



LUNAR AND PLANETARY INSTITUTE

Annual Report

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Respectfully submitted,

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Date



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Executive Summary

Since its inception, the Lunar and Planetary Institute (LPI) has focused its efforts on cultivating and supporting a community of bright, forward-thinking scientists who intellectually lead interdisciplinary research efforts that cut across planetary science, astrobiology, geology, and physics. In addition to their research, the resident and visiting LPI scientists and students work closely with the planetary science community and the NASA organization, understanding the culture and politics that drive the agency. This unique combination of scientific excellence, connection to the scientific community and NASA positions the LPI to be valuable as an advisor, collaborator, and spokesperson for the agency, bridging the gap between basic scientific research at the university level and applied efforts that allow NASA to realize the Exploration Vision set forth by President Bush in 2004.

As Director of the LPI since 2002, Dr. Mackwell has refocused the Institute on scientific excellence, research productivity, and service to NASA and the planetary community. By increasing the flow of visiting scientists and postdoctoral fellows and by actively encouraging collaboration, the Institute has taken on a more productive and scientifically energized atmosphere. This more dynamic scientific environment has led to an increase in scientific collaboration with the university community and the NASA organization, as well as marked increases in all aspects of research productivity, with a significant increase in both grant dollars and published peer-reviewed papers over those for 2005.

Several exciting scientific developments have emerged from the research work being undertaken at the LPI this year. With the hiring of Dr. David Kring as a Visiting Scientist for Lunar Exploration, the Institute has renewed its focus on lunar science and exploration. In addition to his strong lunar science activities, Dr. Kring brings current activities with development of small lunar robotic missions, and a passion for education and outreach activities. Associated with Dr. Essam Heggy's laboratory, field and modeling activities in developing and calibrating radar instruments for Mars exploration, Dr. Heggy participated in remote sensing measurements in the Southwestern Egyptian desert that identified and characterized the largest impact crater field on Earth. More recently, his use of radar technologies to find a large buried meteorite in Kansas was picked up by the national press and covered online and in newspaper articles across the country.

The LPI was pleased to host Prof. Kevin Burke as the LPI's second Heritage Fellow. As an icon in the field of plate tectonics, Prof. Burke brought his significant knowledge and insight into the nature of mantle plumes to the scientists at the LPI, stimulating lively conversations and catalyzing the exchange of new ideas. He will return to the Institute for a month in 2007 to continue his stimulating interactions.

This year the scientific staff at the LPI continues to take an active role in supporting NASA's Exploration Vision by participating in a variety of steering committees and analysis groups. These venues offer the LPI an opportunity to contribute scientific expertise as well as provide input to the leadership within NASA on key programmatic decisions. LPI scientists also participate in national and international space mission activities as part of instrument teams, through planetary data analysis, and in education and outreach activities. Drs. Laurel Kirkland and Allan Treiman continued their activities on instrument teams for the 2010 Mars Science Laboratory mission, and Drs. Essam Heggy and Steven Clifford continued their work on a number of ESA missions including MARSIS (NASA-ESA 2004, Mars Express mission), WISDOM (ESA-2011, ExoMars program), and CONSERT (ESA-2004, Rosetta mission).

The LPI has largely completed its first topical initiative on *Oxygen in the Solar System*, with the book project due to press in early 2007. The workshop associated with the second initiative on *Differentiation of the Terrestrial Planets*, organized by Dr. Chip Shearer, will occur in Sonoma, CA, in December 2006. A third initiative entitled *From Earth to Mars: Terrestrial Analog Models for Planetary Interpretations* is planned for a first field-oriented workshop in the late summer of 2007.

The LPI remains strongly committed to its service role for the scientific community and the public. This year LPI hosted the 37th Lunar and Planetary Science Conference (LPSC), one of its major contributions to the scientific community. Over the last four decades this meeting has evolved into the most important planetary conference in the world, and this year's meeting attracted 1546 active researchers (including 359 students) from 24 different countries. In addition to LPSC, the LPI continues to sponsor workshops, conferences, and publication activities in a wide variety of topical areas, including support of current NASA missions and foci.

We continue to see strong growth in the total number of hits on the LPI Web site and in the amount of data transferred to users. A significant driver for this growth is believed to be the renewed emphasis on lunar science resulting from the President's Exploration Vision for NASA. This new focus has required many in the extended NASA community to revisit much of the historic lunar data, developing projects to make use of the highest-quality data and images that exist for the lunar surface. These images are maintained in the Regional Planetary Imaging Facility (RPIF) at LPI and in the library collection, which is focused on planetary and space sciences. It is important to note the marked increase in the amount of data transferred from the LPI to end-users over the last year. This seemingly disproportionate increase is driven significantly by the LPI's success in digitizing a major portion of the lunar collection and publishing it on the LPI Web site.

Education and outreach activities continue to gain national recognition, expanding these efforts into a number of new states and gaining significant momentum with funding from successful grant applications. Further validation of the success of these programs can be seen in the significant increase in page views in the education section of the LPI Web site.

Mission Statement

The Lunar and Planetary Institute, a division of the Universities Space Research Association, was established during the Apollo missions to foster international collaboration and to serve as a repository for information gathered during the early years of the space program.

Today, the LPI is an intellectual leader in lunar and planetary science. The Institute

- serves as a scientific forum attracting world-class visiting scientists, postdoctoral fellows, students, and resident experts;
- supports and serves the research community through newsletters, meetings, and other activities;
- collects and disseminates planetary data while facilitating the community's access to NASA science; and
- engages, excites, and educates the public about space science and invests in the development of future generations of explorers.

The research carried out at the LPI supports the National Aeronautics and Space Administration's (NASA) efforts to explore the solar system.

Background

Since its inception, the Lunar and Planetary Institute (LPI) has focused its efforts on cultivating and supporting a community of bright, forward-thinking scientists who intellectually lead interdisciplinary research efforts that cut across planetary science, astrobiology, geology, and physics. In addition to their research, the resident and visiting LPI scientists and students work closely with the NASA organization, understanding the culture and politics that drive the agency. This unique combination of scientific excellence and NASA acumen positions the LPI to be valuable as an advisor, collaborator, and spokesperson for the agency, bridging the gap between basic scientific research at the university level and applied efforts that allow NASA to realize the Exploration Vision set forth by President Bush in 2004.

The Lunar and Planetary Institute promotes this collegial environment by requiring its scientists to closely collaborate with scientists and engineers at the individual NASA centers, by maintaining contact and interaction with the university community, and by participating actively in NASA advisory committees and mission planning, all while maintaining cutting-edge research programs. To assist the resident scientific staff in this task, the Institute recruits a steady flow of visiting scientists, postdoctoral fellows, students, and interns who bring unique scientific expertise and intellectual energy to create a dynamic think-tank-like environment that has become the hallmark of the LPI.

Director — Dr. Stephen Mackwell

The Institute has been under the leadership of Dr. Stephen Mackwell since 2002. As a scientist of international reputation who has made fundamental advances that have led to increased understanding of planetary processes, Dr. Mackwell brought the necessary scientific credentials, management experience, and vision to lead the LPI.

