FINAL TECHNICAL REPORT

PROJECT TITLE:

Support for the 1999 Precambrian Paleobiological Workshop "Bridging Two Worlds: From the Archean to the Proterozoic," February 18-20, 1999

PRINCIPAL INVESTIGATOR:

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AGENCY NAME:

National Aeronautics and Space Administration
Exobiology Program

GRANT:

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DATES:

04/01/99-03/31/00

Precambrian paleobiology workshop

BRIDGING TWO WORLDS: FROM THE ARCHEAN TO THE PROTEROZOIC

February 18-20, 1999

IGPP Center for the Study of Evolution and the Origin of Life

University of California, Los Angeles

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WORKSHOP STRUCTURE AND GOALS

ORGANIZING COMMITTEE

Sherwood Chang, David DesMarais, John Grotzinger, Dick Holland, Jim Kasting, Andy Knoll, and Bill Schopf (Chair).

FORMAT

This was a "Gordon Research Conference-type" workshop: NO subsequent attribution of ideas presented. NO resultant publication. NO tape recordings. Attendance by invitation only.

WORKSHOP FOCUS AND GOALS

As now known, the Archean and Proterozoic appear to have been different worlds -- the ***geology*** (tectonic style, basinal distribution, dominant rock types), ***atmospheric composition*** (O_2, CO_2, CH_4), and ***surface environment*** (day-length, solar luminosity, ambient temperature) all appear to have changed over time. And virtually all paleobiologic indicators can be interpreted as suggesting there were significant biotic differences as well:

- ***Stromatolites*** older than 2.5 Ga are rare relative to those of the Proterozoic; their biotic components are largely unknown; and the biogenicity of those older than ~3.2 Ga has been questioned.
- Bona fide ***microfossils*** older than ~2.4 Ga are rare, poorly preserved, and of uncertain biological relations. Gaps of hundreds of millions of years in the known record make it impossible to show that Archean microorganisms are definitely part of the 2.4 Ga-to-present evolutionary continuum.
- In rocks older than ~2.2 Ga, the sulfur ***isotopic record*** is subject to controversy; phylogenetically distinctive bio-markers are unknown; and nearly a score of geologic units contain organic carbon anomalously light

isotopically (relative to that of the Proterozoic and Phanerozoic) that may reflect the presence of Archaeans ("Archaebacteria" of earlier classifications) but may not (since cellularly preserved Archean-age Archaeans have never been identified).

These and other observed differences can be interpreted in terms of: (1) historical, secular change; (2) lack of change masked by biases of the geological record (e.g., preservation, metamorphism); or (3) a combination of (1) and (2).

How can we understand the relative contributions of historical change and shifting biases in producing the differences observed between the Archean and Proterozoic records? For differences due to genuine historical change, what is the pattern of change over time and the likely cause(s) of the change? How might changes in geology, atmospheric composition, surface environment, and biology have influenced one another? How can we do a better job resolving these complex problems?

WORKSHOP ORGANIZATION

To address these topics, the two-day workshop was devoted to:

1. SUMMARIZING FACTS

Judging from the known geologic-paleobiologic Archean/Paleoproterozoic record (3.8 to 2.0 Ga ago), what is the factual basis for preceived changes in:

(A) tectonics/crustal development (including radiogenic isotopes)?

(B) microfossils and stromatolites?

(C) biogeochemical signals (biomarkers, biological isotopes)?

(D) atmospheric and ocean chemistry?

2. GROUP DISCUSSION

What is the range of interpretations that can be supported by reported observations? Do some or all observations require secular changes in the atmosphere, oceans, liothosphere, and/or biota? If not, how can they be interpreted in terms of incomplete or biased sampling? In other words, to what extent do the available facts mesh with interpretations of historical change rather than biases of the preserved record? What new data and ideas

(approaches/techniques/questions to be answered) are needed to resolve uncertainties?

Time was also set aside for **SHOW & TELL SESSIONS** (for participants to show each other their latest finds in an room set aside for hand specimens, microscopes, viewing of 35 mm slides, etc.)

