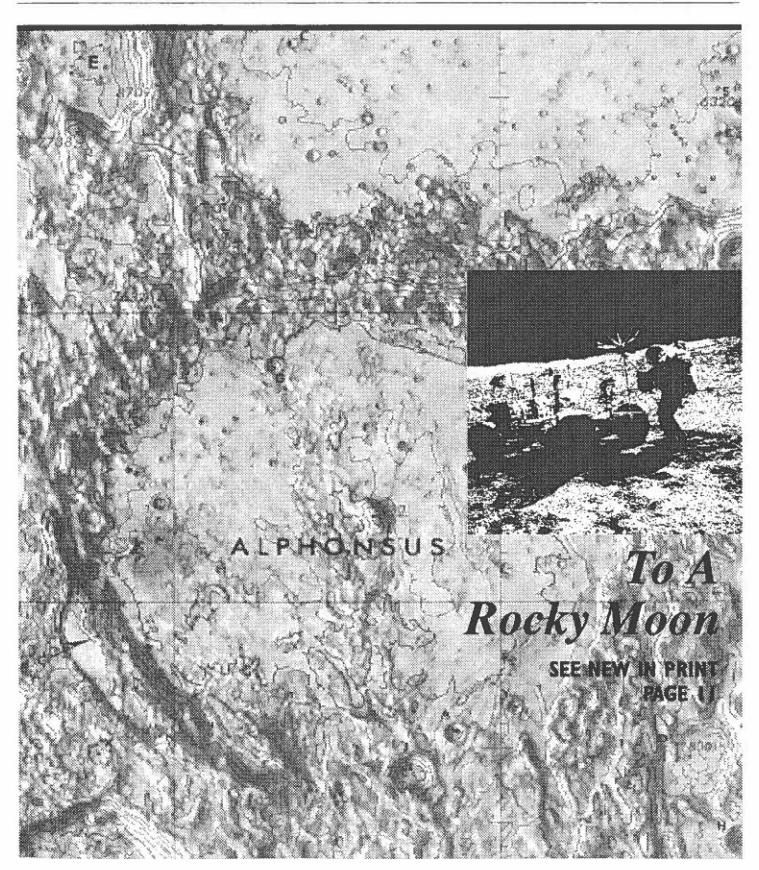
BULLETIN BULLETIN



MAY 1993/NUMBER 67 - LUNAR AND PLANETARY INSTITUTE - UNIVERSITIES SPACE RESEARCH ASSOCIATION



LPI PROGRAM SERVICES/PUBLICATIONS DEPARTMENTS REORGANIZE

SEEK TO EXPAND TRADITION OF HIGH-QUALITY SERVICES AND COST EFFECTIVENESS

Longtime Manager
Pamela A. Jones Will Leave
the Institute after 18 Years

After 18 years with the Lunar and Planetary Institute, Pamela A. Jones has resigned to move to the Washington, DC area. She leaves the post of Manager of Program Services where she has served with great distinction, overseeing the variety of meetings, workshops, conferences, and review panels sponsored by LPI for the planetary science community.

"It never occurred to me so many years ago, when I apprehensively accepted the job of organizing my first scientific meeting for LPI, that more than 200 would follow, taking me literally around the world in the process!" Jones said recently. "We all learned as we went, determined to make the next project better than the last. I always began with the premise that every individual is important—that the views and suggestions of each deserve a hearing and a reasonable response. While it probably can't be said that we've ever done a truly 'perfect' meeting, that quest has become a hallmark of our efforts," she noted with obvious pride.

"The dedicated people at LPI and members of the scientific community we serve have become my second family, and

they number among my closest and dearest friends. So it's with profoundly mixed feelings that I move on to meet the challenges of a new post in Washington. I hope it will allow me to maintain close ties with the community that I've grown to value far more than I can say."

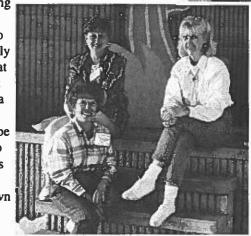


"Under Pam's leadership, the LPI has become known internationally for the quality of its workshops and conferences," said David Black, Director of the Institute. "That comes from a high level of staff dedication and support for NASA's planetary program, and from person-toperson relationships built up over years of activity. Pam is the example par excellence of this dedication and support, and she has infused that spirit in her staff. Her leadership will be missed."



Ms. Jones is well known to the planetary community in a variety of roles!





TIME OF TRANSITION FOR SUPPORT DEPARTMENTS

During this time of transition, Black has taken an intensive look at the current tasks of the Program Services Department and the Publications Services Department as well as what their future roles are likely to be. The desire to take advantage of developments in electronic dissemination of information from both offices and to seek additional ways to hold costs down for meetings and meeting-related publications led him to combine the departments under a single umbrella.

"Increasingly, both departments were facing common problems of rising costs in an extremely constrained budgetary environment. Emerging technologies that might be one avenue for maintaining services while holding the line on costs also have application in both departments," commented Black. "By combining the meeting-to-publication process under a single manager, we see ways to increase operational efficiency through effective use of publications-related technology, as well as through crosstraining of the combined staff."

The newly consolidated department, known as Publications and Program Services, will be managed by Mary H. Cloud, formerly Manager in the Publications Services Department. "We intend to not only continue but to expand the extremely high standards of service and user-friendliness to the community that have been established over the years," commented Cloud, "In these budget-conscious times, we want to make every effort to work with conveners and authors to hold costs down."

KEEPING MEETING COSTS DOWN

NASA program offices are exploring ways to trim meeting costs as well. An obvious way is to select meeting facilities that are already supported by NASA (such as Washington, DC and LPI in Houston). The advantages of these venues are many. They are located at hub airports, eliminating expensive travel hops to locations that are more difficult to reach. Scientific and program personnel are readily available for consultation.

Tammy Dickinson, Discipline Scientist for Planetary Materials and Geochemistry in NASA's Solar System Exploration

Division described the effort, "Our goal is to keep the overall costs of meetings to a minimum, including conserving civil servant travel funds when appropriate. In the current budgetary climate it is undesirable to hold meetings in exotic locations or where meeting facilities must be rented, "she cautioned, "Meeting locations other than Washington, DC, LPI, or other NASA/Government facilities will need to be justified in detail, on an individual basis."

A NASA-funded facility, LPI provides many support services such as a highly experienced staff, a variety of meeting rooms and gathering places, records of past deliberations on file, word-processing facilities, graphic arts and editorial staff, extensive computer facilities, and electronic networking capabilities.



Incoming manager, Mary Cloud plans to explore ways in which the consolidated department can use electronic communications to organize meetings and publish results quickly.

COMMUNITY EFFORT SOUGHT

In planning cost-effective meetings and publications the community has a large role to play in defining its future. In restructuring and reorganizing, LPI personnel (as well as the academic community as a whole) struggle with broad issues of electronic meeting formats and dissemination of data, peer reviewing, and archiving. Traditional methods will be reexamined in light of emerging technologies. "By working closely with our community at every step, I feel that we can arrive at the best solutions, upholding a tradition of responsiveness to its needs and responsibility to funding concerns," said Cloud.

"ONE-STOP SHOPPING" FOR MEETINGS AND RELATED PUBLICATIONS

In addition to being a NASA-funded facility capable of housing meetings of various sizes, the LPI's expert staff in Publications and Program Services offers the following comprehensive support services.

- Costing and drafting budgets; monitoring meeting and travel budgets
- Procurement of all meeting-related services, e.g., meeting rooms, hotels, caterers, audio-visual computer equipment, transportation, meeting support personnel, and other vendors
- Communication of meeting information through announcements, correspondence, and newsletters
- Receipt of abstracts, author information, and copyright status
- Assistance to program committees with program and meeting logistics
- Production, printing, and distribution of abstract volumes, technical reports, program booklets, and other meetingrelated documents
- Receipt of registration information and fees; badging, receipts, etc.
- Communication with NASA and other agency program managers, heads of panels and working groups, and conveners to determine scheduling, appointments of panel/working group members, budgetary constraints, etc.
- Administration and supervision of peer review of proposals received in response to NASA Research Announcements (NRAs)
- Maintainance of extensive filing system for electronic and physical storage of tens of thousands of confidential documents relating to panel and working group activities. This information is accessible on demand for program managers, panel and working group members.
- Administration of travel arrangements and documentation and reimbursement of travel expenses
- On-site management of meetings, ancillary field trips, working groups, and review panels
- Technical writing, copyediting, and proofreading services
- Desktop publishing and typesetting services
- Graphical design and illustration services
- Computer networking

NEWS FROM SPACE

MICRODIAMONDS CHALLENGE GALAXY EVOLUTION THEORIES



PHOTO NO: 579-29461

A piece of the microdiamond-bearing meteorite Allende.

Scientists at NASA Ames Research Center have observed huge amounts of microscopic diamonds in star-forming clouds in the Milky Way galaxy. In the thin space between clouds, however, softer hydrocarbons are prevalent. The two kinds of interstellar hydrocarbon dust apparently don't mix very much despite the galaxy's rotational motion.

"We thought that the dust and chemicals in spiral galaxies — rotating pinwheels of stars — mixed freely over relatively short astronomical periods," said Lou Allamandola, head of the science observation team. "We were looking at star-forming clouds expecting to find simpler forms of hydrocarbons, molecules that make up materials similar to candle wax or gasoline," he said.

"Instead of finding the expected simpler hydrocarbon molecules we found large quantities

— the equivalent of planetary masses — of microdiamonds dominating every starforming cloud we looked at. This shoots a hole in a major premise of galactic chemical evolution theories," science team member Scott Sandford said.

"The surprise is that in the dense clouds, the waxy, saturated hydrocarbons are not there. Because of the slowly spinning spiral arms of the galaxy, we assumed they would be mixing," Allamandola said.

"The current theory is that star-forming clouds form by gravitational forces in space. As their masses increase, so do the gravitational forces. Eventually stars ignite in the densest regions in galaxies. The pressure from the light in new stars pushes outward, breaking up the remains of the clouds and pushing all the left-over material from the clouds out into space. Then the cycle starts again," Sandford said.

"The carbon crystals of microdiamonds are good tracers because they're tough enough to stand getting kicked in and out of a star-forming cloud. You would expect to see them in both dense clouds and in the near-empty space between them," he said.