Dr. Mackwell was born in New Zealand, receiving his master's degree in physics from the University of Canterbury and his doctoral degree in geophysics from the Australian National University in Canberra, Australia. After receiving his degree, he spent two years as a research fellow at Cornell University before accepting a faculty position in the Department of Geosciences at the Pennsylvania State University. While at Penn State, Dr. Mackwell established himself as a world-recognized expert in experimental geophysics, establishing a world-class research program.

In 1998 Dr. Mackwell moved to the Universität Bayreuth in Bayreuth, Germany, and quickly rose to the position of Director of the Bayerisches Geoinstitut, where he served until 2002. Under his guidance the Geoinstitut strengthened its position as one of the preeminent experimental geosciences facilities in the world, and broadened its research programs to more fully address deep-Earth issues.

As Director of the LPI, Dr. Mackwell has refocused the Institute on scientific excellence, recruiting world-class scientists and working closely with NASA in a variety of roles and initiatives to support the new Exploration Vision (the Moon, Mars, and beyond). Dr. Mackwell has participated in the Solar System Exploration Subcommittee, is actively involved in the Lunar Exploration Analysis Group, and is a member of the Venus Exploration Analysis Group. He also is a member of the Management Operations Working Group and is the Panel Chief for Planetary Geology and Geophysics.

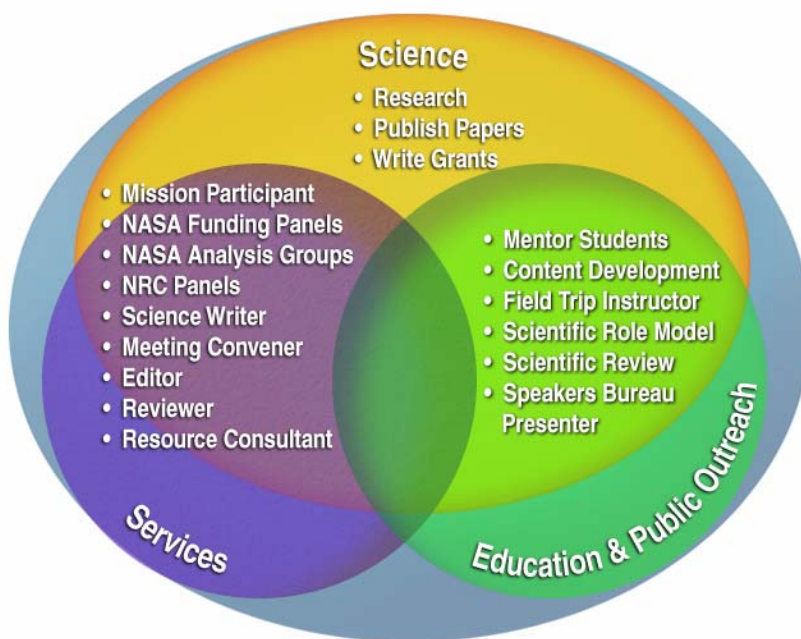
Dr. Mackwell maintains an active research program focused on mantle and crustal processes on Earth and other terrestrial planets.

Scientific Staff and Visiting Scientists

Within the Lunar and Planetary Institute there is a small core of Staff Scientists, whose fields of research represent much of the breadth of the planetary science community. While most of the scientists who work at the Institute reside there for periods from several days up to three years, the Staff Scientists remain for longer periods, bringing stability to the LPI science program and acting as access points into unique subsections of the planetary community. While they are expected to perform cutting-edge, world-class science, produce quality publications, and present research at national and international conferences and workshops, the Staff Scientists are tasked with additional service roles that occupy approximately 50% of their time; they are required to provide at least 25% of their salaries from external grants, but can increase the percentage of time devoted to research by bringing in additional funds. These scientists are a critical part of the role of the Institute in the service of NASA, the scientific community, and the broader community at large. Scientists who have neither the interest nor aptitude for such service are not encouraged to remain at the Institute.

All activities, programs, and projects undertaken by the Institute require some level of scientific knowledge and expertise. Although the Institute can tap into the resources of the external community for support, easy access to Staff Scientists due to their proximity and their extensive experience with our service programs contribute efficiencies that enable the Institute to provide quality service and expedience at a significantly reduced cost to our constituency.

Roles of the LPI Staff Scientists



Staff Scientists are also expected to contribute fundamentally to NASA program activities. Because they receive salary support under the LPI, scientists are rewarded for taking on significant roles on panel activities, as well as on analysis and working groups.

Staff Scientist Research Foci*

Dr. Stephen Clifford focuses on the nature and evolution of the martian hydrosphere. His recent work with Essam Heggy on interpretation of radar imaging of Mars analog sites on Earth provides important constraints on present and planned observations of Mars.

Dr. Walter Kiefer uses both gravity modeling and numerical mantle convection simulations to constrain the internal structure and the tectonic, volcanic, and thermal evolution of Mars, Venus, and the Moon. His current work combines computer models with martian meteorite geochemistry to constrain temperatures in the martian mantle and the role of mantle water in the magmatic evolution of Mars.

Dr. Laurel Kirkland works jointly with Department of Defense researchers on remote identification of mineralogy using infrared spectrometers, providing her with access to unique high-quality laboratory, field, and airborne instrumentation. The results of her recent work have fundamentally changed our interpretation of infrared spectra of Mars.

Dr. Patrick McGovern performs geophysical analysis of volcanic and tectonic features and crustal structures of the terrestrial planets, with emphasis on the growth and evolution of large volcanic edifices subject to lithospheric flexure.

Dr. Julianne Moses performs theoretical investigations of physical and chemical processes in planetary and satellite atmospheres, with particular emphasis on photochemical modeling, aerosol formation and dynamics, aeronomy, and atmosphere-surface interactions. She is currently conducting comparative studies of the thermal structure, chemistry, and climate of the upper atmospheres of Jupiter, Saturn, Uranus, Neptune, extrasolar giant planets, and brown dwarfs.

Dr. Paul Schenk investigates the geologic evolution and history of icy satellites from geologic mapping and cratering studies. His recent research has focused on developing and applying tools for topographic mapping and visualization of jovian and saturnian satellites.

Dr. Tomasz Stepinski is currently developing and implementing machine learning methods to automate the process of geomorphic mapping of Mars and other planetary surfaces. His research has led to a new, precise global map of martian valley networks that show an order of magnitude more valleys in Noachian terrain than were previously manually mapped, pointing strongly to ubiquitous precipitation on early Mars.

Dr. Allan Treiman's work emphasizes volatile species in planets and asteroids, applying evidence from solid samples (meteorites and lunar rocks). Some of his most important recent work is on water-deposited carbonate minerals in the martian meteorite ALH84001, aqueous alteration (on Mars) of the nakhlite martian meteorites, and the origin of water-bearing high-temperature minerals in an ordinary chondrite (LAP 04840).

* Highlights the research activities of the Staff Scientists; their recent activities in support of the LPI's Service and Education and Public Outreach activities can be found in the Appendices.

Table I. Core scientific staff resident at the LPI

The research areas are diverse within the planetary sciences, with studies of atmospheres, tectonics, dynamics, surface processes, and remote sensing of planets, impact processes, and planetary materials.

Visiting Scientists come to the Institute to collaborate with researchers at the Institute and the Johnson Space Center (JSC) Astromaterials Research and Exploration Science Directorate (ARES) and access the astromaterial samples housed at JSC. A complete list of visiting scientists who have spent time at the Institute this year may be found in Table II. Contributing activities of the Visiting Scientist may be found in the Appendices.

