

APPENDIX 2: LIST OF WORKSHOP PARTICIPANTS, AND EXPERIENCE RELEVANT TO MARS EXPLORATION

List of Workshop Participants

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Experience Pertinent to Mars Exploration

AGEE, CARL B.

Chief Scientist for Astromaterials, NASA Johnson Space Center

Agee's research expertise is in high-pressure experimental petrology. The research focuses on the origin, evolution, and present state of planetary interiors. One of his current projects is an investigation of the early differentiation of the martian crust, mantle, and core. He has recently taken the position of Chief Scientist for Astromaterials at Johnson Space Center, and is coordinating JSC plans for receiving samples from Mars.

ALLEN, CARLTON C.

Planetary Geologist, Lockheed Martin/NASA Johnson Space Center

Allen is a planetary geologist with Lockheed Martin at Johnson Space Center. He earned a Ph.D. in Planetary Science at the University of Arizona with a combined field and remote-sensing study of subglacial volcanic eruptions in Iceland and on Mars. He then completed postdoctoral field studies at the University of New Mexico on subglacial eruptives of British Columbia. Switching career paths, he joined the Basalt Waste Isolation Project in Washington State, investigating the interactions of buried nuclear waste with the Columbia River flood basalts. Allen returned to the space program in Houston, and demonstrated the extraction of oxygen from lunar soils and rocks. He developed, characterized and still distributes NASA lunar and martian soil simulants. Recently he has been sampling and analyzing bacteria from Yellowstone and Hot Springs National Parks in support of JSC's Astrobiology Institute. Allen is active in the preparation for Mars sample-return missions, and is completing research on sterilization of martian samples using gamma radiation.

BRASIER, MARTIN

Paleobiologist/Paleontologist, Oxford University

Martin investigates the geological context for early biosphere evolution: time-frame and environmental setting using paleobiology, paleoecology, bio-, litho-, sequence- and chemostratigraphy, and geochronology. He is interested in innovative approaches to paleobiology; questions of interlinkage between biosphere evolution and crustal evolution. Field experience: Proterozoic paleobiology and stratigraphy in cold deserts (Gobi); hot deserts (Arabia); Proterozoic meteorite crater fill, Australia. Modern microbial/protistan habitats in lagoons, lakes. He believes in Mars-analogue field work for optimizing fossil sampling strategies. Paleontology: microfossils (textbook), microbialites, trace fossils; recent papers on origins of eukaryotes, symbiosis in protists, skeletal function in protists, multicellularity in animals (sponges), early trace fossil evolution. He believes that diverse paradigms for martian life need exploring. Laboratory experience: microfossils in thin section, disaggregation, maceration, SEM; whole rock stable isotopes using PRISM mass spectrometry; high-resolution stable-isotope studies (C, O, Sr) of carbonate and phosphate biomaterials by UV laser ablation. Chemical markers probably provide optimal clues to life, but C and O isotopic fractionation on Mars is poorly understood — high resolution isotopic monitoring is urgently needed in the field.

BUDDEN, NANCY ANN

Planetary Geoscientist, Lunar and Planetary Institute/NASA Office of Exploration (JSC)

Budden has worked for the past 10 years in the NASA/JSC Office of Exploration on human missions to Earth's Moon and Mars: (1) mission planning, (2) requirements development, (3) integration of all science disciplines, proposed programs and surface payloads. She was co-leader of the Mars Exploration Science Study Team that developed the Mars Reference Mission. She was detailed to NASA/HQ's chief scientist for a year to work on science policy for NASA. She spent five years with the Geosciences Directorate, National Science Foundation, in strategic science planning, (programs and budgets) and in developing interagency science programs among NSF, NASA, USGS, and NOAA, and DOE. She served as program scientist for the NASA/NSF Antarctic Analogs Project. Her thesis research was in paleo-oceanography of biogenic deep sea sediments

(60 Ma to present) and on tectonic/stratigraphic evolution of the Antarctic Ocean. She served as chief scientist for UNOCAL (Union Oil of California) research cruises, sampling and analyzing Miocene sediments offshore California and investigating the diagenetic history of Miocene biogenic sediments (SEM, TEM, geochemistry).

BURBANK, DANIEL C.

