

PROCEEDINGS OF SPIE

[SPIDigitalLibrary.org/conference-proceedings-of-spie](https://spiedigitallibrary.org/conference-proceedings-of-spie)

Front Matter: Volume 6694

, "Front Matter: Volume 6694," Proc. SPIE 6694, Instruments, Methods, and Missions for Astrobiology X, 669401 (26 October 2007); doi: 10.1117/12.775479

SPIE.

Event: Optical Engineering + Applications, 2007, San Diego, California, United States

PROCEEDINGS OF SPIE

***Instruments, Methods, and
Missions for Astrobiology X***

**Richard B. Hoover
Gilbert V. Levin
Alexei Y. Rozanov
Paul C. W. Davies**
Editors

**28–30 August 2007
San Diego, California, USA**

Sponsored and Published by
SPIE

Volume 6694

Proceedings of SPIE, 0277-786X, v. 6694

SPIE is an international society advancing an interdisciplinary approach to the science and application of light.

The papers included in this volume were part of the technical conference cited on the cover and title page. Papers were selected and subject to review by the editors and conference program committee. Some conference presentations may not be available for publication. The papers published in these proceedings reflect the work and thoughts of the authors and are published herein as submitted. The publisher is not responsible for the validity of the information or for any outcomes resulting from reliance thereon.

Please use the following format to cite material from this book:

Author(s), "Title of Paper," in *Instruments, Methods, and Missions for Astrobiology X*, edited by Richard B. Hoover, Gilbert V. Levin, Alexei Y. Rozanov, Paul C. W. Davies, Proceedings of SPIE Vol. 6694 (SPIE, Bellingham, WA, 2007) Article CID Number.

ISSN 0277-786X
ISBN 9780819468420

Published by

SPIE

P.O. Box 10, Bellingham, Washington 98227-0010 USA
Telephone +1 360 676 3290 (Pacific Time) · Fax +1 360 647 1445
SPIE.org

Copyright © 2007, Society of Photo-Optical Instrumentation Engineers

Copying of material in this book for internal or personal use, or for the internal or personal use of specific clients, beyond the fair use provisions granted by the U.S. Copyright Law is authorized by SPIE subject to payment of copying fees. The Transactional Reporting Service base fee for this volume is \$18.00 per article (or portion thereof), which should be paid directly to the Copyright Clearance Center (CCC), 222 Rosewood Drive, Danvers, MA 01923. Payment may also be made electronically through CCC Online at copyright.com. Other copying for republication, resale, advertising or promotion, or any form of systematic or multiple reproduction of any material in this book is prohibited except with permission in writing from the publisher. The CCC fee code is 0277-786X/07/\$18.00.

Printed in the United States of America.

Publication of record for individual papers is online in the SPIE Digital Library.

The logo for SPIE Digital Library features the word "SPIE" in a bold, sans-serif font above the words "Digital Library" in a smaller, lighter font. To the right of the text is a stylized graphic consisting of three vertical bars of increasing height from left to right, with a curved line above them.

SPIDigitalLibrary.org

Paper Numbering: Proceedings of SPIE follow an e-First publication model, with papers published first online and then in print and on CD-ROM. Papers are published as they are submitted and meet publication criteria. A unique, consistent, permanent citation identifier (CID) number is assigned to each article at the time of the first publication. Utilization of CIDs allows articles to be fully citable as soon they are published online, and connects the same identifier to all online, print, and electronic versions of the publication. SPIE uses a six-digit CID article numbering system in which:

- The first four digits correspond to the SPIE volume number.
- The last two digits indicate publication order within the volume using a Base 36 numbering system employing both numerals and letters. These two-number sets start with 00, 01, 02, 03, 04, 05, 06, 07, 08, 09, 0A, 0B ... 0Z, followed by 10-1Z, 20-2Z, etc.

The CID number appears on each page of the manuscript. The complete citation is used on the first page, and an abbreviated version on subsequent pages. Numbers in the index correspond to the last two digits of the six-digit CID number.