Visiting Scientist at the Institute During 2006 *

Marc Norman	Australian National University
Jim Karner	University of New Mexico
Vickie Bennett	Australian National University
Wei Luo	Northern Illinois University
Valerie Malavergne	Universite de Marne-la-Vallee
David Kring	University of Arizona
Hilary Downes	Birkbeck University, London
Kevin Burke	University of Houston
John Lindsay	Australian Geological Survey
Kaori Joho	Kyushu University
Brad Thomson	Brown University
David Evans	University College, London
Brian Bue	Purdue University
Karla Keubler	Washington University, St. Louis
Souyma Ghosh	University of Houston
Cyn Ti Lee	Rice University
Holger Sommer	Rice University
Alice Legall	CETP-IPSL
Clive Neal	University of Notre Dame

* Highlights the research activities of the Staff Scientists; their recent activities in support of the LPI's Service and Education and Public Outreach activities can be found in the Appendices.

Table II. Visiting scientific staff

Core Scientific Accomplishments

The scientific work being pursued at the LPI runs a diverse gambit of topics ranging from astrobiology and planetary geology to computational simulations of planetary atmospheres and Martian landscapes. This year scientists have made advancements in many of these areas; representative examples are delineated below.

Dr. Walter Kiefer

Musselwhite, D.S., H.A. Dalton, W.S. Kiefer, and A.H. Treiman, Experimental Petrology of the Basaltic Shergottite Yamato-980459: Implications for the Thermal Structure of the Martian Mantle, Meteoritics Planet. Sci. 41, 1271-1290, 2006.

Martian meteorite Yamato 980459 (Y98) is an olivine-rich, basaltic shergottite that formed on Mars about 472 million years ago. A recently completed experimental petrology study of Y98 demonstrated several important facts. First, comparison of the olivine chemistry in Y98 and in the experimental charges demonstrates that Y98 is a primary melt of the martian mantle. This means that observations of Y98's melting behavior can be used as constraints on the thermal structure of the martian mantle. Second, multiple saturation of melt with olivine and low-calcium pyroxene was observed a pressure of 12 kilobars. This is the first time multiple saturation has been documented in a martian meteorite and implies that the melt separated from its mantle source region near a depth of 100 km. Third, the very high melting temperature, 1540 degrees C at the multiple saturation pressure, places severe constraints on the thermal structure of the martian mantle. The most likely explanation for these observations is that the core of Mars is at least 100 °C hotter than previously believed.

Drs. Allan Treiman and Molly McCanta

Treiman A.H., McCanta M.C., and Essene E.J. (2006) The Amphibole-bearing chondrite meteorite LAP04840: Metamorphism and 'tectonics' in a hydrous asteroid. *EOS Trans. AGU*, 87, Fall Meet. Suppl., Abstract #7854.

The Earth and Mars are unusual in the inner solar system for having abundant water – the planets Venus and Mercury are very dry, as are nearly all meteorites from the asteroid belt. The new meteorite LAP 04840 is an exception – a water-rich meteorite from an asteroid. Its water is contained in minerals like amphibole and mica, which occur on Earth in metamorphic rocks that formed at high temperature and pressures. In LAP 04840, these minerals grew at about 675°C at a pressure of 1000-2000 atmospheres, in the presence of liquid water. This pressure and temperature require that LAP 04840 formed inside a large asteroid (larger than 100 km diameter), which must have been broken apart to release the meteoroid to space and eventual travel to Earth. The source of the water is not yet known – why is this meteorite (and its parent asteroid) wet while all others are dry?

Dr. John Lindsay

Lindsay, J.F. and Clemett, S., 2006. Progress towards an understanding of biogenesis. (Abstract) Geological Society of America, Philadelphia, October, 2006.

Lindsay, J.F., Brasier, M.D., McLoughlin, N., Green, O.R., Fogel, M. Steele, A. and S. A. Mertzman, S.A., 2005, The problem of deep carbon – An Archean paradox. *Precambrian Research*, 143, 1-22.

The only direct evidence of biogenesis and the prebiotic environment in which it occurred is preserved in Earth's early rock record. Ultimately any model of biogenesis must be tempered by an understanding of the environment of early Earth. Biogenesis must, by necessity, have been a stochastic process occurring in an environment abundant in organic compounds where complex reaction could occur regularly. One of the most likely settings proposed for such a primordial environment is in and around the preserved remains of ancient hydrothermal vents. In an attempt to understand these ancient setting and to establish the details of the point in time at which biogenesis occurred we have been working on the Pilbara Craton of Western Australia for the past seven years in rocks as old as 3.5 billion years. Our work has shown that indisputable evidence of life in terrestrial rocks older than 3.0 billion years is rare and often equivocal. This reflects both poor preservation and the fact that Earth's early biomass was small. We have mapped and sampled these ancient hydrothermal systems in detail and have been able to show that during the Archean hydrothermal systems were synthesizing prebiotic organic at elevated temperatures and pressures. The prebiotic organic compounds were then transported to the seafloor in a silica-rich slurry, with a low pH and a high CO₂ content (Lindsay et al., 2005). On the seafloor they were deposited, along with any biospheric organics, to form laminated chert units. The "primordial medium" in which life first evolved may thus have been a silica-rich slurry which contained basic prebiotic organic building blocks fundamental to the origins of life. We are now analysing the organic compounds trapped in these ancient cherts and attempting to discriminate between prebiotic and biotic compounds (Lindsay and Clemett, 2006).

Postdoctoral Fellows and Students

Postdoctoral Fellows –

Fellows, students, and interns are a key component of the cultural mix at the Institute. The LPI has long demonstrated its commitment to educating the next generation of planetary science researchers at all levels with programs targeted to postdoctoral fellows, graduate students, and undergraduates.

This year the LPI hosted nine resident post doctoral fellows, with one additional professional working at other universities but in collaboration with LPI scientists.

Students –

The LPI welcomed a large number of students throughout the year. Some are associated with local universities, while others come for weeks at a time from universities throughout the world to collaborate with LPI scientists. For many students, this work will form the basis for their thesis research.

Postdoctoral Fellows at the LPI in 2006

Dr. Daniel Nunes studies some of the large geologic provinces on Venus and how they relate to the history of the planet as a whole.

Dr. Donald Musselwhite works with Dr. Allan Treiman studying the formation and evolution of the terrestrial planets from a geochemical perspective.

Dr. Sylvie Demouchy is working with Dr. Stephen Mackwell to study in detail the effect of hydrogen on physical processes, as ionic diffusion, in solid phases relevant of the Earth's interior. A large portion of her research time is spent in the Kohlstedt lab at the University of Minnesota.

Dr. Thomas K. Greathouse works with Dr. Julianne Moses. Dr. Greathouse studies the spatial and temporal variations of temperature and key photochemical molecules in the atmospheres of the Giant Planets. He uses TEXES, the Texas Echelon cross Echelle Spectrograph, mounted on NASA's IRTF to retrieve the high spectral resolution mid-infrared data required to derive stratospheric temperature and the abundances of C₂H₂ and C₂H₆.

Dr. Molly McCanta focuses on determining the effects of oxygen fugacity on melting and crystallization in magmatic systems with an emphasis on elemental partitioning. Quantification of the conditions under which a melt equilibrates is used to better understand the variations in the interior of a planet such as Earth or Mars.