Astronaut/Aeronautical Scientist, NASA Johnson Space Center

Burbank was a survival instructor for the Coast Guard in Alaska — he provided classroom instruction and led week-long wilderness survival training sessions during winter on a remote island. While the course dealt with basic survival skills, a major emphasis was on the psychological aspects of survival. He was a Coast Guard helicopter pilot with more than 1,800 missions, including 300 search and rescue missions, many flown in adverse conditions. This gave him a different perspective on human performance in stressful, or even hopeless, situations. Mars exploration plans must acknowledge the limitations (physical and psychological) and the capabilities (judgement, creativity, initiative, etc.) of the human beings who are integral to those missions. He is committed to cultivating an exploration culture within NASA: "...we train excellent 'operators', and give far less attention to developing 'explorers'. And yet exploration fires people's imagination a lot better than operations ever could (and this from a career operator)." Burbank is the crew procedures lead for the flights that will deliver Node 1 (first US flight) and the US Laboratory module for the International Space Station. He is working in Moscow with Russian engineers and authors on crew procedures and on Russian ISS hardware. Astronaut training included classroom and field training in geology. A week spent in the Rio Grande rift convinced him of the importance of building a solid foundation of field research skills in the crewmembers we send back to the Moon and on to Mars. It's vital to develop and send field researchers, rather than artifact retrievers, particularly if the mission architecture places crewmembers on Mars for 500+ days. Send the necessary instruments to begin analysis, or at the very least to make proper specimen selection.

BURCHFIEL, B. CLARK

Field Geologist/Tectonist, Massachusetts Institute of Technology

Burchfiel is a field geologist who investigates the processes of orogenesis and their relation to plate interactions and intra-plate deformation. His major research efforts are in five areas: (1) the Cordilleran orogenic belt of western North America, (2) Alpine belt of Eastern Europe, (3) the Caledonian belt of Scandinavia, (4) the Andean belt in Peru, Bolivia, and Colombia, and (5) north-central China and Tibet. His research focuses on processes of intracontinental deformation. It is designed to examine orogenic belts and other regions of significance within the continents of different ages, tectonic settings, and hence at different levels of exposure. The Alpine and Caledonian belts are collisional orogens, whereas the Cordilleran belt and Andean belts are partly noncollisional. The work in China is a study of neotectonics in active orogenic belts: normal faulting in the High Himalaya and the tectonic evolution of the Tibetan Plateau, Tien Shan and southeastern Asia. The eastern Alpine studies also include extensional regions coeval with convergence during a precollisional stage. He attempts to solve specific problems or develop conceptual models from field mapping integrated with geophysical and geodetic studies and, where relations permit, to attack mechanical problems on a theoretical basis.

DICKERSON, PATRICIA WOOD

Field Geologist-Geophysicist, Lockheed Martin/NASA Johnson Space Center

Dickerson is engaged in field and classroom training of astronauts/cosmonauts in tectonics and geomorphic analysis; creation of electronic handbooks on global tectonics is an aspect of that instruction. Her research emphasis has been on continental and oceanic rifts and transforms: global patterns in tectonic geomorphology, volcanism, and sedimentation, both temporal and geometric. Comparative studies, especially of Rio Grande and western East African rifts and transforms, have included remote sensing, geophysical, and field structural analyses. Investigations of transform faults have included physical modeling of strike-slip deformation. In the context of Quaternary faults and dating of fault activity, she has developed an isotopic/palynologic technique for determining timing of fault movement through analysis of spring deposits. Other investigations have been in contractional orogenic zones: Ouachita, Laramide (New Mexico through Mexico), the Argentine Precordillera,

north Norwegian Caledonides. She has collaborated in developing and field-testing shallow-penetration seismic instruments and has explored for resources (water, gold, petroleum) in various remote and rigorous environments.

EPPLER, DEAN B.