Contents

ix *Conference Committee*

SESSION 1 THE ORIGIN OF LIFE

- 6694 02 **Reduced condition on early Earth and ATP-related mechanism of prebiological evolution (Keynote Paper)** [6694-01]
E. M. Galimov, V.I. Vernadsky Institute of Geochemistry and Analytical Chemistry (Russia)
- 6694 03 **Advanced search for the origin of life's homochirality: asymmetric photon induced processes on chiral compounds with far UV circularly polarized synchrotron radiation (Invited Paper)** [6694-02]
L. Nahon, G. Garcia, Synchrotron Soleil (France); I. Powis, Univ. Nottingham (United Kingdom); U. Meierhenrich, Univ. of Nice-Sophia Antipolis (France); A. Brack, Ctr. de Biophysique Moléculaire, CNRS (France)
- 6694 04 **Could there have been a single origin of life in a big bang universe?** [6694-03]
R. Gordon, Univ. of Manitoba (Canada); R. B. Hoover, NASA Marshall Space Flight Ctr. (USA) and National Space Science and Technology Ctr. (USA)
- 6694 05 **Importance of the interaction between sodium silicate and organic materials to astrobiology: alcohol-based organo-silicates as potential biosignatures** [6694-04]
P. J. Liesch, V. M. Kolb, Univ. of Wisconsin-Parkside (USA)
- 6694 06 **Contribution to a symbiogenic approach in astrobiology** [6694-05]
F. Carrapiço, L. Pereira, T. Rodrigues, Univ. de Lisboa (Portugal)

SESSION 2 MICROFOSSILS IN ANCIENT ROCKS AND METEORITES

- 6694 08 **Microfossils of cyanobacteria in carbonaceous meteorites** [6694-07]
R. B. Hoover, NASA Marshall Space Flight Ctr. (USA)
- 6694 09 **Early Proterozoic (2.04 GA) phosphorites of Pechenga Greenstone Belt and their origin (Invited Paper)** [6694-08]
A. Y. Rozanov, M. M. Astafieva, Paleontological Institute (Russia); R. B. Hoover, NASA Marshall Space Flight Ctr. (USA) and National Space Science and Technology Ctr. (USA)
- 6694 0A **Liquid water in comets: implications for astrobiology** [6694-56]
J. T. Wickramasinghe, N. C. Wickramasinghe, W. M. Napier, Cardiff Ctr. for Astrobiology, Cardiff Univ. (United Kingdom)

SESSION 3 CHEMICAL AND MINERAL BIOMARKERS

- 6694 0B **Stable sulfur isotopes as probes for ancient life in the solar system (Invited Paper)** [6694-10]
M. H. Engel, Univ. of Oklahoma (USA)

- 6694 0C **The case for vestiges of early solar system biota in carbonaceous chondrites: petroleum geochemical snapshots and possible future petroleum prospects on Mars expedition (Invited Paper)** [6694-11]
P. K. Mukhopadhyay, Global Geoenergy Research, Ltd. (Canada); D. J. Mossman, J. M. Ehrman, Mt. Allison Univ. (Canada)
- 6694 0D **Ratios of biogenic elements for distinguishing recent from fossil microorganisms** [6694-12]
R. B. Hoover, NASA Marshall Space Flight Ctr. (USA) and National Space Science and Technology Ctr. (USA)

SESSION 4 COMETS, METEORITES, AND THE BIOSPHERE

- 6694 0G **Stardust and comets (Invited Paper)** [6694-14]
M. Burchell, Univ. of Kent (United Kingdom)
- 6694 0H **The cometary biosphere (Invited Paper)** [6694-15]
R. B. Sheldon, Universities Space Research Association (USA) and National Space Science and Technology Ctr. (USA); R. B. Hoover, NASA Marshall Space Flight Ctr. (USA) and National Space Science and Technology Ctr. (USA)
- 6694 0I **Dust jets, outbursts, and fragmentation of comets (Invited Paper)** [6694-16]
Z. Sekanina, Jet Propulsion Lab. (USA)