Dr. Justin Filiberto works with Dr. Allan Treiman focusing on terrestrial and martian experimental petrology. The primary goal is to utilize poly-baric experiments in a piston-cylinder apparatus, to study the effects of the volatiles F, Cl, and Br on the de-gassing behavior of Martian compositions in an effort to connect magmatic degassing with the acid-fog model of the Martian atmosphere.

Dr. Qinsong Li works with Dr. Walter Kiefer and focuses on martian volcanism. Utilizing theoretical models his work supports the conclusion that present-day mantle convection on Mars remains relatively vigorous.

Dr. Vinciane Debaille works with Dr. Al Brandon (ARES) studying terrestrial planets (Earth, Moon, and Mars) in a global geodynamic context as revealed by isotope geochemistry, focusing more particularly on the study of formation of chemically distinct reservoirs and mixing between these reservoirs, mantle convection, mantle plumes, the role of the source mineralogy and early planetary differentiation.

Dr. Michelle Kirchoff focuses on the geology and geodynamics of the outer planet satellites. Dr. Kirchoff is working with Dr. Paul Schenk exploring cratering statistics as a tool to determine relative ages of the satellite surfaces and features on those surfaces in addition to resolving the outer solar system cratering rate. Additionally, she is studying the distribution of features on Europa, such as chaos regions and domes, which may provide constraints for dynamical models of the ice shell.

Dr. Essam Heggy works with Dr. Stephen Clifford mapping subsurface hydrological and geological structures in planetary arid and cold-climate environments using radar imaging and sounding techniques.

Table III. Postdoctoral Fellows at the LPI in 2006

LPI Summer Intern Program

The Program -

The LPI's tradition of educating the next generation is readily apparent in the long-standing LPI Summer Intern Program. For the past 29 years, the LPI has identified a diverse group of top undergraduate students throughout the world and brought them to Houston to work with scientists at LPI and JSC/ARES. The 10-week program traditionally begins in June and runs until August. Typical intern projects include studies in formation of the planets and the solar system, lunar resource utilization, interplanetary dust

particles, lunar samples, meteorites and their origins, planetary regoliths and atmospheres, planetary volcanism, geophysical data analysis and modeling, geochemistry, petrology, experimental petrology, remote sensing and photogeology, tectonic processes, impact cratering, spectroscopic observations of planets, and astrobiology. Additional learning opportunities such as the summer Brown Bag seminars are geared toward filling in the gaps that may exist in the students' understanding of planetary science.

Intern	University	Research Advisor	Project
Erica Browning	Mount Holyoke College	J. Lindsay	A Stable Isotope History of Cambrian Carbonates from the Georgina Basin, Northern Australia
Daniel Card	University of Manitoba	S. Clifford E. Heggy	Investigating the Radar Reflectivity and Internal Structure of the Martian Polar Layered Deposits, Using the Finite Difference Time Domain Method
Melanie Channon	Arizona State University	L. Danielson K. Righter	Liquidus Phases of the Richardton-H Chondrite at High Pressures and Temperatures
Amine El Younsi	University of Bordeaux	E. Heggy S. Clifford	Experimental Electromagnetic Characterization of the Ice-Mixtures as an Analog Study to the Martian Polar Layered Deposits
Joshua Garber	University of Texas, Austin	L. Danielson K. Righter	Crystallizing Phases in a Magma Ocean Scenario
Patricia Hredzak	Chatham College	P. Niles	Determination of the Carbon Isotope Fractionation During Experimental Synthesis of Cryogenic Carbonates Under Mars-like Conditions
Michael Mendenhall	Washington University, St. Louis	T. Stepinski	Building an Automated Crater Recognition Routine
Kristen Paris	State University of New York, Buffalo	C. Allen	Mars Science Laboratory Landing Site
Margaret Rosenberg	Massachusetts Institute of Technology	W. Kiefer	Morphometry of Quasi-Circular Depressions in the Southern Hemisphere of Mars: Implications for Resurfacing History
M. Elise Rumpf	State University of New York, Buffalo	P. McGovern	The Influence of Lithospheric Flexure and Volcano Shape on Magma Ascent at Large Volcanoes on Venus
Anna Schneider	Ohio Wesleyan University	D. Mittlefehldt	<i>Compositional Models of Hematite-Rich Spherules (Blueberries) at Meridiani Planum, Mars and Constraints on their Formation</i>
Stephen Seddio	University of Rochester	P. Schenk	Expanding Our Knowledge of the Cratering of Enceladus and the Bright Terrain of Ganymede

Table IV. Undergraduates participating in the 2006 LPI/NASA Summer Intern Program

As the capstone of their summer experience, all interns present their scientific work at a special one-day conference. The seminar has become a time-honored tradition that is widely attended by all LPI and many JSC scientists. It is anticipated that a number of these projects will result in submission of abstracts to the LPSC in 2007. The LPI provides partial support for the participation of interns at that meeting.

The Alumni –

The Intern Program enjoys the support of a dedicated alumni network. For many interns, their experience at the LPI proves to be a defining moment in their careers, and consequently these 10-week experiences often hold a revered place in the minds of the alumni. This common experience proves to be enough to

perpetuate a tight knit community of alumni lead by the Intern Alumni Association. The President, 2003 Intern Kathryn Gardner, serving with 2002 Intern Jana Berlin, Vice-President of Communications, and 1988 Intern Tracy Gregg, Vice-President of Council, continue to lead the group. The group's activities include organizing an annual reunion, held this year in March during the 37th Lunar and Planetary Science Conference, and alumni gathering at the Meteoritical Society annual meeting in Zurich, Switzerland. More information about the Alumni Association is on the Alumni Web site at www.lpi.usra.edu/lpiintern/alumni/.



Heritage Fellow

The Heritage Fellow program was established at the LPI to bring venerable, distinguished researchers in the planetary science community to the Institute.

This year the Heritage Fellow was Dr. Kevin Burke of the University of Houston. Dr. Burke holds a Ph.D. in geology from the University of London. His more than 50 years of geological experience literally span the globe. Before assuming the chairmanship of the Department of Geological Sciences at the State University of New York at Albany in 1973, Burke served in academic and government positions in Ghana, Ireland Great Britain, Republic of Korea, Jamaica, Nigeria and Canada. Dr. Burke served as Director of the Lunar and Planetary Institute for 5 years during the mid 80's. Since 1983, Dr. Burke has held a tenured appointment as Professor of Geosciences at the University of Houston.

Throughout his career Dr. Burke's research interests have been wide-ranging. He has written more than 150 articles on various topics in regional and structural geology. His primary research interest is in the application of the findings of plate tectonics to the interpretation of the geological history of the earth. His recent focus of mantle plumes is particularly applicable to processes on terrestrial planets.



Research Productivity

Funding –

In the last three years the LPI has become more focused on encouraging the resident and visiting scientists to look for additional funding sources to support at least 25% of their salary. This increased emphasis, coupled with the high-quality science being produced at the Institute has resulted in a significant increase in grant dollars over the 2005 grant numbers. The funds released in this way are used in support of the Urey and Heritage Fellows, as well as the postdoctoral fellow and visiting scientist programs.

NASA is the primary source for this funding, although a number of grants were made from the National Science Foundation as well as funding from the French Space Agency and the Australian Research Council. Further diversification of funding sources (e.g., NSF, DOE) is being encouraged, as well as increased grant support of students and postdoctoral fellows.