"You would expect to find other materials such as ice crystals only in one environment. Ice crystals are present in dense clouds but don't survive in the diffuse regions between them because of heat and searing radiation. Once formed in the dusty, cold clouds, the ices are cooled and protected," said Xander Tielens, another team member.

"Apparently the shorter chains of saturated hydrocarbons do not survive the transit into dense clouds. This means that we don't understand how matter moves in and out of these clouds. This means that our models of galaxy evolution are flawed," Sandford said.

"In retrospect, our discovery of microscopic diamonds should not have come as a surprise, because they previously have been found in several types of primitive meteorites," Allamandola said. The team's observations from Hawaii's Mauna Kea infrared telescope found microdiamonds to be widespread and very abundant, comprising 10–20% of all interstellar carbon. This suggests that uncommon star types or relatively rare supernova need not be invoked as the sources of the diamond-bearing meteorites.

NASA AND RUSSIAN SPACE AGENCY SIGN MARS '94 CONTRACT

ASA Administrator Daniel S. Goldin and Russian Space Agency (RSA) Director Yuri Koptev have signed a contract with a potential value of \$1.5 million to fly two U.S. Mars Oxident Experiment (MOX) instruments on the Russian Mars '94 Mission. The mission to be launched in November 1994 will deploy small landing stations and penetrators and carry instruments to study the martian surface and atmosphere.

Under the contract, the Babakin Engineering Research Center, Moscow, and the Space Research Institute of the Russian Academy of Sciences, Moscow, will provide technical services for integrating and testing the U.S. MOX instruments. A duplicate MOX instrument will fly on each of the two Russian small stations. These instruments will conduct soil reactivity/composition experiments to provide chemical information about the volatile components in the martian soil. These experiments will enable scientists to characterize the martian physical and chemical surface environment.

Subject to appropriation of funds in FY 94, NASA plans to exercise an option under the contract to procure an engineering model of the Mars '94 small station. This will allow NASA to perform integration tests with the U.S.-supplied flight instrument systems in preparation for integration on the flight models with minimal impact to existing instrumentation. The model also will improve NASA's understanding of lander technology for future Mars missions.

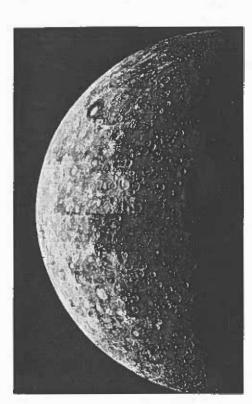
I DISCOVERY MISSION CONCEPTS CHOSEN FOR STUDY THIS YEAR

n February, NASA announced the selection of 11 new science mission concepts in the Discovery Program for further study during this fiscal year. Discovery missions are designed to proceed from development to flight in less than 3 years, combining well-defined objectives, proven instruments and flight systems, costs limited to no more than \$150 million and acceptance of a greater level of risk.

"The Discovery Program is probably the most exciting new initiative in planetary exploration," said Dr. Wes Huntress, Associate Administrator of NASA's Office of Space Science. "We now will be able to more effectively take advantage of emerging technology and quickly—and relatively cheaply—undertake more new missions of discovery than at anytime since the beginning of the space age. Also, because of the shorter time frames and lower costs, these missions will allow greater participation from the academic and aerospace communities," Huntress said.

Mission Concepts

- Mercury Polar Flyby: study the polar caps and complete the photographic reconnaissance of the planet. Principal Investigator (PI): Paul D. Spudis, Lunar and Planetary Institute
- Hermes Global Orbiter to Mercury: remote sensing of the surface, atmosphere, and magnetosphere. PI: Robert Nelson, Jet Propulsion Laboratory
- Venus Multiprobe Mission: placement of 14 small entry probes over one hemisphere to measure winds, temperature, and pressure. Pl: Richard Goody, Harvard University
- Venus Composition Probe: measure atmospheric structure and composition on a parachute descent during daylight. PI: Larry W. Esposito, University of Colorado, Boulder



- Cometary Coma Chemical Composition: rendezvous with a cometary nucleus at or near perihelion and conduct 100 days of scientific operations. PI: Glenn C. Carle, NASA Ames Research Center
- Mars Upper Atmosphere Dynamics, Energetics, and Evolution Mission: study upper atmosphere and ionosphere. Pl: Timothy Killeen, University of Michigan, Ann Arbor
- Comet Nucleus Tour: study of three comets during a 5-year mission, focusing on structure and composition of the nucleus. Pl: Joseph Veverka, Cornell University
- Small Missions to Asteroids and Comets: four separate spacecraft launches to study distinctly different types of comets and asteroids. PI: Michael Belton, National Optical Astronomy Observatories
- Near-Earth Asteroid Returned Sample: acquire and return samples from six sites on a near-Earth asteroid. Pl: Eugene Shoemaker, U.S. Geological Survey, Flagstaff
- Earth Orbital Ultraviolet Jovian Observer: study the Jovian system from Earth orbit with a spectroscopic imaging telescope. Pl: Paul Feldman, Johns Hopkins University
- Solar Wind Sample Return: collect and return solar wind material to Earth. PI: Don Burnett, Caltech

Other Concepts to be Considered

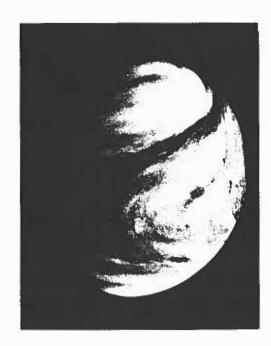
Three other concepts will be considered further this year. They include a Mainbelt Asteroid Rendezvous Explorer, a Comet Nucleus Penetrator, and a Mars Polar Pathfinder. "It was a difficult task narrowing the list down," said Dr. Richard Vorder Bruegge, a member of the Discovery Advanced Study Review Group that made the selections. "The formal selection process will be open to all interested parties. Anyone will be able to submit a proposal for a Discovery mission in the formal competition. These proposals will have to be more extensive than the studies and include science rationale, spacecraft design, observations, data systems — a start-to-finish proposal for a new mission."

PIONEER DATA BOLSTERS CASE FOR A ONCE-WET VENUS

The Pioneer Venus Orbiter spacecraft has provided new evidence that ancient Venus may have had three and a half times more water than even advocates of a once-wet Venus thought—enough water to cover the entire surface between 25 and 75 feet deep. Pioneer entered Venus' atmosphere on October 8, 1992 and burned up soon after, ending 14 years of exploration.

"Many of us have long thought that early in its history Venus had temperate conditions and oceans like Earth's," said Dr. Thomas Donahue, University of Michigan, head of the Pioneer Venus science steering group. "Findings that Venus was once fairly wet does not prove that major oceans existed, but make their existence far more likely. The new Pioneer data provides evidence that large amounts of water were definitely there," said Donahue.

"Most scientists think Venus' early oceans vaporized and 'blew off' 3 billion years ago in a runaway greenhouse effect when the cool early Sun increased its luminosity and heated the planet very hot," he said. "The oceans evaporated. Solar ultraviolet radiation split the water molecules into hydrogen and oxygen, and the hydrogen was lost to space. Pioneer Venus Probe and Orbiter data showed early in the mission that, on Venus, heavy hydrogen (deuterium) is 150 times more abundant relative to ordinary hydrogen than on Earth and everywhere else we've looked in the solar system — Mars, Comet Halley, meteorites, Jupiter, and Saturn." Venus' unusual hydrogen/deuterium ratio has since been confirmed by independent measurements.



Abundant deuterium is taken as evidence that Venus once had 150 times as much water in its atmosphere as today, he said. As water molecules split, the lighter isotope ("ordinary" hydrogen) would readily escape to space. But most of the heavier isotope, deuterium, (twice the mass of ordinary hydrogen) would be retained by gravity. Donohue believes his reexamination of Pioneer data supports a 3.5 times greater hydrogen abundance on early Venus than is indicated by the hydrogen/deuterium ratio observed.

"We found a new and important easy-escape mechanism, which accelerates hydrogen and deuterium away from the planet," Donohue said. "This means that much more hydrogen had to escape to build up the present high deuterium concentration. A lot more hydrogen lost means a lot more water early on," he said. "This also rules out theories of a dry-from-the-beginning Venus, whose present meager supply of water comes from an occasional comet impact." Working with Donahue were Drs. Richard Hartle and Joseph Grebowsky of NASA's Goddard Space Flight Center.

RUSSIANS TEST FIRST SOLAR SAIL FOR ILLUMINATION

The first ever solar sail deployment occurred on the night of February 3 from a robot supply ship docked to Russia's space station Mir. The Progress ship undocked and then unfurled a 66-ft-diameter umbrella-shaped reflector. The objective was to see if a spherical reflector could be deployed and oriented to reflect light (similar to full-moon illumination) to a spot on the ground—perhaps for use in lighting cities at night or other regions that do not receive much light in winter.

Reports from Europe indicate that even though the experiment lasted only five hours, a bright light was seen from Switzerland, France, and other areas, but details are sketchy. The project, known as Banner, will be repeated in the future. The February deployment was a technology demonstration experiment for giant 600-ft-diameter reflectors that the Russians have proposed deploying to illuminate regions on Earth. The concept is somewhat troubling to those concerned with orbital debris and possible interference with groundbased astronomical research.

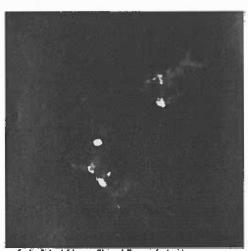
(Courtesy of Paul Maley, Starscan: Newsletter of the JSC Astronomical Society)

HST REVEALS GROWTH PROCESSES OF YOUNG STAR

ASA's Hubble Space Telescope (HST) has provided astronomers with their clearest look yet at a vast cloud of gas being heated by the birth of a new star. Called Herbig-Haro object #2 (HH-2), the cloud is heated by shock waves from jets of high-speed gas being ejected from a newborn star. Because the star itself is embedded in a dusty cocoon, HH-2 provides the only visible clues to physical processes occurring in the young star.