SESSION 5 LIFE AS WE DO NOT KNOW IT

- 6694 0K **Searching for an alternative form of life on Earth (Keynote Paper)** [6694-19]
P. C. W. Davies, The Beyond Ctr., Arizona State Univ. (USA)

SESSION 6 ASTROBIOLOGY OF VENUS, MARS, AND ICY MOONS

- 6694 0L **Titan: an astrobiological laboratory in the solar system (Keynote Paper)** [6694-20]
F. Raulin, M.-J. Nguyen, P. Coll, LISA, CNRS, Univ. Paris 7 and Univ. Paris 12 (France)
- 6694 0M **The revival of life on Mars (Invited Paper)** [6694-21]
G. V. Levin, Spherix, Inc. (USA)
- 6694 0N **The hydrogen peroxide-water hypothesis for life on Mars and the problem of detection** [6694-22]
J. M. Houtkooper, Justus-Liebig Univ. of Giessen (Germany); D. Schulze-Makuch, Washington State Univ. (USA)

- 6694 0O **The Biological Oxidant and Life Detection (BOLD) mission: an outline for a new mission to Mars** [6694-23]
D. Schulze-Makuch, Washington State Univ. (USA); J. M. Houtkooper, Justus-Liebig Univ. of Giessen (Germany); M. Knoblauch, Washington State Univ. (USA); R. Furfaro, Univ. of Arizona (USA); W. Fink, California Institute of Technology (USA); A. G. Fairén, NASA Ames Research Ctr. (USA); H. Vali, McGill Univ. (USA); J. N. Head, Raytheon Missile Systems (USA); D. S. S. Lim, NASA Ames Research Ctr. (USA); J. Dohm, Univ. of Arizona (USA); L. N. Irwin, Univ. of Texas at El Paso (USA); M. Daly, MDA, Ltd. (USA); D. Andersen, Carl Sagan Ctr. for the Study of Life in the Universe (USA)
- 6694 0P **The Phoenix mission to Mars (Invited Paper)** [6694-24]
P. H. Smith, The Lunar and Planetary Lab., Univ. of Arizona (USA)

SESSION 7 DISTRIBUTION OF LIFE

- 6694 0S **Diatoms: unique eukaryotic extremophiles providing insights into planetary change (Invited Paper)** [6694-27]
J. P. Kocielek, California Academy of Sciences (USA) and Univ. of Michigan Biological Station (USA)
- 6694 0T **How do bacteria reach the stratosphere?** [6694-29]
M. Wainwright, Univ. of Sheffield (United Kingdom)
- 6694 0U **VUV-UV absorption spectroscopy of DNA and UV screens suggests strategies for UV resistance during evolution and space travel (Invited Paper)** [6694-30]
A. Zalar, D. Tepfer, Institut National de la Recherche Agronomique (France); S. V. Hoffmann, Univ. of Aarhus (Denmark); A. Kollmann, Institut National de la Recherche Agronomique (France); S. Leach, Observatoire de Paris-Meudon (France)
- 6694 0V **Diatoms in space: testing prospects for reliable diatom nanotechnology in microgravity** [6694-31]
R. Gordon, Univ. of Manitoba (Canada); R. B. Hoover, NASA (USA); J. A. Tuszyński, Univ. of Alberta (Canada); J. de Luis, Payload Systems, Inc. (USA); P. J. Camp, Univ. of Edinburgh (United Kingdom); M. A. Tiffany, San Diego State Univ. (USA); S. S. Nagy, Montana Diatoms (USA); M. Fayek, University of Manitoba (Canada); P. J. Lopez, Ecole Normale Supérieure (France); B. E. Lerner, Univ. of Manitoba (Canada)

SESSION 8 MICROBIAL EXTREMOPHILES

- 6694 0W **Extremophiles and chemotrophs as contributors to astrobiological signatures on Europa: a review of biomarkers of sulfate-reducers and other microorganisms (Invited Paper)** [6694-32]
J. Seckbach, The Hebrew Univ. of Jerusalem (Israel); J. Chela-Flores, The Abdus Salam International Ctr. for Theoretical Physics (Italy) and Instituto de Estudios Avanzados (Venezuela)
- 6694 0X **Characterization of a moderately halo-acidophilic bacterium isolated from Lake Brown, western Australia** [6694-33]
M. R. Mormile, B. Hong, N. T. Adams, Univ. of Missouri-Rolla (USA); K. C. Benison, Central Michigan Univ. (USA); F. Oboh-Ikuenobe, Univ. of Missouri-Rolla (USA)

