in the development of the Terrestrial Planet Finder (TPF) mission, by elucidating the history of oxygenic photosynthesis and the oxygenation of the atmosphere. This will help in the interpretation of future spectroscopic analyses of the atmospheres of extrasolar planets.

A guiding principle of the MtEE Focus Group is that precious samples obtained by communal NAI-sponsored efforts should be carefully archived and made available to the research community. In this way, the Focus Group hopes to stimulate the development of a vigorous, collaborative, multidisciplinary sampling-and-research enterprise similar to that of the Ocean Drilling

Program and NASA's lunar sampling and meteorite collection operations.

Activities:

Summer 2001: With support from the NAI, the first major activity of the MtEE Focus Group was to organize a field expedition for the summer of 2001 to Western Australia. This general area of Australia is one of the few places on Earth with well-preserved sediments (including biosignatures) from the Archean, that is, the period before 2.5 billion years ago (2.5 Ba) –the first half of Earth history. As a result, a number of exciting, astrobiologically-relevant publications have emerged recently from research into this region.

The MtEE expedition had two "legs". One was to the Jack Hills region under the guidance of Steve Mojzsis (University of Colorado Team); its primary goal was to obtain samples from the earliest geologic record. The second visited the Pilbara, under the guidance of Roger Buick (University of Washington Team); its primary goal was to become familiar with the local stratigraphy and astrobiologically-relevant localities in order to develop concepts for a pilot astrobiology drilling project. These legs ran in parallel between 1 July and 15 July, meeting for several days to visit classic localities in the Pilbara.

A total of 16 researchers participated. They were from the teams of Harvard University, Pennsylvania State University, the University of Washington, The California Institute of Technology/Jet Propulsion Laboratory, the NASA Johnson Space Center, and the Spanish Centro de Astrobiologia (CAB). Also included were researchers from Curtin University (Australia) and the Australian National University, and a non-NAI researcher from the University of Chicago. Three Ph.D. students were involved, and one NAI post-doctoral fellow. Following the field work, several participants attended the Astrobiology Workshop at Macquarie University sponsored by the Australian Centre for Astrobiology, an NAI Affiliate Member.

Fall 2001: Based on the summer 2001 field expedition, the Focus Group developed a pilot project plan for drill core sampling in the Pilbara (details below). To publicize the objectives of the MtEE Focus Group in general, and this plan in particular, and to solicit feedback from the geoscience community, a poster presentation was developed and presented at the annual meeting of the Geological Society of America (Boston, Oct. 2001) and the fall meeting of the American Geophysical Union (San Francisco, Dec.2001). Feedback was strong and overwhelmingly positive, and earned notice in a news report in *Nature* ((2001). Cores set to unearth hole picture of evolution. *Nature* 414: 476).

Winter, 2001/2002: A formal pilot drilling project proposal was prepared and submitted to the NAI, and also to the International Continental Drilling Program (ICDP). The proposed drill hole would be collared in the lower Dales Gorge Member of the Brockman Iron Formation, lower Hamersley Group. It would be about 1,000 meters deep, sampling about 200 million years of late Archean geological history. This is a critical interval of time, shortly preceding the apparent "Great Oxidation Event" ca. 2.2 billion years ago. Analyses of samples from this core would provide the following Archean

paleoenvironmental and paleobiological information:

- Banded iron formations of the Brockman and Marra Mamba Formations would shed light on Archean ocean chemistry and the oxygenation history of the oceans.
- Black shales of the Mt. McRae, Mt. Sylvia, and Jeerinah Formations, and the Bee Gorge, West Angelas and MacLeod Members of other formations, would shed further light on Archean ocean chemistry;. organic biomarkers from these sediments would provide unique information about biology in the Archean.
- Carbonates of the Wittenoom Dolomite would give insight into the functioning of the carbon cycle, and hence climate, during this time.
- Meteorite impact horizons in the Dales Gorge, Bee Gorge and Roy Hill Members present an opportunity to study the effects of impacts on Archean ecosystems.

Spring 2002: A presentation on these activities was given at the Astrobiology Science Conference (NASA Ames, April 2002). In addition, representatives of the MtEE Focus Group initiated contacts with Russian and Scandanavian colleagues about possible future projects focusing on the Paleoproterozoic oceans.