The Hubble observations made with the Wide Field/Planetary Camera provide new insight into similar events that probably occurred when our Sun and solar system formed 4.6 billion years ago. "The fine detail, never before seen in such objects, provides a challenge to astronomers who are attempting to model the physical processes associated with star formation," said Dr. Richard D. Schwartz, of the University of Missouri at St. Louis.

Dr. Schwartz and an international team of astronomers used Hubble to obtain detailed images which "reveal a rich array of structures with diameters of a few billion



Credic Richard Schwartz (Univ. of Missouri, Sc. Louis)

miles, comparable to the size of the solar system," according to Schwartz. He explained, "The existence of such small features was unexpected based upon earlier images obtained with groundbased telescopes."

HH-2 is one of several peculiar nebulae first discovered by American astronomer George Herbig and Mexican astronomer Guillermo Haro in the early 1950s. The nebula has been an enigma to astronomers because of its irregular, somewhat chaotic appearance. The nebula differs from the regular, symmetric bow-shock structures seen in other HH objects. Such bow-shock structures have the shape of a wave that leads a boat traveling through water. Schwartz said that the structures in HH-2 may result from the fragmentation of a bow-shock at the head of a gas jet coming from the young star.

HH-2 lies at a distance of about 1500 light-years, in a star-forming region of the constellation Orion. The object is located at the leading edge of a supersonic gas flow that emanates from a young star located about 1/2 light-year from the object. The star is detectable only with infrared and radio telescopes.

The high-speed jets that create HH-2 form as a young star contracts under its own gravitational pull. The star reaches a stage where it releases a strong outflow of gas. A thick disk of cool gas and dust around the star, perhaps coupled with a strong magnetic field, forces the hot gas to squirt outward along the system's rotational axis. This forms a pair of narrow jets that plow through the gas of the parent cloud in the star formation region. Gas shoots away from the star at velocities of up to 500,000 miles per hour.

The supersonic flow forms strong shock waves, heating gas in the parent cloud to temperatures more than 200,000°F (93,000°C). Though a cocoon of dust obscures the star from view, the effects of the jets can be seen across great distances. The hot gas radiates energy in visible light associated with atoms of hydrogen, oxygen, nitrogen, sulfur, and other common elements, forming the structure of a Herbig-Haro object. HH objects offer clues about the nature of young stellar objects. "The energetics, degree of collimation, and evolutionary time scales of HH objects all serve to constrain models of the environment and physical properties of the young stellar object at the center of the outflow," said Schwartz.

Co-investigators are Martin Cohen (Univ. of California-Berkeley), Burton Jones (Univ. of California-Santa Cruz), Karl-Heinz Bohm (Univ. of Washington), John Raymond and Lee Hartmann (Harvard-Smithsonian Center for Astrophysics), Reinhard Mundt (Max-Planck-Institüt für Astronomie), Michael Dopita (Mt. Stromlo and Siding Spring Observatories, Australia), and Angie Schultz (graduate student at Washington Univ., St. Louis).



PUBLICATIONS FROM LPI

2.47	CODE	TITLE	PRICE	TOTA
		BOOKS		
	B-ACM	ASTEROIDS, COMETS, METEORS 1991	\$80.00	- 370
	PRO-22	PROCEEDINGS OF LUNAR AND PLANETARY SCIENCE, VOLUME 22	\$25.00	
	PRO-20	PROCEEDINGS OF THE TWENTIETH LUNAR AND PLANETARY SCIENCE CONFERENCE	\$25.00	
	B-ORIGINS	ORIGIN OF THE MOON	\$15.00	
	B-BASES	LUNAR BASES AND SPACE ACTIVITIES OF THE 21ST CENTURY	\$15.00	
	B-PLANS	PLANETARY SCIENCE: A LUNAR PERSPECTIVE (SPECIAL PRICE; SLIGHTLY DAMAGED)	\$5.00	
		SLIDE SETS		
	S-IMPACT	TERRESTRIAL IMPACT CRATERS	\$18.00	
	S-WINDS	THE WINDS OF MARS: AEOLIAN ACTIVITY AND LANDFORMS	\$18.00	
	S-STONES	STONES, WIND, AND ICE: A GUIDE TO MARTIAN IMPACT CRATERS	\$18.00	
	S-VOLC	VOLCANOES ON MARS	\$15.00	
	S-APOLLO	APOLLO LANDING SITES	\$20.00	
	S-OCEANS	SHUTTLE VIEWS THE EARTH: THE OCEANS FROM SPACE	\$20.00	
	S-CLOUDS	SHUTTLE VIEWS THE EARTH: CLOUDS FROM SPACE	\$20.00	
	S-GEOL	SHUTTLE VIEWS THE EARTH: GEOLOGY FROM SPACE	\$20.00	
		TECHNICAL REPORTS AVAILABLE FOR THE COST OF SHIPPING AND	HANDLING,	EXCEPT
	88-03	ASTRONAUT'S GUIDE TO TERRESTRIAL IMPACT CRATERS	\$4.00	EXCEPT
	90-05	ASTRONAUT'S GUIDE TO TERRESTRIAL IMPACT CRATERS WORKSHOP ON COSMOGENIC NUCLIDE PRODUCTION RATES	\$4.00 \$0.00	EXCEPT
		ASTRONAUT'S GUIDE TO TERRESTRIAL IMPACT CRATERS	\$4.00	EXCEPT
	90-05	ASTRONAUT'S GUIDE TO TERRESTRIAL IMPACT CRATERS WORKSHOP ON COSMOGENIC NUCLIDE PRODUCTION RATES	\$4.00 \$0.00	EXCEPT
	90-05 91-01	ASTRONAUT'S GUIDE TO TERRESTRIAL IMPACT CRATERS WORKSHOP ON COSMOGENIC NUCLIDE PRODUCTION RATES WORKSHOP ON PRODUCTION AND USES OF SIMULATED LUNAR MATERIALS TOWARDS OTHER PLANET'ARY SYSTEMS (TOPS): A TECHNOLOGY	\$4.00 \$0.00 \$0.00	EXCEPT
	90-05 91-01 92-01	ASTRONAUT'S GUIDE TO TERRESTRIAL IMPACT CRATERS WORKSHOP ON COSMOGENIC NUCLIDE PRODUCTION RATES WORKSHOP ON PRODUCTION AND USES OF SIMULATED LUNAR MATERIALS TOWARDS OTHER PLANET'ARY SYSTEMS (TOPS): A TECHNOLOGY NEEDS ASSESSMENT WORKSHOP	\$4.00 \$0.00 \$0.00 \$0.00	EXCEPT
	90-05 91-01 92-01 92-02	ASTRONAUT'S GUIDE TO TERRESTRIAL IMPACT CRATERS WORKSHOP ON COSMOGENIC NUCLIDE PRODUCTION RATES WORKSHOP ON PRODUCTION AND USES OF SIMULATED LUNAR MATERIALS TOWARDS OTHER PLANET: ARY SYSTEMS (TOPS): A TECHNOLOGY NEEDS ASSESSMENT WORKSHOP WORKSHOP ON THE MARTIAN SURFACE AND ATMOSPHERE THROUGH TIME WORKSHOP ON THE PHYSICS AND CHEMISTRY OF MAGMA OCEANS	\$4.00 \$0.00 \$0.00 \$0.00	EXCEPT
	90-05 91-01 92-01 92-02 92-03	ASTRONAUT'S GUIDE TO TERRESTRIAL IMPACT CRATERS WORKSHOP ON COSMOGENIC NUCLIDE PRODUCTION RATES WORKSHOP ON PRODUCTION AND USES OF SIMULATED LUNAR MATERIALS TOWARDS OTHER PLANET'ARY SYSTEMS (TOPS): A TECHNOLOGY NEEDS ASSESSMENT WORKSHOP WORKSHOP ON THE MARTIAN SURFACE AND ATMOSPHERE THROUGH TIME WORKSHOP ON THE PHYSICS AND CHEMISTRY OF MAGMA OCEANS FROM 1 BAR TO 4 MBAR	\$4.00 \$0.00 \$0.00 \$0.00 \$0.00	EXCEPT
	90-05 91-01 92-01 92-02 92-03 92-05	ASTRONAUT'S GUIDE TO TERRESTRIAL IMPACT CRATERS WORKSHOP ON COSMOGENIC NUCLIDE PRODUCTION RATES WORKSHOP ON PRODUCTION AND USES OF SIMULATED LUNAR MATERIALS TOWARDS OTHER PLANET'ARY SYSTEMS (TOPS): A TECHNOLOGY NEEDS ASSESSMENT WORKSHOP WORKSHOP ON THE MARTIAN SURFACE AND ATMOSPHERE THROUGH TIME WORKSHOP ON THE PHYSICS AND CHEMISTRY OF MAGMA OCEANS FROM 1 BAR TO 4 MBAR WORKSHOP ON THE EVOLUTION OF THE MARTIAN ATMOSPHERE	\$4.00 \$0.00 \$0.00 \$0.00 \$0.00 \$0.00	EXCEPT
	90-05 91-01 92-01 92-02 92-03 92-05 92-06	ASTRONAUT'S GUIDE TO TERRESTRIAL IMPACT CRATERS WORKSHOP ON COSMOGENIC NUCLIDE PRODUCTION RATES WORKSHOP ON PRODUCTION AND USES OF SIMULATED LUNAR MATERIALS TOWARDS OTHER PLANET:ARY SYSTEMS (TOPS): A TECHNOLOGY NEEDS ASSESSMENT WORKSHOP WORKSHOP ON THE MARTIAN SURFACE AND ATMOSPHERE THROUGH TIME WORKSHOP ON THE PHYSICS AND CHEMISTRY OF MAGMA OCEANS FROM 1 BAR TO 4 MBAR WORKSHOP ON THE EVOLUTION OF THE MARTIAN ATMOSPHERE JOINT WORKSHOP ON NEW TECHNOLOGIES FOR LUNAR RESOURCE ASSESSMENT WORKSHOP ON INNOVATIVE INSTRUMENTATION FOR THE IN SITU STUDY OF	\$4.00 \$0.00 \$0.00 \$0.00 \$0.00 \$0.00 \$0.00	EXCEPT
	90-05 91-01 92-01 92-02 92-03 92-05 92-06 92-07	ASTRONAUT'S GUIDE TO TERRESTRIAL IMPACT CRATERS WORKSHOP ON COSMOGENIC NUCLIDE PRODUCTION RATES WORKSHOP ON PRODUCTION AND USES OF SIMULATED LUNAR MATERIALS TOWARDS OTHER PLANET: ARY SYSTEMS (TOPS): A TECHNOLOGY NEEDS ASSESSMENT WORKSHOP WORKSHOP ON THE MARTIAN SURFACE AND ATMOSPHERE THROUGH TIME WORKSHOP ON THE PHYSICS AND CHEMISTRY OF MAGMA OCEANS FROM 1 BAR TO 4 MBAR WORKSHOP ON THE EVOLUTION OF THE MARTIAN ATMOSPHERE JOINT WORKSHOP ON NEW TECHNOLOGIES FOR LUNAR RESOURCE ASSESSMENT WORKSHOP ON INNOVATIVE INSTRUMENTATION FOR THE IN SITU STUDY OF ATMOSPHERE-SURFACE INTERACTIONS OF MARS, PARTS 1 & 2	\$4.00 \$0.00 \$0.00 \$0.00 \$0.00 \$0.00 \$0.00 \$0.00	EXCEPT
	90-05 91-01 92-01 92-02 92-03 92-05 92-06 92-07 92-04	ASTRONAUT'S GUIDE TO TERRESTRIAL IMPACT CRATERS WORKSHOP ON COSMOGENIC NUCLIDE PRODUCTION RATES WORKSHOP ON PRODUCTION AND USES OF SIMULATED LUNAR MATERIALS TOWARDS OTHER PLANET; ARY SYSTEMS (TOPS): A TECHNOLOGY NEEDS ASSESSMENT WORKSHOP WORKSHOP ON THE MARTIAN SURFACE AND ATMOSPHERE THROUGH TIME WORKSHOP ON THE PHYSICS AND CHEMISTRY OF MAGMA OCEANS FROM 1 BAR TO 4 MBAR WORKSHOP ON THE EVOLUTION OF THE MARTIAN ATMOSPHERE JOINT WORKSHOP ON NEW TECHNOLOGIES FOR LUNAR RESOURCE ASSESSMENT WORKSHOP ON INNOVATIVE INSTRUMENTATION FOR THE IN SITU STUDY OF ATMOSPHERE-SURFACE INTERACTIONS OF MARS, PARTS 1 & 2 WORKSHOP ON CHEMICAL WEATHERING ON MARS, PARTS 1 & 2 WORKSHOP ON THE SPACE ENVIRONMENT: THE EFFECTS ON THE OPTICAL	\$4.00 \$0.00 \$0.00 \$0.00 \$0.00 \$0.00 \$0.00 \$0.00 \$0.00	
	90-05 91-01 92-01 92-02 92-03 92-05 92-06 92-07 92-04	ASTRONAUT'S GUIDE TO TERRESTRIAL IMPACT CRATERS WORKSHOP ON COSMOGENIC NUCLIDE PRODUCTION RATES WORKSHOP ON PRODUCTION AND USES OF SIMULATED LUNAR MATERIALS TOWARDS OTHER PLANET; ARY SYSTEMS (TOPS): A TECHNOLOGY NEEDS ASSESSMENT WORKSHOP WORKSHOP ON THE MARTIAN SURFACE AND ATMOSPHERE THROUGH TIME WORKSHOP ON THE PHYSICS AND CHEMISTRY OF MAGMA OCEANS FROM 1 BAR TO 4 MBAR WORKSHOP ON THE EVOLUTION OF THE MARTIAN ATMOSPHERE JOINT WORKSHOP ON NEW TECHNOLOGIES FOR LUNAR RESOURCE ASSESSMENT WORKSHOP ON INNOVATIVE INSTRUMENTATION FOR THE IN SITU STUDY OF ATMOSPHERE-SURFACE INTERACTIONS OF MARS, PARTS 1 & 2 WORKSHOP ON CHEMICAL WEATHERING ON MARS, PARTS 1 & 2 WORKSHOP ON THE SPACE ENVIRONMENT: THE EFFECTS ON THE OPTICAL PROPERTIES OF AIRLESS BODIES	\$4.00 \$0.00 \$0.00 \$0.00 \$0.00 \$0.00 \$0.00 \$0.00 \$0.00	