- 6694 0Y **Diversity, evolution, and horizontal gene transfer (HGT) in soda lakes** [6694-34]
H. C. Pinkart, Central Washington Univ. (USA); M. C. Storrie-Lombardi, Kinohi Institute (USA)
- 6694 0Z **Investigating microbial diversity and UV radiation impact at the high-altitude Lake Aguas Calientes, Chile** [6694-35]
L. Escudero, G. Chong, Ctr. de Investigación Científica y Tecnológica para la Minería (Chile); C. Demergasso, Univ. Católica del Norte (Chile); M. E. Farías, Consejo Nacional de Investigaciones Científicas y Técnicas (Spain); N. A. Cabrol, E. Grin, NASA Ames Research Ctr. (USA) and CSC, SETI Institute (USA); E. Minkley, Jr., Y. Yu, Carnegie Mellon Univ. (USA)
- 6694 10 **Mitigation of environmental extremes as a possible indicator of extended habitat sustainability for lakes on early Mars (Invited Paper)** [6694-36]
N. A. Cabrol, E. A. Grin, NASA Ames Research Ctr. (USA) and CSC, SETI Institute (USA); A. N. Hock, Univ. of California, Los Angeles (USA)

SESSION 9 INSTRUMENTS AND METHODS FOR ASTROBIOLOGY

- 6694 11 **A nanopore-ARROW biosensor for life detection** [6694-37]
D. Deamer, H. Schmidt, Univ. of California, Santa Cruz (USA); A. R. Hawkins, Brigham Young Univ. (USA)
- 6694 12 **MR PRISM: a software suite for CRISM analysis** [6694-40]
A. J. Brown, SETI Institute (USA); M. Storrie-Lombardi, Kinohi Institute (USA)
- 6694 13 **High-resolution light microscopy of nanoforms** [6694-41]
V. Vodyanoy, O. Pustovyy, A. Vainrub, Auburn Univ. (USA)
- 6694 14 **In situ search for life traces in extraterrestrial samples by synchrotron x-ray fluorescence 2D and 3D imaging** [6694-42]
L. Lemelle, ENS Lyon, Univ. de Lyon (France); A. Simionovici, Observatoire des Sciences de l'Univers de Grenoble (France); M. Salomé, P. Bleuet, J. Susini, European Synchrotron Radiation Facility (France); P. Gillet, ENS Lyon, Univ. de Lyon (France)

SESSION 10 SURVIVABILITY TO RADIATION, DESSICATION, AND SHOCK

- 6694 15 **Great Salt Lake halophilic microorganisms as models for astrobiology: evidence for desiccation tolerance and ultraviolet irradiation resistance** [6694-43]
B. K. Baxter, B. Eddington, M. R. Riddle, T. N. Webster, B. J. Avery, Westminster College (USA)
- 6694 16 **Survival of microbial life under shock compression: implications for Panspermia** [6694-44]
M. Burchell, Univ. of Kent (United Kingdom)
- 6694 17 **ATCG nucleotide fluctuation of Deinococcus radiodurans radiation genes** [6694-45]
T. Holden, R. Subramaniam, R. Sullivan, E. Cheung, C. Schneider, G. Tremberger, Jr., A. Flamholz, D. H. Lieberman, T. D. Cheung, CUNY Queensborough Community College (USA)
- 6694 18 **Radiotolerance of microorganisms isolated from radiation fields on a university campus: implications for shallow subsurface growth of microorganisms on Mars** [6694-46]
M. R. Mormile, J. J. Elmer, S. J. Spsychala, Univ. of Missouri-Rolla (USA)