Field Volcanologist/Spacesuit Test Subject, SAIC, NASA Johnson Space Center

Eppler is presently the prime space suit test subject for advanced planetary EVA system development. He received a B.S. in Geology from St. Lawrence University in 1974, M.S. in Geology from the University of New Mexico in 1976, and Ph.D. in Geology from Arizona State University in 1984. His research has included extensive field work in volcanology and geomorphology in such diverse environments as the Dry Valleys of Antarctica, the interior deserts of Iceland, the Cascade volcanic range in California, and the Rio Grande rift in northern New Mexico. Eppler's work with the advanced EVA system development group has been focused on identifying those elements of EVA suit mobility that are key to the conduct of field geology, and on testing various EVA suit/backpack configurations in the conduct of geologic field work in terrestrial terranes and topographies that are analogs to the lunar and martian environments.

FARMER, JACK

Geologist/Paleontologist, Arizona State University

Farmer is a geologist/paleontologist by training and has field experience in a variety of terrains including Alaska, Arctic Norway, Antarctica, Australia, Mexico, and the deserts of the southwestern U.S. He has also worked at the Ries impact crater site in Germany and in basaltic terrains of Iceland. His recent Mars analog studies have focused on Yellowstone, Wyoming, and on the terminal lake systems of the Great Basin, including Mono and Pyramid Lakes, Nevada. He has participated in several Marsokhod rover trials including Amboy Crater (Mojave), Kilauea, Hawai'i, and most recently on Hopi Lands in northern Arizona. He participated in the JPL Rocky 7 trials at Lavic Lake (Mojave) and will also be involved with the upcoming NASA Ames Marsokhod trial (February, Mojave) and the JPL FIDO trial (successor to Rocky 7) to be held next spring. From the mission-planning standpoint, he has been on many teams in the past 10 years, including the Mars Global Surveyor 2001 Science Definition Team. Currently he is involved with the Mars Expeditions Strategy Planning Group (MESG) at JPL and is a member of the Solar System Exploration Subcommittee (SSES) at NASA Headquarters. He is also lead for ASU-funded astrobiology activities carried out through the NASA Astrobiology Institute; along with 11 other PIs, he is a member of the Executive Board of the Astrobiology Institute.

GARRISON, ROBERT E.

Sedimentologist, University of California at Santa Cruz

Garrison is Professor Emeritus of Earth and Ocean Sciences, University of California at Santa Cruz. His geological interests are in the sedimentology and diagenesis of fine-grained and highly organic sediments. He has carried out field and analytical studies of these kinds of deposits in California, the Middle East, and South America, along with investigations of sediment cores retrieved from the coastal upwelling zones along the Perú margin and in the Mediterranean. Specific interests include the origin of microbially generated sedimentary phosphorites, the formation of authigenic carbonates as a consequence of degradation of organic matter, and sedimentary structures as indicators of paleoenvironments and diagenetic processes. He participated in petrological and electron microscopic studies of lunar samples returned by Apollo 12.

GREELEY, RONALD

Planetary Geologist, Arizona State University

While a research scientist at NASA-Ames Research Center, Greeley was involved in (1) pre-Apollo lunar surface geological studies, (2) field studies of terrestrial analogs for the Moon, (3) wind-tunnel simulations of Mars sand/dust storms, (4) Mars-Mariner 9 data analysis, and (5) site selection for the Viking mission. He has been affiliated with Arizona State University since 1978 and has conducted (1) studies of volcanic rocks and geology for the Viking extended mission, (2) field analog studies of Iceland, Hawai'i, Mt. Etna, Bolivia, (3) Mars 94 preparation, (4) Mars landing site analog studies, (5) Mars rover

tests in the Mojave Desert, at Kilauea volcano, and in the Painted Desert, and (6) studies for the Mars Pathfinder mission. In addition, he has organized NASA field conferences in Hawai'i, the Snake River Plain, and the Mojave Desert; he has chaired a NASA study on Evolution of Climate and Atmosphere of Mars; he has chaired a National Academy of Sciences Committee on Lunar and Planetary Exploration; and he is co-author of the *NASA Atlas of the Solar System*. Greeley was a micropaleontologist with Standard Oil of California before becoming involved in lunar and martian investigations.

HARVEY, RALPH P.