	BALANCE	FROM	PREVIOUS	PAGES	
--	---------	------	----------	-------	--

Shipping and Handling Charges				
	U.S.	Canada Foreign Surface	Foreign Air Europe/S. Am.	Foreign Air Pacific Ocean
Each Proceedings	\$9.00	\$9.00	\$36.00	\$36.00
Each Book	\$5.00	\$5.00	\$28.00	\$28.00
One Slide Set	\$3.00	\$3.00	\$7.00	\$7.00
Ea. Additional Set, add:	\$1.00	\$1.00	\$2.00	\$2.00
One Technical Report	\$5.00	\$5.00	\$10.00	\$10.00
Ea. Additional Report, add	d: \$1.00	\$1.00	\$2.00	\$2.00
Each Abstract Set	\$10.00	\$15.00	\$55.00	\$75.00

SUBTOTAL \$	
SHIPPING AND HANDLING \$(SEE CHART AT LEFT)	
ADD 7.25% SALES TAX \$ FOR TEXAS DELIVERY (APPLY TAX TO SUBTOTAL AND SHI	 PPING)
TOTAL AMOUNT ENCLOSED \$	<u> </u>
PRICES EFFECTIVE THROUGH	1 8/93

Method of Payment				
☐ Check (in U.S	S. dollars drawn on U.S. bank) Money Order			
☐ MasterCard	Account Number			
Expiration Date	Print exact name appearing on credit card			
Signature				
Phone ()	FAX ()			
PLEASE INDICATE BU	JSINESS HOURS PHONE.			

PLACE ALL ORDERS WITH:

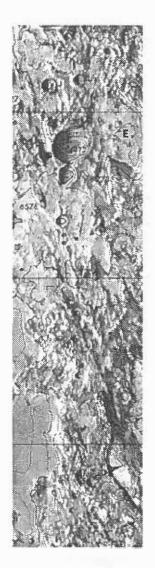
Order Department Lunar and Planetary Institute 3600 Bay Area Boulevard Houston TX 77058-1113

PHONE: (713) 486-2172 • FAX: (713) 486-2186

Ordered By	Ship To All domestic orders must ship to a street address only.
Organization	Organization
Name	Name
Address	Address
City	City
State Zip	State Zip Country
Phone () (required to process order) PLEASE INDICATE BUSINESS HOURS PHONE.	Phone () (required to process order) PLEASE INDICATE BUSINESS HOURS PHONE.

NEW IN PRINT

These publications are available from the publisher listed or may be ordered through local bookstores.



Jack Sevier was in the Apollo Spacecraft Program Office of the Manned Spacecraft Center in Houston during the Apollo Program. He was the Mission Staff Engineer for Apollo 11 and later was Chairman of the Traverse Planning Team for Apollo 15, 16, and 17. He is presently Director of Educational Programs in USRA's Center for Advanced Space Studies in Houston.

A REVIEW

TO A ROCKY MOON: A Geologist's History of Lunar Exploration

by Don E. Wilhelms
University of Arizona Press, 1993, 477 pp.
Black and white photographs. Hardcover. \$29.95

—by Jack Sevier

n 1987 the definitive work on lunar geologic history was published in USGS Professional Paper 1348, Geologic History of the Moon. The "paper," a product of several years work by Don Wilhelms, ran to more than 300 oversized pages with more than 800 references. It was a prodigious undertaking that few authors would have begun and even fewer would have completed. To a Rocky Moon is an equally well-researched and thoroughly readable history of lunar exploration from the point of view of a scientist (who happens to be a geologist) who was involved in the lunar program from almost the very beginning. It is at once a history, a scientific treatise, and a story.

The story begins in 1892 with the publication of a paper entitled "The Moon's Face" by Grove Carl Gilbert, chief geologist of the U.S. Geological Survey. Wilhelms marks this publication as "the first in the history of lunar geoscience with a modern ring." Ever since the invention of the telescope, observers had debated the origin of the lunar features: Were they caused by impacts of objects from space, or were they a result of volcanic action from within? Gilbert's paper carefully considered the evidence and for the most part came down on the side of impact processes, but the debate would continue for many more decades, right up until we actually visited the Moon (more than once) and analyzed the returned samples. Chapter 1 introduces some of the modern players in the then-new discipline of lunar science, notably Ralph Baldwin, Harold Urey, Eugene Shoemaker, Gerald Kuiper, and others, along with a few whom the author will not suffer gladly for the remainder of the story. The chapter ends in 1957 with the surprise launch of the Soviet Sputnik, marking the beginning of our country's Space Age, the creation of NASA (in 1958), and, as it turned out, the race to the Moon.

Chapters 2 and subsequent follow a chronological sequence of lunar programs and missions. The book is almost equally divided between the programs leading up to Apollo (notably Ranger, Lunar Orbiter, and Surveyor) and the Apollo missions themselves, beginning with Apollo 7 in November 1967 and ending five years later with Apollo 17 in December 1972. Throughout the author does an excellent job of describing the growth and evolution of lunar science as we began to acquire the first hard data from the unmanned probes and later from the soft landers. His development of the competing theories and their supporting data is done in such a way as to interest specialists and the lay reader alike.

Early milestones in the modern history of lunar exploration are perhaps best remembered in terms of discrete events. Among these are the first Ranger missions (hard landers designed to gather data for a few short minutes before crashing onto the Moon). Ranger 3, the first one to get out of Earth orbit (January 1962) missed the Moon by 37,000 km; Ranger 4, three months later hit the Moon, but on the farside; and Ranger 5 (October 1962) missed by only 720 km but had already lost power from its solar panels. By today's standards, these failures would be intolerable, but in the primitive beginnings of the space program were not so unusual considering what was being attempted for the very first time.

Another significant event during these early days was the formal establishment by Gene Shoemaker in 1961 of the USGS Astrogeologic Studies Group at Menlo Park, California. In December of 1962, part of the group moved to Flagstaff, Arizona, and together they played a primary role in the lunar program to follow. ("Astrogeology" continues to this day to support NASA's planetary programs with many of the same outstanding personnel recruited during the early years.)