SESSION 11 CHIRALITY AND ASTROBIOLOGY

- 6694 19 **Astrobiological polarimeter** [6694-47]
N. Kothari, A. Jafarpour, T. L. Thaler, R. Trebino, A. S. Bommarius, Georgia Institute of Technology (USA)
- 6694 1A **Apparent biotic micromorphologies of abiotic origin** [6694-50]
G. Konesky, SGK Nanostructures, Inc. (USA)
- 6694 1B **Is there red soil on Mars? (as proof of water and vegetation)** [6694-51]
R. Paepe, Geobound International, BV MUHS (Netherlands)
- 6694 1C **Microbial extremophiles in evolutionary aspect** [6694-52]
E. V. Pikuta, R. B. Hoover, NASA Marshall Space Flight Ctr. (USA) and National Space Science and Technology Ctr. (USA)
- 6694 1D **Remote sensing capacity of Raman spectroscopy in identification of mineral and organic constituents** [6694-53]
B. Chen, C. Stoker, N. Cabrol, C. P. McKay, NASA Ames Research Ctr. (USA)
- 6694 1E **Co-evolution of cyanophage and cyanobacteria in Antarctic lakes: adaptive responses to high UV flux and global warming** [6694-54]
M. C. Storie-Lombardi, Kinohi Institute (USA); H. C. Pinkart, Central Washington Univ. (USA)

POSTER SESSION

- 6694 1F **Living strategies of unusual life forms on Earth and the relevance to astrobiology (Invited Paper)** [6694-48]
P. J. Liesch, V. M. Kolb, Univ. of Wisconsin-Parkside (USA)
- 6694 1G **The importance of the Maillard-metal complexes and their silicates in astrobiology** [6694-49]
P. J. Liesch, V. M. Kolb, Univ. of Wisconsin-Parkside (USA)

ADDITIONAL PAPER

- 6694 1H **Large multicellular filamentous bacteria under the oxygen minimum zone of the eastern South Pacific: a forgotten biosphere** [6694-57]
V. A. Gallardo, C. Espinoza, Univ. de Concepción (Chile)

Author Index

Conference Committee

Conference Chairs

Richard B. Hoover, NASA Marshall Space Flight Center (USA) and
National Space Science and Technology Center (USA)
Gilbert V. Levin, Spherix, Inc. (USA)
Alexei Y. Rozanov, Paleontological Institute (Russia)
Paul C. W. Davies, The Beyond Center, Arizona State University (USA)

Program Committee

Mian M. Abbas, NASA Marshall Space Flight Center (USA)
Sabit S. Abyzov, Institute of Microbiology (Russia)
Marina M. Astafieva, Paleontological Institute (Russia)
Stanley M. Awramik, University of California, Santa Barbara (USA)
Bonnie K. Baxter, Westminster College (USA)
Lee Bebout, NASA Ames Research Center (USA)
Kathleen C. Benison, Central Michigan University (USA)
Adrian J. Brown, SETI Institute (USA)
Donald E. Brownlee, University of Washington (USA)
Mark A. Bullock, Southwest Research Institute (USA)
Mark J. Burchell, University of Kent (United Kingdom)
Nathalie A. Cabrol, NASA Ames Research Center (USA) and CSC, SETI
Institute (USA)
Francisco J. Carrapiço, Universidade de Lisboa (Portugal)
Bin Chen, NASA Ames Research Center (USA)
Max L. Coleman, Jet Propulsion Laboratory (USA)
David W. Deamer, University of California, Santa Cruz (USA)
Michael H. Engel, University of Oklahoma (USA)
Sabrina Feldman, Jet Propulsion Laboratory (USA)
Eric M. Galimov, V.I. Verdansky Institute of Geochemistry and
Analytical Chemistry (Russia)
David H. Grinspoon, Denver Museum of Art and Science (USA)
J. Patrick Kocielek, California Academy of Sciences (USA) and
University of Michigan (USA)
Vera M. Kolb, University of Wisconsin-Parkside (USA)
Jere H. Lipps, University of California, Berkeley (USA)
Gene D. McDonald, The University of Texas at Austin (USA)
David S. McKay, NASA Johnson Space Center (USA)
Uwe Meierhenrich, Université de Nice Sophia Antipolis (France)
Melanie R. Mormile, University of Missouri-Rolla (USA)
David J. Mossman, Mount Allison University (Canada)
Roland R. Paepe, Geobound International, BV MUHS (Netherlands)