For a complete list of all proposals submitted and funded in the last 12 months, please see Appendix III.

Scientific Publications –

The Institute's scientific staff published 57 peer-reviewed papers in 2006 with another 40 papers either submitted or in press. This level of productivity is a continued increase over the last four years and is in part a result of the dynamic scientific environment that has been created by an increased flow of visiting scientists and postdoctoral fellows, with a more-productive and scientifically energized atmosphere.

Topical Initiatives –

The Institute's first effort in the current funding cycle was entitled, "Oxygen in the Solar System," jointly chaired by Dr. James Papike of the University of New Mexico and LPI Director Steve Mackwell. The program of conferences and publications was endorsed by the Cosmochemistry MOWG and CAPTEM. Working closely with the scientific staff in the Institute, in JSC-ARES, and in the larger science community, the meeting and logistics staff coordinated three workshops over a 14-month period. Although the initial response to the project within the community was very positive, attendance at the workshops did not live up to the original expectations (57 for Terrestrial Planets, 38 for Asteroids and Meteorites, and 46 for Earliest Solar System), reflecting a parallel decline in attendance at many other topical conferences over the same period. Reduced budgets for science activities and scientist over-commitment appear to be the main causes of the lower attendance. A volume related to this initiative is currently in preparation in the Reviews in Mineralogy Series of the Mineralogical Society of America: "Oxygen in the Solar System." Most chapters have been received and are in review or revision at this stage.

The second **Topical Initiative** on "Differentiation of the Terrestrial Planets: A Multi-Planetary and Multi-Disciplinary Perspective" was proposed by Dr. Charles (Chip) Shearer of the University of New Mexico, and endorsed by CAPTEM, the Cosmochemistry MOWG, and the Planetary Geology and Geophysics (PG&G) MOWG. A workshop will be held in Sonoma, California, on December 8-10, 2006, with potential for a special volume of the *Journal of Geophysical Research – Planets*. Interest in this meeting has been very strong, with attendance expected to exceed 100 scientists and students. Depending on the success of this meeting and the interest from the community, additional conferences in this series focusing on "Shaping the Evolutionary Paths of the Terrestrial Planets," "Early Impact History," "Volatiles and Atmosphere Evolution," "Crustal Evolution and Planetary Tectonics," and/or "Planetary Formation: the Initial Building Blocks" may be planned.

A third **Topical Initiative** was recommended by the PG&G MOWG, and approved by CAPTEM and the Cosmochemistry MOWG, entitled "From Earth to Mars: Terrestrial Analog Models for Planetary

Interpretations,” and will be organized by Drs. Marjorie Chan (Ohio State University), John Grotzinger (California Institute Technology), and Scott McLennan (Stony Brook University). A series of field-oriented workshops are planned, with visits to sites that may serve as representative analogs of Mars environments. Although initially planned for initiation in the summer of 2006, the organizers felt that a delay for a year was warranted given the ongoing activities of the MER rovers.

Our experience from organizing these topical initiatives to date has indicated that a strong groundswell of interest from the planetary community, which can be sustained throughout the program of activities, is vital, and that strong leadership is needed to maintain momentum and ensure successful products. It is also absolutely critical that a scientist at the LPI have a major role in the organization to ensure that the program remains on track and to facilitate the search for external funds in support of invited speakers and students. Further topical initiatives will be solicited from the advisory groups and scientific community as the existing projects draw closer to completion.

Support of NASA

One of the LPI's major foci is to collaborate with and support the efforts of the NASA organization. This year, making use of a variety of different mechanisms and venues, LPI has successfully contributed to the agency at levels ranging from hosting, sponsoring, and planning meetings to contributing scientific expertise to missions and programmatic decisions.

Analysis Groups –

The Institute has taken a role in the management and support of three of the four community analysis groups - VEXAG (Venus Exploration Analysis Group), LEAG (Lunar Exploration Analysis Group) and OPAG (Outer Planets Analysis Group) - with LPI scientists also actively participating in MEPAG (Mars Exploration, Program Analysis Group). The LPI website serves as a common point of entry for the community to the information regarding each group's activities. As the home website for VEXAG, LEAG, and OPAG, our web team provides continuous support for posting of documents and connection to other sites worldwide. We continuously assess the structure and content of our sites to ensure that they remain easy to navigate and of optimal utility to the community. The LPI has also developed a number of web-based tools that allow the leadership and organizing committees from these communities to work on planning documents and white papers.

Institute scientists currently participate in OPAG, VEXAG and LEAG as active members and have leadership roles in VEXAG and LEAG. Of particular note, the LPI acts as the focus of activities associated with the preparation of the Lunar Exploration Strategy document, elements of which are currently under review by a LEAG Special Action Team, and with the preparation of the VEXAG Venus Goals, Objectives, Investigations, Measurements and Priorities planning document.

Mission Support and Activity on NASA Panels –

LPI scientists, notably the Staff Scientists, are strongly encouraged to take roles in mission activities and to serve on NASA funding panels. Through these activities, they serve NASA and the scientific community. Currently, LPI scientists are on instrument teams for several planned Mars (NASA and ESA) and lunar (NASA) missions, as well as currently active missions (NASA and ESA). The instruments range from seismometers, to chemical analysis tools for rovers, to radar instruments for surface and orbital deployment. The LPI Education and Public Outreach team is also engaged on current and planned NASA Mars and lunar missions. For the most part, this involvement has come to fruition over the past four years, as the scientists have increased their visibility in the community through increased levels of publication, grantsmanship, service, and outreach. It is anticipated that further expansion of these activities will occur in the coming years.

LPI scientists frequently serve as members, Group Chiefs, or Panel Chairs of funding panels for Planetary Geology and Geophysics (PG&G), Cartography, Cosmochemistry, the Mars programs, and others. In recent years, various LPI scientists have performed in each of these roles, demonstrating a level of commitment to service far greater than the average of the scientific community. An LPI scientist currently leads the development of the next Planetary Cartography Ten-Year Strategic Outlook.

Facilities and Logistics –

This year the LPI provided planning and facilities for a large number of NASA meetings, including the Planetary Geology and Geophysics Management Operations Working Group (PG&G MOWG), the Cosmochemistry Management Operations Working Group (Cosmo MOWG), the Curation and Analysis Planning Team for Extraterrestrial Materials (CAPTEM), the Meteorite Working Group (MWG), and the Lunar Exploration Analysis Group (LEAG). The Institute also sponsored a range of other NASA meetings, either associated with the Lunar and Planetary Science Conference or as independent meetings and workshops at the CASS facility.

Scientific collaboration with the NASA organization occurs most frequently and most directly with the JSC's ARES, with most of the LPI visiting scientists having research programs that involve experimental or analytical work within the ARES facility. The two organizations work together to plan the annual Lunar and Planetary Science Conference, and collaborate on a number of conferences and workshops.

For a complete list of LPI's contributions to NASA and its programs, please see the Appendices.

Conferences and Publications

The Lunar and Planetary Science Conference (LPSC) —

The Lunar and Planetary Science Conference, jointly sponsored by LPI and JSC, brings together international specialists in petrology, geochemistry, geophysics, and astronomy to present the latest results of research in planetary science. Since its beginning in 1970 as the Apollo 11 Lunar Science Conference, the LPSC has been a significant focal point for planetary science research, with marked increases in submission of presentations and in attendance over the last 10 years (see chart). The 37th LPSC, held March 13–17, 2006, holds a record for attendance (1546), which included 359 foreign attendees from 24 countries.