On May 25, 1961, President Kennedy had made his bold announcement to the Congress that "... I believe that this nation should commit itself to achieving the goal, before this decade is out, of landing a man on the Moon and returning him safely to Earth. No single space project in this period

NEW IN PRINT



will be more exciting, or more impressive to mankind, or more important to the long-range exploration of space, and none will be so difficult or expensive to accomplish." He went on to outline projected costs of \$7-9 billion over the coming five years and concluded by saying "I believe we should go to the Moon. But I think every citizen of this country as well as members of Congress should consider the matter carefully in making their judgment, to which we have given attention over the past many weeks and months, as it is a heavy burden; and there is no sense in agreeing or desiring that the United States take an affirmative position in outer space unless we are prepared to do the work and bear the burdens to make it successful. If we are not, we should decide today."

Who could resist such a challenge to become a part of the adventure of the century? This reviewer joined the Apollo Spacecraft Project Office in Houston in July of 1962 (the Manned Spacecraft Center was to remain a cow pasture for the next two years), and the author joined the USGS Menlo Park group in December of the same year, three days after completing his Ph.D. dissertation at UCLA. Over the next few months and years they were joined by an outstanding group of scientists, engineers, and managers who devoted their best efforts to making good on President Kennedy's vision.

Meanwhile, the impact versus volcanism controversy continued to be debated, along with such questions as the origin of the lunar maria and of the Moon itself. The USGS folks began training the astronauts in basic geology with emphasis on field observations conducted during frequent trips to sites that served as terrestrial analogues of the Moon. In parallel, the USGS continued with basic geologic mapping of the Moon with emphasis on potential landing sites. Ranger 7, in 1964, gave us the first high-resolution pictures of the lunar surface, the last of which was taken only seconds before impact at an altitude of 1.6 km. Features about 1 m across could be seen in these last photographs, which represented a 200-fold improvement over Earth-based telescopic views. Although "Ranger 7 generated enormous excitement in the data-starved lunar science community," and "was the glamour science of the hour" it did little to settle basic questions.

The Ranger 7 success was followed six months later by Ranger 8 and a month afterward by the last of the series, Ranger 9. Both were highly successful in providing a close-up look at other areas of the Moon and in providing data that allowed USGS analysts to establish relative geologic ages of the three Ranger sites. Ranger 8 crashed into Mare Tranquillitatis only 70 km from where Apollo 11 would touch down four and a half years later. The author was observing the expected impact point through the 36-inch telescope at Lick Observatory at just the right spot at just the right time hoping to see some evidence of the impact but, alas, saw nothing.

The unmanned lunar programs, Ranger, Lunar Orbiter, and Surveyor, had started out being scientific programs in their own right; however, with the decision to establish the manned Apollo Program, they were quickly relegated to a role in support of manned lunar landing; whatever science could be accomplished was secondary. Understandably, there was resentment of these priorities, but there grew to be something of a peaceful coexistence between the two views over the course of the Lunar Orbiter and Surveyor programs, with each group having a proper respect for the others' objectives and priorities.

Lunar Orbiter was devoted to obtaining wide-area photographic coverage at medium (8–10 m) resolution and high (1–2 m) resolution of potential Apollo landing sites. Each mission (of which there were only five) was limited to only 225 exposures. The first mission was partially successful, yielding only medium resolution coverage. It was followed by the second and third missions, which were highly successful and were devoted almost exclusively to coverage of potential Apollo sites—smooth mare of greatest interest for Apollo landing, but of lesser interest for scientists. Lunar Orbiter 4 was released to the scientists, who chose to go for a high-inclination, high-perilune orbit from which 80% of the nearside could be photographed at 50–150 m resolution, about which the author observes that "our present understanding of the Moon's geology would have been impossible without Orbiter 4, whose global resolution has yet to be repeated or excelled." The successful Lunar Orbiter 5 would follow three months later with only 20% of its exposures devoted to cleaning up





some additional Apollo look-sees and the remaining 80% devoted to sites of potential scientific interest, which everyone hoped would be visited by a follow-on manned exploration program, (which had, by no means, been decided).

The Surveyor program of soft landers spanned almost the same period as the Lunar Orbiters, with the first Surveyor landing only two months before the first Orbiter and the last Surveyor landing only two months after the last Orbiter. The second and fourth Surveyors were, unhappily, not-so-soft landers, but the others were most successful, both from the standpoint of the scientists and the Apollo engineers, who sought ground-truth data that the lunar surface was indeed "landable," still a much debated subject by some of the author's "fringe" colleagues.

January 1968 marked the end of the Surveyor Program when Surveyor 7 landed next to Tycho crater on a purely scientific mission. The same year marked the beginning of the Apollo visits to the Moon when Apollo 8 went into lunar orbit (60 nm above the surface) where it remained for the next 20 hours and departed on Christmas Day, after a moving reading from Genesis by the crew on Christmas Eve.

The next Apollo was an Earth-orbit mission to check out the full-up spacecraft (Command and Service Modules and the Lunar Module) and perform a dress rehearsal for rendezvous and docking procedures. Everything went well, and all that was left before the lunar landing attempt was to do a similar exercise in lunar orbit on Apollo 10, which would dip down within 50,000 ft of the lunar surface in a practice descent maneuver. That was accomplished in May of 1969 and the Apollo 11 mission was scheduled two months later in July.

An activity that had been ongoing during the previous two years involved the selection of lunar landing sites for the manned Apollo missions. There was a myriad of constraints to be considered, which the author has done an excellent job of understanding and explaining. Taken together they provided a good balance between flexibility, mission success, and crew safety. For the first mission, there were still many unknowns: for example, could we expect to land with some degree of certainty within a given distance of the target point? Could the crew see well enough during the terminal descent phase to avoid hazardous terrain, or would the combination of lighting and dust obscure their view? Apollo 11 answered these and other questions (no to the first, yes to the second), so that subsequent missions could begin to be freed of some constraints (without unduly sacrificing crew safety) and could consequently plan on visiting sites of greater scientific interest.

This was a continuing process of give and take between the scientists, the top NASA management, and the operational team, which this reviewer believes struck a pretty good balance. The author takes exception to this view in the choice of the Apollo 12 site (Chapter 12, p. 213: "The Wrong Site"). He argues that visiting the Surveyor 1 site further west would have satisfied the operational impetus to develop point landing techniques and would have been much preferable scientifically. However, NASA was not yet ready to give up completely the multiple monthly launch opportunities, although they accepted the reduction from three to two for Apollo 12. The Surveyor 3 site in the mid-western zone coupled with the far western site satisfied this constraint. The author is in error when he says, "The unfavorable Lunar Orbiter screening evaluation of the Surveyor 3 site was ignored despite MSC's obsessive concern for safety" (page 216). The Surveyor 3 site (III-P-9 in the Orbiter designation) had been fully evaluated and had a figure of merit slightly better than the other two western sites; it had, in fact, been one of the eight set "B" sites and was dropped when the number was reduced to five (Set C) only because it was not needed in the three-launch-opportunity strategy.

The author concludes, however, that though the Apollo 12 mission was not wasted, it was not exploited to its utmost, either, and that "others have said the same for one reason or another about each of the later missions that did go where GLEP [i.e.,the scientists] recommended." This was indeed the case; for example, the author's USGS colleague, Jack McCauley, strongly disagreed with

continued on page 23

THREE SPACECRAFT ATTEMPT TO DETECT GRAVITY WAVES

NASA's Mars Observer and Galileo and the European Space Agency's Ulysses spacecraft participated in a unique experiment from March 21 to April 11 as they continued their journeys to Mars, Jupiter, and the poles of the Sun, respectively. Astrophysicists used the craft simultaneously to listen for waves in the gravitational field of the universe.

"Einstein predicted the existence of gravitational waves in his theory of general relativity, and radio astronomy observations of pulsars have suggested they indeed exist — but no one has ver detected a gravitational wave directly," said John W. Armstrong of NASA's Jet Propulsion Laboratory, who worked with the Mars Observer and Galileo spacecraft.

"We're also very excited about the possibility of making a major discovery with such a costeffective experiment. We were able to take advantage of three spacecraft already in space... in the correct relative positions and distances we need to do this experiment. We can just borrow them for a few weeks, without any added cost for equipment and no change to their missions. It's big science on a small budget," said Dr. Robert Stachnik, Gravitational Wave Program Scientist in NASA's Astrophysics Division, Office of Space Science.

The experiment is built around a simple concept. During the 3-week experiment, the antennas of NASA's Deep Space Network (DSN). on Earth sent radio signals to the three spacecraft at precisely known frequencies. Each spacecraft sent signals back to Earth at the same frequency it received. If no gravitational waves were passing through the solar system, the signals returned to Earth should have exactly the same frequencies as the original signals sent from the DSN, shifted only by the Doppler effect of spacecraft motion. However, if a strong enough gravitational wave were passing — produced perhaps from collapsing masses of stars in the hearts of galaxies or from the spiraling together and collision of two black holes — both the Earth and the spacecraft should experience a slight "bobbing" from the ripple-like passage of the gravitational wave. This interaction cannot be directly detected at either the Earth or the spacecraft alone, but should show up as a slight change in the frequency of the radio signal finally received back at Earth.

Detection of the gravitational waves, if they occur, will still take at least several months of patient data analysis. "The spacecraft systems can detect large enough gravitational waves, if they exist," said Dr. Bevan M. French, Program Scientist for Mars Observer. "But it won't be one of those sudden 'Eureka!' situations. We'll be looking for a few small wiggles in a huge amount of radio data. It will take time." To identify the unique signals of gravitational waves, the scien-

"We can just borrow them for a few weeks, without any added cost for equipment and no change to their mission. It's big science on a small budget."

tists also will have to eliminate such mundane effects as planned changes in the orientation of the spacecraft, interference from charged particles (plasmas) in space and even atmospheric changes, rain, and snow on Earth.

Mars Observer, launched in September 1992, will teach the Red Planet August 24 of this year. Launched in 1989, Galileo will arrive at Jupiter in 1995. Ulysses, launched in 1990, will fly over the Sun's poles in 1994 and 1995. Gravitational wave research is supported by the Astrophysics Division of NASA's Office of Space Science and by each of the three spacecraft projects, which scheduled the radio searches during their interplanetary cruise periods.