Petrologist — Martian Meteorites, Case Western Reserve University

Harvey is Principal Investigator and Field Team leader for the Antarctic Search for Meteorites (ANSMET) project (funded by Office of Polar Programs, NSF). He has led eight and participated in two 45-day-long field seasons, operating under conditions of hostile climate, significant isolation, and complete self-sufficiency. He is a Principal Investigator in the NASA Ancient Martian Meteorite program, and long-time researcher on martian meteorites in general. Ralph has produced a wide variety of publications on martian meteorites, including several on ALH84001, focusing on igneous petrology and its relevance to the history and environment of Mars. Other field experience includes geochemical and petrologic studies of basaltic rocks in Iceland, northern Ontario, the Appalachians and New Zealand, and studies of micrometeorites in aeolian sediments, salt deposits, and polar ice. Laboratory research typically involves study of mineral chemistry and texture by means of electron microprobe, transmission electron microscope and scanning electron microscope.

JONES, THOMAS D.

Astronaut/Planetary Scientist, Johnson Space Center

Jones earned his Ph.D. in planetary science from the University of Arizona. His research interests included the remote sensing of asteroids, meteorite spectroscopy, and applications of space resources. He was a program management engineer at the CIA Office of Development and Engineering. While with Science Applications International Corp., he performed advanced program planning for the NASA Solar System Exploration Division, investigating future robotic missions to Mars, asteroids, and the outer solar system. Prior to pursuing doctoral work, Jones graduated from the U.S. Air Force Academy and served as an Air Force pilot, having commanded the combat crew of a B-52D Stratofortress. Jones has logged over 40 days (963 hours) in space. He flew as a mission specialist on successive flights of *Endeavour* (STS 59 and STS 68), both of which demonstrated advanced synthetic aperture radar technology (Space Radar Lab) in investigations across the range of the Earth sciences. On STS 80, while helping set a shuttle endurance record of nearly 18 days in orbit, he used the robot arm of Columbia to release the Wake Shield satellite and later grapple it from orbit. Jones is now chief of the Astronaut Office Station Operations Branch, helping plan the construction and operation of the International Space Station. He is assigned to fly next on Space Station Assembly Mission 5A, STS-98, scheduled for early 2000. The *Endeavour* crew will deliver the U.S. laboratory module to the space station; Jones will help install the lab with a series of three spacewalks. He hopes that success with ISS will lead quickly to long-duration missions beyond low-Earth orbit.

LIPPS, JERE H.

Field Paleontologist/Marine Biologist, University of California, Berkeley

Lipps is a field paleontologist and marine biologist, who has worked extensively in both disciplines (also in field geology) at sites all around the world since 1960. He has taught field geology, paleontology and marine biology at sites in California, Nevada, and French Polynesia. Paleontologic sites for research include East Africa (Pleistocene hominid-bearing lakes), White Sea of Russia (Vendian fossils), Western U.S. (Tertiary, Mesozoic, Paleozoic, and Precambrian fossil-bearing marine sed), Australia (Precambrian of the Kimberleys), Siberia (Vendian, Cambrian), Kazakhstan (Cambrian), Papua New Guinea (Pleistocene reefs, Eocene sediments), and Hawai'i-Tahiti (Deep Sea Drilling Project Leg 8). Marine biology research sites include Antarctica (Palmer Station, McMurdo, and Ross Ice Shelf), Enewetak Atoll, Papua New Guinea (Papuan and Madang Lagoons), French Polynesia, California and Baja California, Lizard Island (Great Barrier Reef), Bimini, Palau, and others where he studied living invertebrates and foraminifera for comparison to, and understanding of, fossil organisms.

MASSELL, WULF***Field Geophysicist/Petroleum Explorationist, Epic Geophysical Co.***

Massell has operational seismic crew and equipment experience in swamps, deserts, jungles, and polar plateaus and has worked for more than a year in Antarctica. He is familiar with most near-surface geophysical methods and, while on the faculty at the University of Texas-Austin, Wulf established the first geophysical field-methods course offered by the Department of Geological Sciences. He has conducted geologic mapping in the Rocky Mountains, the Mid-Continent (flat rocks), and in the Big Bend of west Texas. In support of survey planning he has carried out photo reconnaissance work for near-surface geological, geomorphological, and hazards studies. He has some familiarity with remotely operated (downhole) tools and data, including well logs. Massell now specializes in processing data from 2-D and 3-D seismic surveys as applied in petroleum exploration. The volume of 3-D seismic data can be so large (tens of gigabytes) that data compression schemes are now under development; such techniques will be important in transmitting seismic data from Mars. While working in Antarctica, Massell directed some thought toward selection criteria for a team that might travel to Mars and back.

