



NASA ASTROBIOLOGY INSTITUTE
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Focus Groups: Mission to Early Earth

Focus Group:	<i>Mission to Early Earth</i>
Project Title:	<i>Mission to Early Earth</i>
Chairs:	<i>Ariel Anbar , Roger Buick , Stephen Mojzsis</i> [view project member list]

Project Progress

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 Early Earth Focus Group.

Background

The geologic record is increasingly sparse as one examines the conditions on the early Earth further back in time. Furthermore, the quality of material easily available is not high – particularly when interest in environmental and biological history leads to a focus on biogeochemical signatures that are not robust against oxidation and other alteration processes at the Earth's surface. From the earliest discussions among the 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 concept that the Early Earth 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 focus on deep drilling to acquire pristine sediment samples from the near subsurface (1000 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 types of sampling activities can provide opportunities to test technologies that might prove useful in future Mars exploration. The projects under development by the Focus Group should, in particular, provide information useful in the development of the Terrestrial Planet Finder mission, by elucidating the history of oxygenic photosynthesis and the oxygenation of the atmosphere. This will help in the interpretation of future spectroscopic examination of the atmospheres of extrasolar planets.

A guiding principle of the 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.

Hamersley Hole

In the first two years of the Focus Group, we developed plans for a specific drilling project in late Archean rocks of the Hamersley Basin, Western Australia, as the first step in a proposed "Deep Time Drilling Project". The goal of this project is to obtain clean core for biosignature and geochemical analysis to better understand the early evolution of life and its habitat during this critical time. In addition, this project will test the feasibility of a broader stratigraphic drilling program in Precambrian basins globally. A secondary drilling project is planned in the early Archean, sampling across the oldest land surface (the Warawoona-Coonterunah unconformity, ~ 3.5 Ga). Initial funding for the Hamersley core has been committed by the NAI as part of the Astrobiology Drilling Program.

The planned hole will be collared in the lower Dales Gorge Member of the Brockman Iron Formation, lower Hamersley Group. The site selected will be in the lowest metamorphic grade and least deformed part of the basin, along the front of the Hamersley Range. The hole, obtained using hydrocarbon-free diamond drilling techniques, will be about 1000 meters deep, drilling down to the uppermost flood-basalt of the Maddina Formation in the upper Fortescue Group. Hence, it will sample ~ 200 million years of late Archean geological history. It will pass through rocks providing the following types of data:

- Kerogenous black shales of the Mt. McRae, Mt. Sylvia, and Jeerinah Formations, and the Bee Gorge, West Angelas and MacLeod Members of other formations. This will provide material for analyses of $^{13}\text{C}_{\text{organic}}$, $^{34}\text{S}_{\text{sulfide}}$, redox-sensitive metal abundances and isotopic compositions, and hydrocarbon biomarkers;
- Banded iron formations (BIFs) of the Brockman and Marra Mamba Formations, shedding light on what controls the inception and cessation of BIF deposition;
- Carbonates of the Wittenoorn Dolomite, providing material for $^{13}\text{C}_{\text{carbonate}}$, $^{34}\text{S}_{\text{sulfate}}$ and other isotopic tracers;
- Meteorite impact horizons in the Dales Gorge, Bee Gorge and Roy Hill Members, providing fresh samples for determining target geology and impactor composition.

Core materials will be analyzed for these and other tracers, and ultimately made available to the research community.