Moon/Mars Exploration Efforts Shifted to NASA Office of Space Science

n March 25, NASA Administrator Daniel Goldin announced that, in the interest of maintaining clear and well-defined management responsibilities, the Office of Exploration would be absorbed by the Office of Space Science, effective immediately. Exploration activities will be focused in a new organizational division of the Office of Space Science.

"The Office of Exploration has provided a needed focus for the agency's vision of the future," Goldin said. "But it is only practical that further studies on human expeditions to the Moon and Mars complement and build on the more nearterm robotic missions." Associate Administrator for Exploration, Dr. Michael D. Griffin, has been reassigned as the agency's Chief Engineer. "Dr. Griffin and his organization have served NASA well in charting a course for the future," said Goldin. "The redesigned space station and our robotic missions are the beginning and must be our priority tasks in the near term"

The Office of Space Science itself was created during organizational changes made earlier in March. It is headed by Associate Administrator Wes Huntress.

Ø

The Lunar and Planetary Information Bulletin is published quarterly by the Lunar and Planetary Institute, 3600 Bay Area Boulevard, Houston TX 77058-1113.

Pam Thompson, Editor

Editorial and production support are provided by the LPI Publications and Program Services Department. Copy deadline for the August issue of the LPIB is July 19, 1993.

Please send articles or announcements to: P. Thompson, 3600 Bay Area Boulevard, Houston TX 77058-1113.

Phone: 713-486-2175, Fax: 713-486-2162 E-Mail: (NSI DECNET) LPI::THOMPSON (NASAMAIL)PBTHOMPSON (Internet) thompson@lpi.jsc.nasa.gov

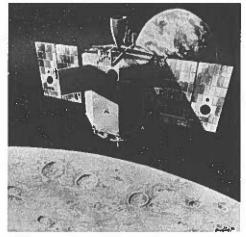
Clementine Mission Science Team Selected

On April 9 NASA announced the science team for the Clementine mission to orbit the Moon and to visit an asteroid. The team will be headed by Dr. Eugene Shoemaker of the U.S. Geological Survey, Flagstaff, who has been very active for many years in both lunar and asteroid research.

Clementine, sponsored by the Strategic Defense Initiative Office (SDIO), will begin with the launch of a small spacecraft in January 1994 to orbit the Moon until early May 1994. The spacecraft will then fly by the near-Earth asteroid 1620 Geographos on August 31, 1994, when the asteroid is several million miles away, its closest approach to the Earth.

Mission goals are to test new, lightweight sensors in a space radiation environment and to demonstrate autonomous navigation and spacecraft operation. Innovative spacecraft components also will be tested including a lightweight star tracker, an inertial measurement unit, lightweight reaction wheels for attitude control, as well as a lightweight nickel hydrogen battery and a lightweight solar panel.

The science team members are Charles Acton, Jet Propulsion Laboratory; Daniel Baker, Goddard Space Flight Center; Jacques Blamont, CNES (France); Bonnie Buratti, Jet Propulsion Laboratory;



Merton Davies, Rand Corp.; Thomas Duxbury, Jet Propulsion Laboratory; Eric Eliason, U.S. Geological Survey, Flagstaff; Paul Lucey, University of Hawaii; Alfred McEwen, U.S. Geological Survey, Flagstaff; Carlé Pieters, Brown University; David Smith, Goddard Space Flight Center; and Paul Spudis, Lunar and Planetary Institute.

The Naval Research Laboratory,
Washington, DC, is responsible for
mission design, providing the spacecraft,
and for mission operations. The Jet
Propulsion Laboratory will be responsible
for tracking the spacecraft using NASA's
Deep Space Network and for accurately
locating Geographos using its Near Earth
Object Center in preparation for the flyby.



Catastrophes in Earth History to be Examined at Feb '94 Meeting

A conference on New Developments Regarding the K/T Event and Other Catastrophes in Earth History will be held in Houston, February 9–12, 1994. In the tradition of the 1981 and 1988 "Snowbird" conferences, scientists will gather to consider new evidence from the K/T boundary, other biological extinction events, and the processes that may drive catastrophic extinctions.

The program committee encourages participation of the broadest spectrum of specialists, who should submit extended abstracts by October 25. Presentation of these papers will be as posters or by title

only. Keynote talks will be invited by the committee to synthesize and stimulate discussion. All types of presentations will be considered for publication in a proceedings volume published after the conference.

A three-day postconference trip will allow participants to examine outcrops of the exotic clastic bed at the K/T boundary in northeastern Mexico, that have been interpreted by some as impact tsunami deposits.

For information, contact Lita Holley, LPI, 713-486-2149; fax: 713-486-2160; Internet: holley@lpi.jsc.nasa.gov.



For the seventeenth year, the LPI Summer Intern Program offers selected undergraduate students an opportunity to participate in current research in lunar and planetary science at the Institute and the NASA Johnson Space Center. The 1993 program begins on June 14 and concludes on August 20. For more information or to apply for internship next year, contact: LPI Summer Intern Program, 3600 Bay Area Boulevard, Houston TX 77058-1113.

JOSEPH A. BIELLO, Columbia University

Advisor: Tomasz Stepinski, Lunar and Planetary Institute

This project concentrates on investigating the nonlinear models of a magnetic dynamo in the solar nebula. It seems that no model of a viscous solar nebula is complete without taking the magnetic fields into consideration. Existing models are linear; they ignore the back reaction of magnetic field on the degree of ionization. A complete dynamo model should take into consideration the fact that the effectiveness of cosmic ray ionization of nebular gas is impaired by the influence of the magnetic field on the propagation of cosmic rays.

GARY G. BOND, University of Arizona

Advisors: Carlton Allen and David McKay, NASA Johnson Space Center

This is an ongoing program of experiments to understand the chemistry and develop the technology for extracting oxygen from rocks, minerals, glasses, and soils using the hydrogen reduction process. Simulants of lunar material will be used as feed stock, and possibly actual lunar samples as well. The intern will assist in running experiments and interpreting reaction data. An important part of the project is analysis using optical microscopes, scanning electron microscopes, X-ray diffraction, and possibly Mössbauer spectroscopy. These experiments will provide new data for the design of a practical flight experiment payload for a robotic lunar lander mission and a demonstration unit for the early human return to the Moon.

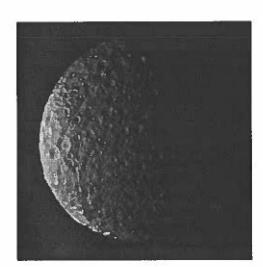


Advisor: Paul Schenk, Lunar and Planetary Institute

The icy satellites Europa, Mimas, and Triton have complex geologic histories reflecting the influence of stress fields of both internal and external origin, which are expressed as global fracture networks. For Europa, fracturing appears to be from tidal distortion of the lithosphere, but the origins of the Mimas and Triton fracture networks are uncertain. Both tidal distortions and internal volume changes can cause fracturing of the lithosphere. In the case of Mimas, the large impact event, Herschel, may have fractured the satellite. On Triton, fracturing could be a relic of capture by Neptune and subsequent circularization of Triton's orbit. Massive tidal heating led to melting of the interior. Triton's lineaments record lithospheric stresses (some are also associated with a volcanic province). All stresses induce a predictable but distinct stress field in the satellite's lithosphere. The goal of this project is to map these fracture patterns, determine their relative ages, and compare lineament orientations with predicted stress fields to understand their role in Triton's and Mimas' history.

TRINA CELESTE COX, Hardin-Simmons University Advisor: Graham Ryder, Lunar and Planetary Institute

The Apollo 15 coarse fines (4–10 mm) samples are a mine of information about the rocks in the region of the Apollo 15 landing site. The intern will work to obtain a more detailed understanding of the rock types they represent than is presently available, to provide a better understanding of regional geology. Starting from the catalog of Apollo 15 coarse fines (*Ryder and Sherman*, 1989) the intern will (1) review the information available in 1989; (2) identify and review any material published since 1989; (3) use unpublished material of Ryder and others to update catalog information; (4) study the



thin sections in Ryder's possession to fill in data gaps using petrographic and microprobe analyses; (5) try to identify genetically significant groupings among samples in more detail than has been so far done; and (6) use the samples to make inferences about local geology.

MARY JOE DUNLAP, University of Florida

Advisor: Michael Golightly, NASA Johnson Space Center

Radiation exposure during space missions is determined by spacecraft orbital altitude, inclination, and position within the solar cycle. Efforts to develop empirical models of expected exposure using shuttle-based measurements have relied on estimates of average spacecraft altitude. Refinements in the models cannot be achieved without more accurate knowledge of average altitude during each mission. This project will begin the first systematic determination of average and various weighted-average altitudes for previous shuttle missions using archived engineering measurements. Altitude data will be used to update databases, graphically compare measurements as a function of altitude, and calculate the expected exposure using standard models.



Advisor: Robert Herrick, Lunar and Planetary Institute

The Magellan mission has provided the first global dataset of high-resolution radar imagery for Venus. A global database of impact craters on Venus has recently been constructed from Magellan data. Preliminary morphometric analysis of this database shows several interesting aspects of venusian craters that are potentially caused by the planet's dense atmosphere. The intern will use detailed morphometry and geologic mapping of selected craters to test and expand upon the preliminary conclusions of previous work.

FRANCOIS P. FOURNIER, Moorhead State University

Advisors: D. C. Golden, Douglas Hing, and Michael Zolensky, NASA Johnson Space Center

Phyllosilicates are an important group of silicate minerals in chondritic meteorites. Their identification and analysis is difficult because of the electron beam sensitivity of these minerals. Saturation of the phyllosilicates with long-chain amines (as ammonium ions) is one way to stabilize them. This technique will be used to characterize phyllosilicates in two meteorite samples using electron beam techniques.

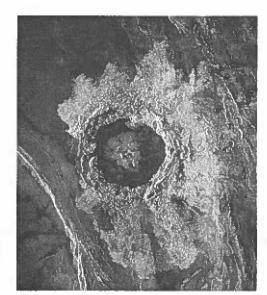
LEAH JOSEPH, University of Rochester

Advisors: Michael Zolensky and Lauren Browning, NASA Johnson Space Center

This project involves the collection of mineralogical and textural evidence for the origin of the low-temperature phases in CM chondrites. Relevant data will be documented using both petrographic and scanning electron microscopes. The results of this project will be directly applicable to ongoing studies of the early evolution of the solar system.