LPSC/YEAR	# OF ABSTRACTS	# OF POSTERS	ATTENDANCE
26th/1995	805	247	820
27th/1996	776	251	742
28th/1997	830	255	851
29th/1998	968	367	1033
30th/1999	1052	429	1082
31st/2000	1096	454	1116
32nd/2001	1197	529	1173
33rd/2002	1075	516	1164
34th/2003	1132	516	1179
35th/2004	1176	580	1317
36th/2005	1409	783	1460
37th/2006	1437	825	1546

Table V. Attendance at the 2006 Lunar and Planetary Science Conference

Oral presentations were organized into numerous concurrent sessions over five days, for a total of 497 oral presentations. Approximately 825 posters were split into two sessions over the week, with highlighted sessions on Tuesday and Thursday evenings. Categories of presentations included astrobiology; comets, asteroids, and other small bodies; early solar system evolution and planetary formation; education and public outreach; impacts; interplanetary dust particles and solar grains; Mars; meteorites; the Moon; Mercury; outer planets; satellites and rings; and Venus.

Dr. Jonathan Lunine, Lunar and Planetary Laboratory, University of Arizona, presented the Masursky Lecture, titled “Beyond the Asteroid Belt: What to do Next in the Solar System, and Why?” Special sessions focused on the Hayabusa asteroid and Deep Impact missions and the Bosumtwi Meteorite Impact Crater Drilling Project. Two interactive evening sessions included soliciting input from the community on planning potential sites for the Mars Exploration Program’s Phoenix Lander and a discussion on the importance of planetary cartography.

Special events included an education/public outreach workshop on Public Understanding of Planetary Science; an open house for displays of outreach programs and activities; a NASA Early Careers Workshop; a NASA Headquarters briefing; and a student/scientist reception held on Monday evening to honor the Masursky Lecturer, the winners of the GSA Stephen Dworkin Student Awards for 2005, and all students who made presentations.

A special feature each year at LPSC is the Stephen E. Dornik Planetary Student Paper Awards for the best research presentations — one for an oral presentation and one for a poster presentation — by a student who is a U.S. citizen (recent graduates, precollege students, and postdoctoral fellows are not eligible). Given by the Planetary Geology Division of the Geological Society of America, the awards are appropriate for recognizing student participation and excellence. A student/scientist reception held during the conference provided opportunities for students from all countries to meet and interact with scientists. The conference remains one of the most affordable meetings for student attendance, with 359 students in attendance at the 37th LPSC.

Planning for LPSC takes approximately one year and involves extensive interaction between experienced personnel from the Publication and Program Services Department, Computer Center, Department of Education and Public Outreach, and the Center for Information Research Sciences as well as JSC staff and a variety of local vendors. This process involves working with the Science Co-Chairs (Dr. Stephen Mackwell, LPI, and Dr. Eileen Stansbery, JSC) to establish policies and deadlines for the following year's conference; negotiating contracts to establish sites and services for conference activities; making arrangements for shuttle services and poster board rentals; meeting with audio-visual technicians, transportation specialists, etc.; producing and distributing meeting announcements; contacting and confirming members of the Program Committee; accepting and processing abstract submissions; producing appropriate meeting products (abstract CD-ROM, program booklet, attendee badges, etc.), and providing onsite logistical administration of the meeting to handle registration, provide e-mail access, oversee poster setup, staff publishers' exhibits, interact with hotel staff, etc. This year's conference resulted in the publication of *Lunar and Planetary Science XXXVII*, LPI Contribution No. 1303, a CD-ROM containing the program and abstracts accepted for presentation at the 37th LPSC.

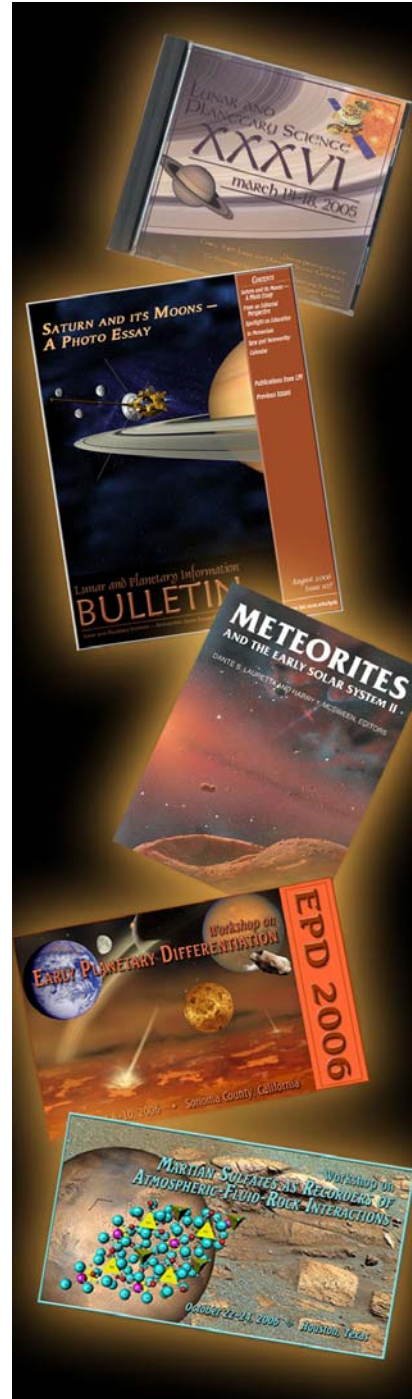
The venue of the conference was the South Shore Harbor Resort and Conference Center, located in League City, near JSC and LPI. The conference facility provides extensive meeting room space for technical sessions, peripheral meetings, and guestroom accommodations to provide convenience for participants and attendees.

Other Conferences and Workshops –

In addition to the Lunar and Planetary Science Conference, LPI sponsored a variety of other workshops and conference from October 1, 2005, to September 30, 2006. A complete list of meetings may be found in Appendix IX

Books –

The LPI Publications and Program Services Department completed prepress services for the production of *Meteorites and the Early Solar System II (MESS II)*, the latest book to be published in the prestigious



Space Science Series of the University of Arizona Press. Services provided included accepting manuscripts electronically, coordinating and tracking reviews, copyediting, formatting, and page layout. *MESS II* was released in June 2006.

Prepress services are currently being provided for *Protostars and Planets V*, the next book scheduled for publication in the Space Science Series. Services include coordination of production with the scientific editors, copyediting, formatting, page layout, and indexing. *Protostars and Planets V* is scheduled for publication in late 2006 or early 2007.

Discussions with the editors have begun for production of *Trans-Neptunian Objects**, the book to immediately follow *Protostars and Planets V*. Production of *Trans-Neptunian Objects* is scheduled for December 2006 through December 2007. (*Final title to be determined.)