SCIENTIFIC PROGRAM

THURSDAY EVENING (February 18)

1800-2100 OPENING RECEPTION

Jane and Bill Schopf's home

FRIDAY (February 19) UCLA Faculty Center

0830-0845 Introduction/Logistics (Schopf)

(A) "FACTS" -- TECTONICS/CRUSTAL DEVELOPMENT, 3.8 to 2.0 Ga AG0 (including radiogenic isotopes)

0845-0910 SAM BOWRING (MIT)
0910-0930 PAUL HOFFMAN (Harvard)
0930-1000 Coffee Break
1000-1200 ***GROUP DISCUSSION OF FACTS AND FUTURE RESEARCH*** -- JOHN GROTZINGER (MIT), Chair

1200-1300 Lunch (sandwiches in ***SHOW & TELL*** room)

(B) "FACTS" -- FOSSILS AND STROMATOLITES, 3.8 to 2.0 Ga AGO

1300-1325 BILL SCHOPF (UCLA)
1325-1345 HANS HOFMANN (Univ. Montreal)
1345-1415 Coffee Break

1415-1615 ***GROUP DISCUSSION OF FACTS AND FUTURE RESEARCH*** -- ANDY KNOLL (Harvard), Chair

1615-1730 ***SHOW & TELL*** (specimens, 35 mm slide presentations)

1730 ***MIXER***, UCLA Faculty Center

SATURDAY (February 20) UCLA Faculty Center

(C) "FACTS" -- BIOGEOCHEMICAL SIGNALS, 3.5 TO 2.0 Ga AGO (including biological isotopes)

0845-0910 DAVID DesMARAIS (NASA, Ames)

0910-0930 DON CANFIELD (Odense, Denmark)

0930-1000 Coffee Break

1000-1200 ***GROUP DISCUSSION OF FACTS AND FUTURE RESEARCH*** -- JOHN HAYES (WHOI), Chair

1200-1300 Lunch (sandwiches in ***SHOW & TELL*** room)

(D) "FACTS" -- ENVIRONMENTAL HISTORY, 3.8 to 2.0 Ga AGO

1300-1325 DICK HOLLAND (Harvard)

1325-1345 HIROSHI OHMOTO (Penn State)

1345-1415 Coffee Break

1415-1615 ***GROUP DISCUSSION OF FACTS AND FUTURE RESEARCH*** -- JIM KASTING (Penn State), Chair

1615-1730 ***SHOW & TELL*** (specimens and 35 mm slide presentations)

1730 ***RECEPTION***, UCLA Faculty Center

1900 ***BANQUET***, UCLA Faculty Center

SUNDAY (February 21)

Workshop closed. Departure after breakfast.

ALPHABETICAL LIST OF INVITEES (109) & ATTENDEES(74*)

*1. ALTERMANN, Wlady -- GERMANY
*2. AWRAMIK, Stanley – USA
3. BAULD, John -- AUSTRALIA
*4. BEAUMONT, Valerie -- FRANCE
*5. BENGTSON, Stefan -- SWEDEN
*6. BEUKES, Nic -- SOUTH AFRICA
*7. BLANKENSHIP, Bob -- USA
*8. BOWRING, Sam -- USA
*9. BRAGIN, John -- USA
*10. BROCKS, Jochen -- AUSTRALIA
*11. BUICK, Roger -- AUSTRALIA
*12. CANFIELD, Don – DENMARK
13. CASTENHOLZ, Dick -- USA
*14. CHANG, Sherwood -- USA
*15. CHAPMAN, David -- USA
16. CHEN, Yanjing -- CHINA
17. DAVIES, Paul -- AUSTRALIA
*18. DES MARAIS, David -- USA
19. DOOLITTLE, Ford -- CANADA
20. DOOLITTLE, Russel -- USA
21. ERNST, Gary -- USA
*22. EVANS, David -- USA
23. FAIRCHILD, Tom -- BRAZIL
*24. FARMER, Jack -- USA
*25. FEDONKIN, Misha -- RUSSIA
*26. FERRRIS, Jim -- USA
27. GEST, Howard – USA
*28. GOGARTEN, Peter -- USA
*29. GROTZINGER, John -- USA
*30. GUTZMER, Jens -- SOUTH ARFRICA
*31. HABICHT, Kirsten -- DENMARK
*32. HARRISON, Mark -- USA
*33. HAYES, John -- USA
*34. HECKL, Wolfgang -- GERMANY
35. HENGEVELD, Rob -- NETHERLANDS