JENNIFER C. McGUIRE, State University of New York at Stony Brook Advisors: A. J. G. Jurewicz and John H. Jones, NASA Johnson Space Center

A class of stony meteorites (chondrites) are believed to be the rocky building blocks of the inner solar system, and other stony meteorites were probably derived from chondrites through igneous processes. The types of melts that can be generated by partially melting chondrites is being explored experimentally. At low partial pressures of oxygen, the partial melts resemble eucrites, the most common type of meteoritic basalt. At slightly higher pressures of oxygen (fO₂), the partial melts resemble angrites, another kind of meteoritic basalt. However, in a single high-fO₂ experiment on a silica-



rich type of chondrite, the melt did not resemble angrites, which are silica undersaturated. Instead, the melt was silica rich and appeared more like a terrestrial andesite. This summer, this unusual result will be verified or disproved experimentally. If verified, the igneous phase relations that make this possible will also be explored.

TAKASHI MIKOUCHI, University of Tokyo

Advisor: Gordon McKay, NASA Johnson Space Center

This project is a study of the origin of Cr-rich cores in olivine crystals in angrite LEW 87051, using experimental and theoretical approaches. The origin of these cores has a major bearing on what this meteorite sample can tell us about igneous processes in the early solar system.

VICTOR E. MILLINGS, III, College of Charleston

Advisor: Everett Gibson, NASA Johnson Space Center

The intern will study the isotopic compositions of trapped atmospheric gases in a suite of well-characterized, unaltered Archean sediments ranging from 3.5 b.y. to the end of the Archean. They will be analyzed using stepped combustion and/or vacuum extraction techniques. The released gases will be purified and analyzed for carbon, oxygen, and hydrogen isotopic compositions. Previous studies have shown that gases released in the 900°-1100°C intervals are representative of trapped atmospheric components and do not represent decomposition or contamination products of other volatile phases. The study will examine 10 to 12 sediments of different ages in the hope that the isotopic compositions of the trapped gases will show changes during the interval of enhanced oxygen production during the Earth's early history, especially during changes in the Earth's early atmosphere.

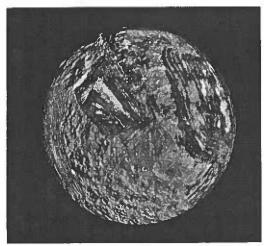
KATHERINE D. OCKER, Sam Houston State University Advisors: James Gooding and Fred Hörz, NASA Johnson Space Center

Melting, glass formation, and crystal-structural damage are typical effects of shock metamorphism produced by impact cratering. Measurement of shock effects has usually been made by petrographic examination of thin sections or by X-ray diffractometry. A possible alternative method for quantitative analysis of thermal and pressure histories of bulk samples is to directly measure strain energy contained in samples as they are subjected to programmed heating. Such measurements will be made by differential scanning calorimetry (DSC) on milligram-scale quantities of experimentally shocked quartz as well as on naturally shocked quartz sandstone from Meteor Crater. DSC-derived shock indices will be compared with thin-section observations on the same samples. Results will be used to evaluate prospects for developing calorimetric thermobarometers for shock-metamorphosed terrestrial rocks, meteorites, and lunar rocks.



Advisors: Deborah Domingue and Renu Malhotra, Lunar and Planetary Institute

Uranus' satellite, Miranda, has a geologically interesting surface that has been divided into two basic types of terrains: plains and coronae. At present there is no definitive understanding of how the coronae were formed. Current hypotheses relate corona formation to internal deformation processes, either upwelling from or downwelling into the interior of the satellite because of density contrasts. Miranda's orbital history shows that tidal heating of the interior probably played a large role in shaping surface geology. The intern will do a photometric analysis of the geologic units to determine surface textures and optical characteristics that may constrain the geologic processes that formed Miranda's surface.





RICK L. SAYLOR, Western Kentucky University Advisor: Scott Hurchie, Lunar and Planetary Institute

Visible color and albedo properties of Mars show that the planet's surface is divided into two basic units: dark gray regions and bright reddish regions. Spectroscopic investigations provide information on the mineralogic composition and lithology of these two units. The dark areas contain pyroxene and are probably basaltic, and the bright reddish regions contain ferric iron and water, suggesting that they are highly altered chemically. High-quality spectral measurements of about 20% of the equatorial region were acquired in 1989 by the ISM imaging spectrometer on the Phobos 2 spacecraft. ISM obtained nine "images" with 20-km spatial resolution and in 128 spectral channels in the 0.76-3.16 µm near-infrared wavelength range, useful for recognizing major rock-forming minerals as well as molecular water adsorbed or dissolved in the surface material. The intern will map variations in the near-infrared spectral properties and compare them with variations in visible color and albedo measured by Viking. Results will be compared with properties of Mars analog materials and with martian surface geologic units to assess the possible mineralogic and lithologic variations in the planet's surface materials.

SELINA TRIBE, University of British Columbia Advisor: Stephen Clifford, Lunar and Planetary Institute

Observational evidence of ancient fluvial activity on Mars suggests that water was abundant in the planet's early crust. However, with the decline in the planet's internal heat flow, a freezing front developed within the regolith that propagated downward with time—creating a thermodynamic sink for any crustal H₂O. One consequence is that, if the initial inventory of water on Mars was small, the frozen region may have eventually grown to the point where all the available water was taken up as ground ice. Alternatively, if the inventory of H₂O exceeds the current pore volume of the frozen crust, then Mars has always had extensive bodies of subpermafrost groundwater. This latter possibility is strongly supported by outflow channels with apparent ages of less than 1 b.y. To identify possible origins and evolutionary trends in the formation of these channels, their relative age, elevation, geographic distribution, and geologic setting will be investigated in detail. If the geologically recent occurrence of fluvial activity is confirmed, it is likely to provide persuasive evidence that Mars is indeed water rich.

PEDRO VERA SANCHEZ, Mexican National University Advisors: Yirgil Sharpton and Benjamin Schuraytz, Lunar and Planetary Institute

The Chicxulub structure is a 200-km impact structure buried beneath approximately 1 km of limestone on the northern Yucatán Peninsula. The only available samples of impact breccias and melt rocks are from drill cores retrieved by Pemex (Petróleos Mexicanos, the petroleum industry of Mexico). Samples of the melt rocks from the Chicxulub impact structure have been dated and analyzed by several institutions, and it has become clear that Chicxulub is temporally and chemically linked to material deposited at the KT boundary 65 m.y. ago and associated with a major biological extinction event. Still, many fundamental questions regarding the formation and evolution of the melt rocks produced during such large impact events remain unanswered. This project will focus on understanding the chemical variations within available melt rock samples from Chicxulub.



CALENDAR 1993

M AY

12-15

The High Frontier Conference XI: Bringing the Vision of Space into Reality, Princeton, New Jersey. Contact: Tracy Kenny, P.O. Box 82, Princeton NJ 08542. Phone: 609-921-0377; Fax: 609-921-0389.

15-17

Workshop on the Analysis of Interplanetary Dust Particles, Houston, Texas. Contact: Publications and Program Services Department, LPI, 3600 Bay Area Boulevard, Houston TX 77058-1113. Phone: 713-486-2150; Fax: 713-486-2160.

17-19

Annual Meeting of the Geological Association of Canada and Mineralogical Association of Canada, Edmonton, Alberta, Canada. Contact: J. W. Kramers, Alberta Geological Survey, P.O. Box 8330, Station F, Edmondton, Alberta T6H 5X2, Canada. Phone: 403-438-7644; Fax: 403-438-3644.

24-28

1993 Joint Spring Meeting of the American Geophysical Union, Mineralogical Society, and Geochemical Society, Baltimore, Maryland. Contact: AGU Meetings Department, 2000 Florida Avenue NW, Washington DC 20009. Phone: 202-462-6900; toll free in North America: 1-800-966-2481; Fax: 202-328-0566. Internet: sbell@kosmos.agu.org

26-29

The Case for Mars V, Boulder Colorado. Contact: Tom Meyer, P.O. Box 4877, Boulder CO 80306. Phone: 303-494-8144; Fax: 303-494-8446.

SPAN: zodiac::marscase Internet: marscase@zodiac.colorado.edu NASAMAIL: TMEYER

31-.June 2

Eighteenth Symposium on Antarctic Meteorites, Tokyo, Japan. Contact: Keizo Yanai, Department of Antarctic Meteorites, National Institute of Polar Research, 9-10, Kaga 1-chome, Itabashi-ku, Tokyo 173, Japan. Phone: 03-3962-4711 ext. 155; Fax: 03-3962-5711.

JUNE

5-11

ICOG-8: Eighth International Conference on Geochronology, Cosmochronology, and Isotope Geology, Berkeley, California. Contact: ICOG-8, Krebs Convention Management Services, 555 De Haro Street, Suite 200, SanFrancisco CA 94107-2348. Phone: 415-255-1297; Fax: 415-255-8496.

JUNE (CONTINUED)

6-9

5th International Space Conference of Pacific-Basin Societies, ISCOPS, Shanghai, China. Contact: AAS Business Office. Phone: 703-866-0020.

8-10

1st GEOTAIL Workshop, Sagamihara, Japan. Contact: A. Nishida, ISAS, 3-1-1 Yoshinodai, Sagamihara, Kanagawa 229, Japan. Phone: +81-427-51-3911; Fax: +81-427-59-4236.

14-18

Asteroids, Comets, Meteors 1993, Belgirate (Novara), Italy. Contact: Vincenzo Zappala, Astronomical Observatory, Strada Observatorio 20, 10025 Pino Torinese (70), Italy, or Publications and Program Services Department, LPI, 3600 Bay Area Boulevard, Houston TX 77058-1113. Phone: 713-486-2150; Fax: 713-486-2160.

19-27

Space Transportation Systems: Today and the Future., Moscow, Russia. Contact: International Center for Advanced Studies (Cosmos), P.O. Box 9, A-80, 125080 Moscow, Russia. Phone: 095-158-5126; Fax: 095-229-3237.