Focus Group Description & Activities

Previous activities and accomplishments:

1. First Focus Group meeting held at fall (Dec.) 2000 AGU Meeting in San Francisco. Attended by ~ 20 people.
2. Second Focus Group meeting held at 2001 Astrobiology Annual Meeting in Washington, D.C. April 2001. Attended by ~ 75 people.
3. Organized Australian excursion, planned for summer 2001. Funding approved by NAI Central.

Year 4 activities and accomplishments:

1. Conducted Australian excursion over 10 days in July 2001. A total of 16 researchers participated, including NAI members from the Harvard, PSU, UW, UC, Caltech/JPL and JSC teams, and from the Spanish affiliate. Also included researchers from Curtin U. and the ANU in Australia, and a non-NAI US researcher from the University of Chicago. Three Ph.D. students were involved, and one NAI post-doctoral fellow. Participants divided into two groups to conduct field surveys of two regions. Details in prior section. Following field work, some participants attended the Astrobiology Workshop sponsored by the Australian Astrobiology affiliate in Sydney.
2. Based on field work, developed plans for a pilot drilling project in Western Australia. Proposed project would recover about 1,000 m of sediment core. Analyses of target sediments would provide information on environmental conditions and ocean

- biology shortly before the rise of oxygen.
3. To advertise activities and solicit feedback from the research community, pilot drilling plans were presented at the annual meeting of the Geological Society of America (Oct. 2001, in Boston) and at the fall meeting of the American Geophysical Union (Dec. 2001, in San Francisco). At both meetings, a poster presentation was given as part of the regular meeting sessions (PDF file appended).
 4. Based on GSA poster presentations, activities were reported in a news item in *Nature* in November 2001 (PDF file appended).
 5. Presentation about pilot project was made at the December 2001 meeting of the NAI Executive Council.
 6. Formal proposal for funding of pilot project as an MtEE Focus Group activity was submitted in early February 2002.
 7. Update of pilot project plans provided at Focus Group ?break out? session at 2002 Astrobiology Science Conference, NASA Ames Research Center..
 8. Initiated exploration of collaboration with researchers in Russia and Finland to sample sediments from the early Proterozoic. Discussions initiated by at Russian Astrobiology Workshop in March 2002, and during visit to Finland in June 2002.

Highlights

- MtEE Focus Group travels to Western Australia to plan drilling project.
- MtEE Focus Group presents sampling plans at 2001 meetings of the GSA and AGU.
- MtEE Focus Group proposes sampling plan to study life in ancient oceans.

Mission Involvement

Mission Class*	Mission Name (for class 1 or 2) OR Concept (for class 3)	Type of Involvement**
2	TPF	Background research

- * Mission Class: Select 1 of 3 Mission Class types below to classify your project:
1. Now flying OR Funded & in development (e.g., Mars Odyssey, MER 2003, Kepler)
 2. Named mission under study / in development, but not yet funded (e.g., TPF, Mars Lander 2009)
 3. Long-lead future mission / societal issues (e.g., far-future Mars or Europa, biomarkers, life definition)

**** Type of Involvement = Role / Relationship with Mission**
 Specify one (or more) of the following: PI, Co-I, Science Team member, planning support, data analysis, background research, instrument/payload development, research or analysis techniques, other (specify).

A rational search for life beyond Earth requires some concept of the conditions under which life originates and begins to evolve, and of the environmental "fingerprints" of primitive biospheres. This concept must be informed by a solid understanding of the only planet on which life is known to exist– the Earth. Hence, the study of life and the environment on early Earth is a critical component in developing mission plans for Astrobiology space missions. This is the underlying rationale of the Mission to Early Earth Focus Group.

The projects under development by MtEE should provide information useful in particular to development of the Terrestrial Planet Finder mission, by elucidating the history of oxygenic photosynthesis and the oxygenation of the atmosphere.

Field Expeditions

Field Trip Name: MtEE Australia Expedition ?01

Start Date: 07/01/2001	End Date: 07/02/2001
Continent: Australia	Country: Australia
State/Province: Western Australia	Nearest City/Town: Port Hedland
Latitude: N	Longitude: W
Name of site(cave, mine, e.g.):	Keywords:

Description of Work: Survey of opportunities for drilling project, Pilbara region; exploration for samples of earliest Earth crust, Jack Hills region.

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