MUEHLBERGER, WILLIAM R.***Field Geologist/Tectonicist/Astronaut Instructor, The University of Texas at Austin***

Muehlberger and his students have made geologic maps of many regions of Central and North America, the Dead Sea fault zone in Turkey, and of the Moon. Lunar mapping included the fold belts on the mare surfaces; an interpretation of the tectonic history of the Apollo 17 landing site accompanied maps of the area. Bill has been involved in geological training of astronauts since 1964: He was Principal Investigator of the Apollo Field Geology Experiment for Apollo Missions 16 and 17, in addition to serving as co-investigator for the Earth Observations Experiment for Skylab 4 and the Apollo-Soyuz mission. Since inception of the Space Shuttle program, he has been part of the Earth Observations team at Johnson Space Center, and he has now begun training crews for International Space Station.

RICE, JIM***Astrogeologist, University of Arizona***

Rice is a member of the Imaging Team of the '98 Mars South Polar Lander at the Lunar and Planetary Laboratory at the University of Arizona. He specializes in martian periglacial, fluvial, and lacustrine geomorphology and is currently working on the fluvial geomorphology and history of the Mars Pathfinder landing site. He is also involved with landing site selection for the '98 Mars South Polar Lander and 2001 Mars Surveyor Lander. Rice has also been a field team member on Mars rover tests and worked on a Manned Mars Mission Study at Marshall Space Flight Center. Rice has conducted Mars analog field investigations in the Antarctic, Arctic, Iceland, Channeled Scabland of Washington, and the deserts of Arizona, California, and Mexico. He was a member of the first joint NASA/Russian expedition to the ice-free regions of eastern Antarctica. He spent six months on this joint scientific expedition where he conducted geologic and geomorphic field investigations and was also a Research Diver on the SCUBA Diving Team, which explored the ice covered lakes of this region. Rice has spent the last two years conducting field investigations at the Haughton impact crater on Devon Island in the High Arctic. This summer he'll conduct further field work in both the Haughton impact crater and Iceland.

SPUDIS, PAUL***Planetary Geologist, Lunar and Planetary Institute (Houston)***

Spudis is a geologist who received his education at Arizona State University (B.S., 1976; Ph. D., 1982) and at Brown University (Sc.M., 1977). Since 1982, he has been a Principal Investigator in the Planetary Geology Program of the NASA Office of Space Science, Solar System Exploration Division, specializing in research on the processes of impact and volcanism on the planets. He has served on NASA's Lunar and Planetary Sample Team (LAPST), which advises on allocations of lunar samples for scientific research, the Lunar Exploration Science Working Group (LEXSWG), that devised scientific strategies of lunar exploration, and the Planetary Geology Working Group, which monitors overall directions in the planetary research

community. He has also been a member of the Committee for Planetary and Lunar Exploration (COMPLEX), an advisory committee of the National Academy of Sciences, and the Synthesis Group, a White House panel that in 1990–1991 analyzed a return to the Moon to establish a base and the first human mission to Mars. He was Deputy Leader of the Science Team for the Department of Defense Clementine mission to the Moon in 1994. He is the author or co-author of more than 100 scientific papers and two books, including his most recent, *The Once and Future Moon*, which was published in the Smithsonian Library of the Solar System series for the general public.

WESTALL, FRANCES

Micropalaeontologist/Exobiologist, NRC-Johnson Space Center

Westall's principal expertise is in the field of fossil bacteria and bacterially produced biofilms. She is experienced in working with the modern microbial environment (shallow- to deep-water marine environments, among others) and with biofilm formation in nature and in the laboratory. She has conducted research in the experimental fossilization of bacteria. Westall has studied fossil bacteria and biofilms from different parts of the rock record, representing different types of microbial environments: (1) silicified marine bacteria and biofilms from the Early Miocene (South Atlantic Ocean); (2) phosphatized bacteria from a reducing volcanic lake, Early Eocene (southern Germany); (3) silicified bacteria and biofilms from the 3.3 to 3.5 Ga Early Archean terrains of the Barberton greenstone belt, South Africa, and the Pilbara Craton, Australia.