21-23

Catastrophic Disruptions of Small Solar System Bodies, Gubbio (Umbria), Italy. Contact: Paolo Paolicchi, Departimento di Fisica, Universita di Pisa, Piazza Torricelli 2, 1-56126, Pisa, Italy.

22-25

Io: An International Conference, San Juan Capistrano, California. Contact: Doug Nash, San Juan Institute, 31872 Camino Capistrano, San Juan Capistrano CA 92675. Phone: 714-240-2010; Fax: 714-240-0482.

28-30

MSATT Workshop on Atmospheric Transport on Mars, Corvallis, Oregon. Contact: Publications and Program Services Department, LPI, 3600 Bay Area Boulevard, Houston TX 77058-1113. Phone: 713-486-2150: Fax: 713-486-2160.

JULY

5-9

Gordon Research Conference on Origins of Solar Systems, New London, New Hampshire. Contact: John A. Wood, Harvard-Smithsonian Center for Astrophysics, 60 Garden Street, Cambridge MA 02138. Phone: 617-495-7278; Fax: 617-495-7001.

SPAN: cf.a::wood Bitnet: wood@cfa

Internet: wood@cfa.harvard.edu

JULY (CONTINUED)

6-9

Pluto & Charon, Flagstaff, Arizona. Contact: Mary Guerrieri, Lunar and Planetary Laboratory, University of Arizona, Tucson AZ 85721. Phone: 602-621-2902.

SPAN: looney::guerrieri Internet: mary@lpl.arizona.edu

10-16

105th Annual Meeting of the Astronomical Society of the Pacific, San Diego, California. Contact: ASP, 390 Ashton Avenue, San Francisco CA 94112. Phone: 415-337-1100.

10-11

Universe '93—A Weekend Astronomy Exposition and Fair, San Diego, California. Contact: Meeting Information, Astronomical Society of the Pacific, 390 Ashton Avenue, San Francisco CA 94112. Phone: 415-337-1100.

13-14

The Universe in the Classroom: A Workshop on Teaching Astronomy in Grades 3–12, San Diego, California. Contact: Meeting Information, A. S. P., 390 Ashton Avenue, San Francisco CA 94112. Phone: 415-337-1100.

13-17

Solar Terrestrial Physics Gordon Conference on Active Phenomena in Solar System Plasmas, Plymouth, New Hampshire. Contact: Marty Lee, EOS-SERB, University of New Hampshire, Durham NH 03824. Phone: 603-862-3509.

15

Teaching About the Universe, a one-day program on astronomy education in the U.S., San Diego, California. Contact: Meeting Information, Astronomical Society of the Pacific, 390 Ashton Avenue, San Francisco CA 94112. Phone: 415-337-1100.

Environmental Context of Human Evolution (International Scientific Congress and Exhibition), The Netherlands and Indonesia. Contact: Hans Beijer, Geological Survey of the Netherlands, P.O. Box 157, NL-2000 AD Haarlem, The Netherlands. Fax: 31 23 351614.

19-23

56th Meteoritical Society Meeting, Vail, Colorado. Contact: Publications and Program Services Department, LPI, 3600 Bay Area Boulevard, Houston TX 77058-1113. Phone: 713-486-2150; Fax: 713-486-2160.

26-28

MSATT Workshop on Early Mars: How Warm and How Wet? Breckenridge, Colorado. Contact: Publications and Program Services Department, LPI, 3600 Bay Area Boulevard, Houston TX 77058-1113. Phone: 713-486-2150; Fax: 713-486-2160.

AUGUST

8-14

MSATT Workshop/Field Trips on the Martian Northern Plains: Sedimentologic, Periglacial, and Paleoclimatic Evolution, Fairbanks, Alaska. Contact: Publications and Program Services Department, LPI, 3600 Bay Area Boulevard, Houston TX 77058-1113. Phone: 713-486-2150; Fax: 713-486-2160.

9-13

Earth Science Summer School: Processes of Global Change, Pasadena, California. Contact: Jeff Plescia, Jet Propulsion Laboratory. Phone: 818-354-6936.

16-19

AAS/AIAA Astrodynamics Conference, Victoria, British Columbia, Canada. Contact: AAS Business Office. Phone: 703-866-0020.

16-20

Planetary Science Summer School: Near-Earth Objects, Pasadena, California. Contact: Neil L. Nickle, Jet Propulsion Laboratory. Phone: 818-354-8244.

SEPTEMBER

27-28

Particle Capture, Recovery, and Velocity/Trajectory Measurement Technologies, Houston, Texas. Contact: Publications and Program Services Department, LPI, 3600 Bay Area Boulevard, Houston TX 77058-1113. Phone: 713-486-2166.

25-Oct 1

International Association of Volcanology and Chemistry of the Earth's Interior General Assembly, Canberra, Australia. Contact: IAVCEI ACTS, GPO Box 2200, Canberra ACT 2601, Australia. Phone: 61-6-257-3299; Fax: 61-6-257-3256.

OCTOBER

18-22

25th Annual Meeting of the Division for Planetary Sciences of the American Astronomical Society, Boulder, Colorado. Contact: Publications and Program Services Department, LPI, 3600 Bay Area Boulevard, Houston TX 77058-1113. Phone: 713-486-2150; Fax: 713-486-2160.

18-22

Cosmic Winds and the Heliosphere, Tucson, Arizona. Contact: Amy Schumann, Lunar and Planetary Laboratory, University of Arizona, Tucson AZ 85721. Phone: 602-621-2902; Fax: 602-621-4933. Internet: mary@lpl.arizona.edu

CALENDAR

OCTOBER (CONTINUED)

25-28

Geological Society of America Annual Meeting, Boston, Massachusetts. Contact: Vanessa George, GSA, Box 9140, Boulder CO 80301. Phone: 303-447-2020.

27-28

Earth Observations and Global Change Decision Making: A National Partnership, Global Change: A New Direction for Decision Making, Washington, DC. Contact: ERIM Conferences. Phone: 313-994-1200 ext. 3453; Fax: 313-994-5123.

NOVEMBER

15-17

MSATT Conference—Mars: Past, Present, and Future Results from the MSATT Program, Houston, Texas. Contact: Publications and Program Services Department, LPI, 3600 Bay Area Boulevard, Houston TX 77058-1113. Phone: 713-486-2150; Fax: 713-486-2160.

DECEMBER

6-10

American Geophysical Union, Fall Meeting, San Francisco, California. Contact: AGU Meetings Department, 2000 Florida Avenue NW, Washington DC 20009. Phone: 202-462-6900; Fax: 202-328-0566. Internet: sbell@kosmos.agu.org

JANUARY 1994

18-20

International Conference on Comparative Planetology, Pasadena, California. Contact: Neil L. Nickle, Jet Propulsion Laboratory. Phone: 818-354-8244.

FEBRUARY

9-12

New Developments Regarding the K/T Event and Other Catastrophes in Earth History, Houston, Texas. Contact: K/T Event, LPI, 3600 Bay Area Boulevard, Houston TX 77058-1113. Phone: 713-486-2149; Fax: 713-486-2160.

Internet: holley@lpi..jsc.nasa.gov

5-15

26-Mar 3

Space 94: 4th International Conference and Exposition on Engineering, Construction, and Operations in Space and Conference and Exposition/Demonstration on Robotics for Challenging Environments, Albuquerque, New Mexico. Contact: Stewart W. Johnson, Space 94 General Chair, BDM International, Inc., 1801 Randolph Road SE, Albuquerque NM 87106. Phone: 505-848-4013; Fax: 505-848-5528. Or: Action Center, Space 94; Phone: 1-800-SPACE94; Fax: 505-272-7355.



NEW IN PRINT

continued from page 13

the selection of Apennine-Hadley for Apollo 15 and said so in a premission interview on national TV. The author obviously has a different view (see Chapter 15, "Golden Apennine-Hadley").

The subsequent Apollo missions (13–17) are discussed in the corresponding chapter numbers and the author does an excellent job of developing how they built upon one another and how their results helped the scientists converge on some answers. The final chapter, aptly titled "Debriefing," covers the period 1973–1984 and summarizes what has happened since the last Apollo mission in December 1972 and what some of the key players have been doing in the meantime. Of particular interest is the "new" theory of the origin of the Moon that had been percolating for some time and came together in a 1984 conference in Hawaii. It departs from all previous theories (none of which Apollo resolved) and hypothesizes that the Moon is a result of an early tangential collision with Earth by a Mars-size object. The collision vaporized part of the Earth's mantle, ejecting it into orbit where it joined the remains of the impactor and accreted as the Moon. The theory will no doubt continue to be debated, but it explains many things, and it makes a proper ending for the book.

This review has grown longer than intended but has only touched on the highlights of this delightful story. There is a wealth of history and personalities and egos and anecdotes and good science and not-so-good science that I haven't begun to convey. You'll have to read it for yourself. Finally, I kept expecting to find an explanation of the title. Is it a toast like "Here's to a rocky Moon!" that might have been uttered over a beer in San Francisco or Flagstaff or Cocoa Beach or Taos or Tonopah or wherever? It could be, . . . anyway, "Here's to a great story, Don. Thanks for writing it."

- 2 LPI Departments Reorganize
- News From Space
- New In Print: To A Rocky Moon
- Spacecraft Seek Gravity Waves
- LPI Summer Interns
- Calendar

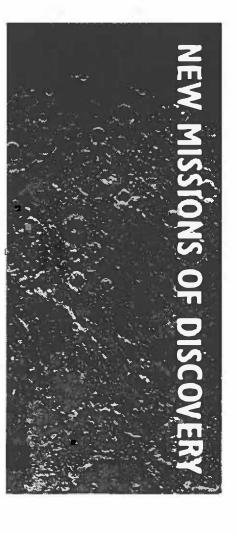


Universities Space Research Association USRA

Center for Advanced Space Studies
LUNAR AND PLANETARY INSTITUTE

Houston TX 77058-1113 3600 Bay Area Boulevard

ADDRESS CORRECTION REQUESTED



SEE PAGE 5

U.S. POSTAGE PAID HON-PROFIT

PERMIT NO. 600

X1 MOLSOON