Lunar and Planetary Information Bulletin (LPIB) —

Issue No. 104 of the *Lunar and Planetary Information Bulletin* was published in November 2005. This 15-page issue featured a cover story entitled “The Falcon and the Asteroid: Sumo Wrestling in Space,” highlighting the Hayabusa mission to asteroid Itokawa. Other features include “News from Space,” providing mission updates from New Horizons, Mars Global Surveyor, and the Mars Exploration Rovers, as well as news from the Hubble Space Telescope and Spitzer Space Telescope; “In Memoriam,” a tribute to Alastair Cameron; “Spotlight on Education,” featuring upcoming and recent education and public outreach activities of NASA’s Broker/Facilitator program; “Research Opportunities for Students,” providing information about a number of internship opportunities in the planetary sciences; “New and Noteworthy,” listing new products of interest to the community; and a calendar of upcoming scientific conferences and workshops.

Issue No. 105 of the *Lunar and Planetary Information Bulletin* was published in February 2006. The 16-page issue featured a cover story entitled “Going to Pluto: The New Horizons Mission,” highlighting the launch of the New Horizons spacecraft from the point of view of a firsthand observer; “News from Space,” providing mission updates from Stardust and the Mars Exploration Rovers, along with new discoveries by the Spitzer and Hubble Space Telescopes; “In Memoriam,” a tribute to Petr Jakeš; “Spotlight on Education,” featuring upcoming and recent education and public outreach activities of NASA’s Broker/Facilitator program; “Resources for Researchers,” covering online forums and blogs of interest to planetary scientists; “New and Noteworthy,” listing new products of interest to the community; and a calendar of upcoming scientific conferences and workshops.

Issue No. 106 of the *Lunar and Planetary Information Bulletin* was published in May 2006. The 20-page issue featured a cover story entitled “37th LPSC: The Conference in Review,” which provided highlights of this year’s Lunar and Planetary Science Conference, including the text of the Masursky Lecture presented by Dr. Jonathan Lunine, “Beyond the Asteroid Belt: Where to Go Next in the Solar System, and Why”; “News from Space,” featuring news from the Mars Orbiter, Cassini, Lunar Reconnaissance Orbiter, Mars Exploration Rovers, and Stardust missions, as well as the Hubble Space Telescope; “Milestones,” featuring news about the NASA Solar System Ambassadors Class, GSA Dwornik Student Award winners, Ambassadors of Exploration, the Bethe Prize, and the Division for Planetary Sciences Kuiper Prize, Urey Prize, Carl Sagan Medal, and Harold Masursky Award; “New and Noteworthy,” listing new products of interest to the community; and a calendar of upcoming scientific conferences and workshops.

Issue No. 107 of the *Lunar and Planetary Information Bulletin* was published in August 2006. The 16-page issue featured a cover story entitled “Saturn and Its Moons — a Photo Essay,” highlighting some of the spectacular new images obtained by the Cassini mission; an editorial about the recent decision of the International Astronomical Union to “demote” Pluto from planetary status; “Spotlight on Education,” featuring upcoming and recent education and public outreach activities of NASA’s Broker/Facilitator

program; "In Memoriam," a tribute to George Wetherill; "New and Noteworthy," listing new products of interest to the community; and a calendar of upcoming scientific conferences and workshops.

These issues, along with past issues dating back to 1994, are available in electronic format via the LPI website. Subscribers are sent an e-mail notification message whenever a new issue is published.

Computational Support and Web Activity

Computational support is a key resource for the scientific staff at the LPI, assisting scientists in developing and utilizing existing computing resources to address fundamental issues in planetary sciences and in defining new computational approaches to answer known planetary science problems. In addition to the technical support this group provides to the scientific staff, the Computer Center is tasked with maintaining the LPI's Web site and monitoring the activity and usage of the site. Table VI below gives a quantitative summary of the usage of the LPI Web site from October 1, 2004, to September 30, 2006.

	9/1/04-8/31/05	9/1/05-8/31/06
Total number of page views	7.8 million	10.4 million
Average page views per day	21,312	28,543
Average data transferred per day	4.5 GB	6.2 GB

Table VI. Quantitative comparison of web site usage

The LPI website is an indispensable and dynamic resource for the planetary science community. The Institute continues to evolve, with many of the pages updated and added to daily as new material becomes available. The Institute currently houses a large number of resources that translate into a significant amount of data. The website serves as one of the planetary community's key access points for meeting registration, the archive of meeting abstracts, planetary images and data, and educational material. The Institute webpage receives 28,500 "page views" a day, with 80% of those being registered in the service sections of the website. In the recent LPI survey 60% of the queried community reported using the website on a monthly basis, while 88% found the archive of meeting programs and abstracts useful or very useful.



The Institute also hosts secure internal sites for mission-related activities such as websites for the curation aspects of the Stardust and Genesis missions. Since the mission teams include many foreign scientists, export control and security issues result in cumbersome and time-consuming limits on NASA password-protected sites. The LPI serves as a highly secure, responsive middle ground to facilitate collaboration without issues of national security.

NASA Regional Planetary Image Facility and Library

NASA Regional Planetary Image Facility and Library -

The operation of library services and the NASA Regional Planetary Image Facility (RPIF) is managed under the Center for Information and Research Services (CIRS). The general mission of CIRS is to develop, organize, maintain, and provide access to a collection of space-science related materials in a variety of media that serve the needs of the scientific and educational communities as well as the public. To assist with the mission, CIRS is a member of the Online Computer Library Center (OCLC), a network of over 55,000 international libraries, and AMIGOS, a network of over 750 regional libraries, as well as Texas Library Connection, a network of 5300 Texas school libraries.

CIRS continues to serve a broad range of patrons, including funded scientists, educators, students, and the public. The collection is refreshed on a regular basis with the addition of books, journals, and data within the scope of the CAN. Imagery and cartography are available through the Internet for those in remote locations. The CIRS facilities are open to researchers and the public during normal business hours. The library provides multimedia resources and is a site for documentary and news film crews.

Items in collection	55900
Items processed / cataloged	1263
Average # library card holders	177
Items circulated	711
Interlibrary loans / photo dups	208
Requests for information	267
Walk-in patrons	2363
Tours	29

Table VII. Facility use in 2006

CIRS supports a "What's New" page (www.lpi.usra.edu/library/whats_new.shtml) with "Recent Additions to the Collection" and "New and Noteworthy." These pages are also available through RSS feeds and audio files. These options give users the ability to access information about library and RPIF news in formats that suits the users' needs. "What's New" is also available as a paper copy for walk-in patrons. The staff maintains a Calendar of Events for non-LPI-sponsored conferences and workshops and compiles a section on newly published materials for the quarterly Lunar and Planetary Information Bulletin (LPIB).

The staff continues to develop displays and exhibits using library and RPIF materials. Topical displays feature imagery, maps, books, and items from the LPI's collection, the Internet, and other resources. Examples of the exhibits include "Astrophotography", "Rosetta Mission", "Searching the Web", "Robotics", "Meteorites", "Return to Flight", "Lunar Materials", "Geology of Mars", "Night Sky", "Best Book Award Winners", "Life in the Universe", "Solar Eclipse", "Texas!", "Stardust", "New Horizons", "Challenger: 20 Years Later", "Planetary Climatology", "Teaching Science", and "Asteroids". Support and display materials for the monthly Family Space Days were provided on topics such as "Robotics", "Near Earth Objects" and "New Horizons".

Support continued in the expansion of the "Gateway to the Moon" web pages. The staff provides calendar updates, additional resources, and other information.