Randall S. Perry, Imperial College London (United Kingdom)
Elena V. Pikuta, NASA Marshall Space Flight Center (USA) and National
 Space Science and Technology Center (USA)
Holly C. Pinkart, Central Washington University (USA)
Malcom Potts, Virginia Polytechnic Institute and State University (USA)
Lisa M. Pratt, Indiana University (USA)
Francois C. Raulin, LISA, CNRS, Université Paris 7 and Université Paris 12
 (France)
Birgit I. Sattler, Leopold-Franzens-University Innsbruck (Austria)
Joseph Seckbach, The Hebrew University of Jerusalem (Israel)
Zdenek Sekanina, Jet Propulsion Laboratory (USA)
Mark A. Sephton, Imperial College London (United Kingdom)
Alexandre S. Simionovici, Observatoire des Sciences de l'Univers de
 Grenoble (France)
Paul P. Sipiera, Harper College (USA)
Peter H. Smith, The Lunar and Planetary Laboratory, University of
 Arizona (USA)
Michael C. Storrie-Lombardi, Kinohi Institute (USA)
Vitaly J. Vodyanoy, Auburn University (USA)
Milton Wainwright, University of Sheffield (United Kingdom)
Max K. Wallis, Cardiff University (United Kingdom)
Nalin C. Wickramasinghe, Cardiff Center for Astrobiology, Cardiff
 University (United Kingdom)
Andreja Zalar, Institut National de la Recherche Agronomique
 (France)
Georgi A. Zavarzin, Institute of Microbiology (Russia)

Session Chairs

- 1 The Origin of Life
David S. McKay, NASA Johnson Space Center (USA)
David W. Deamer, University of California, Santa Cruz (USA)
- 2 Microfossils in Ancient Rocks and Meteorites
Eric M. Galimov, V.I. Vernadsky Institute of Geochemistry and
 Analytical Chemistry (Russia)
Vera M. Kolb, University of Wisconsin-Parkside (USA)
- 3 Chemical and Mineral Biomarkers
Mark J. Burchell, University of Kent at Canterbury (United Kingdom)
Zdenek Sekanina, Jet Propulsion Laboratory (USA)
- 4 Comets, Meteorites, and the Biosphere
Gilbert V. Levin, Spherix, Inc. (USA)
Max L. Coleman, Jet Propulsion Laboratory (USA)

- 5 Life as We Do Not Know It
Richard B. Hoover, NASA Marshall Space Flight Center (USA) and
National Space Science and Technology Center (USA)
- 6 Astrobiology of Venus, Mars, and Icy Moons
Peter H. Smith, The Lunar and Planetary Laboratory, University of
Arizona (USA)
- 7 Distribution of Life
Francois C. Raulin, LISA, CNRS, Université Paris 7 and Université Paris 12
(France)
Melanie R. Mormile, University of Missouri-Rolla (USA)
- 8 Microbial Extremophiles
Mark A. Bullock, Southwest Research Institute (USA)
J. Patrick Kocielek, California Academy of Sciences (USA) and
University of Michigan (USA)
- 9 Instruments and Methods for Astrobiology
Richard B. Hoover, NASA Marshall Space Flight Center (USA) and
National Space Science and Technology Center (USA)
Michael C. Storrie-Lombardi, Kinohi Institute (USA)
- 10 Survivability to Radiation, Dessication, and Shock
Nathalie A. Cabrol, NASA Ames Research Center (USA) and CSC, SETI
Institute (USA)
Lee Bebout, NASA Ames Research Center (USA)
- 11 Chirality and Astrobiology
Joseph Seckbach, The Hebrew University of Jerusalem (Israel)
Milton Wainwright, University of Sheffield (United Kingdom)