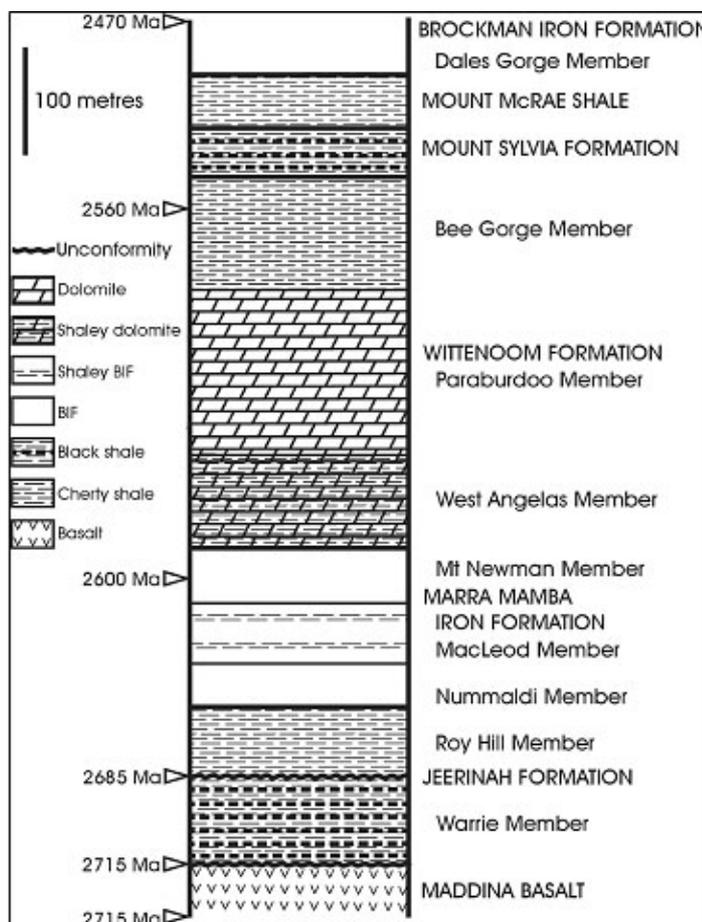


Fig. 1. Stratigraphic section to be sampled by the Hamersley drill core of the Early Earth Focus Group

Such research on some of the least-altered sediments of the late Archean will provide unique insight into: the rise of atmospheric oxygen and the oxygenation of ancient oceans; the chemical composition of ancient oceans; long-term global temperature regulation; the impact history of the early Earth and its effect on evolution; and the radiation of life, as recorded in molecular hydrocarbon biomarkers in carbonaceous sediments and stable isotope records.

The primary activity of the group during Year 5 was to develop plans for smooth integration of this drilling project into the newly formed Astrobiology Drilling Program (ADP). The Hamersley drill core of the Focus Group is presently planned for Summer 2004, as part of the ADP's efforts. A brief overview of the ADP is given below.

The Astrobiology Drilling Program

The Astrobiology Drilling Program (ADP) of the NASA Astrobiology Institute (NAI) is an initiative that aims to coordinate the activities of participating drilling projects, some of which may require supplementary support from the NAI. The ADP will be administered by NAI and directed by a steering committee that includes representation from current and former project leaders, the astrobiology community, and persons appointed by the NAI Director.

Appropriate participants from field site host countries will also be invited. Participating projects will be presented to the astrobiology research community prior to drilling so that scientists who are not members of the project team may register their interest in associated samples. Requests for access will be transmitted to the ADP steering committee and to the relevant project's lead. This creates an opportunity to modify the drilling plan in light of community requests. NAI funding may be available to support such modifications. Members of the original project team will retain privileged access to their core samples, nominally for one year from the time the core becomes available to them. If requests involve investigations that are not part of the original plan, the project leader may grant immediate access to core samples for specific purposes within this proprietary period. Archival of the drill cores is to be addressed, including the applicable national policies of host countries.

The ADP's efforts at collaborative distribution and analysis of materials are anticipated to generate increased productivity for participating drilling efforts. Individual projects will benefit from the opportunity to optimize and expand their objectives. Overall, the determined leveraging of projects will benefit the community scientifically and demonstrate a unity of purpose influential with funding sponsors. Two projects have adopted the ADP; the Deep Time Drilling Project initiated by the NAI's Early Earth Focus Group and the Archean Biosphere Drilling Project led by Dr. Munetomo Nedachi. These two groups are committed to working with each other, and with the broad astrobiology community.

Focus Group Description & Activities

A primary activity of Year 5 was development of plans to integrate the planned drilling activities of the Early Earth Focus Group into the Astrobiology Drilling Program (ADP) of the NAI. The latter program is in many ways an outgrowth of the Focus Group's activities. It will serve as an "umbrella" for collaborative early Earth sampling activities under NAI auspices. Focus Group leadership also played a key role in formulating policies for the ADP.

In the coming year, we anticipate intense activity raising external funds to conduct research on the anticipated drill core sampling; initiation of detailed logistical planning for sampling in Summer 2004; and continued work with the NAI Director to develop the ADP as a program that will facilitate both sampling and outreach to the broader astrobiology community.

Highlights

- NAI Astrobiology Drilling Program emerges as an outgrowth of Focus Group activity.

Roadmap Objectives

- [**Objective No. 4.1: Earth's early biosphere**](#)
- [**Objective No. 4.2: Foundations of complex life**](#)
- [**Objective No. 4.3: Effects of extraterrestrial events upon the biosphere**](#)
- [**Objective No. 5.1: Environment-dependent, molecular evolution in**](#)

[microorganisms](#)

- [Objective No. 7.1: Biosignatures to be sought in Solar System materials](#)

Mission Involvement

<i>Mission Class*</i>	<i>Mission Name (for class 1 or 2) OR Concept (for class 3)</i>	<i>Type of Involvement**</i>
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).