*36. HOFFMAN, Paul -- USA
*37. HOFMANN, Hans -- CANADA
*38. HOLLAND, Dick -- USA
*39. HOTINSKI, Roberta -- USA
*40. HOUSE, Chris -- USA
*41. INGERSOLL, Ray -- USA
*42. JAKOSKY, Bruce -- USA
43. JØRGENSEN, Bo -- DENMARK
44. KAKEGAWA, Takeshi -- JAPAN
*45. KAPLAN, Ian -- USA
*46. KASTING, Jim -- USA
*47. KHALID, Al-Arouri -- AUSTRALIA
*48. KIRSCHVINK, Joe -- USA
*49. KLEIN, Kase -- USA
*50. KNOLL, Andy -- USA
*51. KUMP, Lee -- USA
52. KURLAND, Chuck -- SWEDEN
*53. LAKE, Jim -- USA
54. LAMBERT, Ian -- AUSTRALIA
*55. LAZCANA, Antonio -- MEXICO
*56. LIPPS, Jere -- USA
57. LOGAN, Graham -- AUSTRALIA
58. LOWE, Don -- USA
*59. MANKIEWICZ, Carol -- USA
60. MANNING, Craig -- USA
*61. MANTONYA, Richard -- USA
*62. MARSHALL, Charles -- USA
63. MATZIGKEIT, Udo -- GERMANY
64. McKEEGAN, Kevin -- USA
*65. MENDELSON, Carl -- USA
66. MEYER, Michael -- USA
67. MOJZSIS, Steve -- USA
*68. MOORE, Toby -- USA
*69. NARAOKA, Hiroshi -- USA
*70. NEALSON, Ken -- USA
71. NELSON, Doug -- USA
*72. NIKOS, Kyrpides -- USA
*73. OHMOTO, Hiroshi -- USA
*74. OLSEN, Gary -- USA
75. ONO, Shuhei -- USA

76. PACE, Norm -- USA
77. PALMISANO, Anna --USA
78. PIERSON, Beverly -- USA
*79. RUNNEGAR, Bruce -- USA
*80. RYE, Rob -- USA
*81. SCHIDLOWSKI, Manfred -- GERMANY
*82. SCHOONEN, Martin -- USA
*83. SCHOPF, Bill -- USA
*84. SEIFERT, Janet -- USA
85. SEPKOSKI, Jack -- USA
86. SERGEEV, Vladi -- RUSSIA
*87. SHEN, Yanan -- DENMARK
*88. SHENMILLER. Jane -- USA
*89. SHOCK, Everett -- USA
*90. SOGIN, Mitch -- USA
*91. SOWERBY, Stephen -- NEW ZEALAND
*92. STETTER, Karl -- GERMANY
93. STEVENSON, David -- USA
*94. STRATHEARN, Gary -- USA
*95. STRAUSS, Harald – GERMANY
*96. SUMMONS, Roger -- AUSTRALIA
*97. SUMNER, Dawn -- USA
98. THAMDRUP, Bo -- DENMARK
99. TOWE, Ken -- USA
*100. VEIZER, Jan – CANADA
101. WALKER, Jim -- USA
*102. WALTER, Malcolm -- AUSTRALIA
103. WARD, David -- USA
*104. WATANABE, Yumiko -- USA
*105. WESTALL, Frances -- USA
106. WU, Chaodong -- CHINA
*107. YAMAGUCHI, Kosei -- USA
108. YUN, Zhang -- CHINA
*109. ZUBAY, Geoffrey -- USA