Library Services -

The subject emphasis of the collection continues to be astronomy and geology, with secondary collection development extending into support fields of computer science and remote sensing. Enhancements in

the fields of astromaterials and astrobiology continued this year. Special attention was devoted to the upgrade of formats in the various multi media materials.

Work continued on the scanning of volumes in the early LPI Technical Report and abstract volume series. These documents will be available as searchable PDF files on the LPI Web site, providing accessibility of out-of-print publications to a wider audience for future mission planning and studies.

CIRS hosted the annual Combined Publishers Exhibit in conjunction with the 37th Lunar and Planetary Science Conference (LPSC), March 13–17, 2006, in League City, Texas. The exhibit featured materials from 52 publishers and included 275 books, journals, audiovisual materials, and miscellaneous products. This exhibit gives LPSC attendees the opportunity to review new books and other materials in their field of interest. Special discount pricing was offered by many of the publishers for those interested in adding the items to their personal collection or recommending to their local library. Through the generosity of participating publishers, we were able to distribute over 400 complimentary space art calendars and sample scientific journals to LPSC attendees.

Since the beginning of this reporting period, there have been 303 items donated by publishers, NASA, and other government agencies. A prime source has been items submitted to the LPSC Combined Publishers Exhibit.

DONATIONS QUANTITY

Books	223
CD-ROMs	13
DVDs/Videos	9
Maps	16
Posters	12
Miscellaneous	30

Table VIII. Donations made to the LPI library in 2006

Regional Planetary Image Facility -

The NASA Regional Planetary Image Facility (RPIF) at the Lunar and Planetary Institute is led by Dr. Paul Schenk. As RPIF Director, Dr. Schenk provides overall direction of the facility, interfaces with NASA RPIF program management, and serves on NASA's RPIF Board of Directors. The day-to-day operation is within CIRS. The facility maintains an open-access policy for users and is available to the public during normal business hours. Requests and questions can be submitted through the Internet. Imagery, data, and other information is provided for researchers, educators, students, media, and the general public, from Texas to California to New York to New Zealand and Belgium. Below is a partial list of publishers and projects supported by CIRS staff.

Source of Request	Project
Field Museum	Exhibit: <i>Evolving Planet</i>
Workaholic Production	History Channel documentary
San Jacinto Museum	Exhibit: San Jacinto Museum from Space
Astropis	Czech astronomy journal article
Apollo Lunar Surface Journal	Image requests
Griffith Observatory	Exhibit support
Creative Differences	History Channel documentary
National Library of Australia	Image request for publication
Fragment Productions	Unnamed documentary
Filament Design Studio	Apollo image for exhibit
Ames Research Center	World Wind project
Abu Dhabi Astronomy Club	General information request

Pearson Education	Book: <i>Sigma Mathematics</i>
Astrovisuals	Apollo imagery for unnamed book
Glenn Research Center	Lunar document
Holtzbrink Publisher	Image request
California Academy of Science	Crater image request
Rautaki	Image for Maori language website
Harcourt	Book: <i>Dreamers and Doers</i>
Gala Film Production	Mars Rising
Future Channel	Documentary: Young Explorers
Soluri - Niolleti	Presentation support
Legrand	Website / CD: <i>Virtual Moon Atlas</i>
Freeman Publishers	Principles in Paleontology
Editorial Santillana Columbia	Textbook: <i>Natural Science</i>

Table IX. Representative requests for information

The LPI RPIF continues to expand access to the imagery and cartography through the Web site. The collection of Apollo Metric (Mapping) Camera images was enhanced with the addition of higher resolution imagery. Both the Apollo Metric and Panoramic camera images are searchable by feature name and coordinate. The search feature is in preparation for the Apollo Hasselblad (70mm) camera images.

The NASA Special Publication series document Ranger VII Photographs the Moon joined the existing Ranger VIII and Ranger IX Photographs of the Moon on the website (www.lpi.usra.edu/resources/ranger/). It features documentation, imagery, and an interactive slide show that provide dramatic impact for these early missions to the Moon.

The Lunar Cartographic Dossier is now available on the LPI website (www.lpi.usra.edu/lunar_resources/lc_dossier.pdf). The Dossier is a classic document outlining the lunar photographic and mapping efforts from pre-telescopic days through the Apollo-related mapping program. This document will aid Return to the Moon efforts with its documentation of previous lunar exploration efforts.

The Lunar Map Catalog (www.lpi.usra.edu/research/mapcatalog/) expanded with the addition of the USGS Geologic Atlas of the Moon. These 44 geologic maps are the primary set covering the Nearside of the Moon at 1:1,000,000. These maps are at the same scale as the Lunar Chart (LAC), Lunar Map (LM), and Lunar Shaded Relief (LSR) series. MARC records for the USGS Geologic Atlas of the Moon are available on the website. This will give assistance to librarian in adding the bibliographic records into their own library's catalog, which will provide wider access to the map series. Another series added was the special scale Lunar Topophotomap series (www.lpi.usra.edu/resources/mapcatalog/topophoto/). Individual sheets of this series have 1:10,000, 1:25,000, or 1:50,000 scale depending on the characteristics of the site and the availability of photographic coverage. Topographic information represented by 20-meter contours for the 1:50,000 and 1:25,000 scale maps. The 1:10,000 scale maps have 5-meter supplements. In cooperation with the U. S. Geological Survey – Astrogeology Branch, we prepared and processed the Lunar Equatorial Zone Mosaics (LEMC) map series www.lpi.usra.edu/resources/mapcatalog/LEMC/. This series is of particular interest with its lunar farside numbering system. The numbering schema was an interim system to reference significant surface features prior to International Astronomical Union (IAU) approval in 1970.

Education and Public Outreach

The Education and Public Outreach Department continued its efforts to engage formal and informal educators and families in planetary science through workshops, courses, field experiences, and public events.

Workshops, short courses and multiple-day institutes were provided for over 500 educators, primarily in the Houston region, during 2006. The E/PO Department partnered with the Harris County Department of Education and ARES staff to offer monthly day-long training sessions covering a variety of standards-aligned astronomy and planetary science workshops. Workshops and short courses also were offered regionally through the Brokering Program. A bi-annual semester-long course, presented in collaboration with Rice University's Earth Science Department, shares *Earth and Planetary Science* with elementary and middle-school teachers.

Efforts are being undertaken to work more closely with districts and to offer multiple-day institutes that permit educators to be immersed in the process of science, content, and best practices. This model proved successful with the Aldine Independent School District. Cypress Fairbanks and Harris County districts have requested single-day trainings. Collaborations actively are being pursued with the Dickinson, Friendswood, Galena Park, Pasadena, and Santa Fe districts.

In July, the Lunar and Planetary Institute led its sixth annual week-long field experience for middle-school educators. Twenty six educators participated in *The Heat From Within: Earthly Insights into Planetary Volcanism*. Attendees accompanied LPI scientists Drs. Allan Treiman and Walter Kiefer to field sites in the Bend, Oregon region to build an understanding of volcanism and volcanic features on Earth and extend this knowledge to volcanic processes in the solar system. The Education and Public Outreach Department worked closely with Treiman and Kiefer to coordinate the experience, identifying and implementing hands-on, standards-aligned activities, and guiding team report-outs. Supplemental funding recently was awarded by the Science Mission Directorate for field experiences through 2009.

This is "the BEST workshop I have attended!"

- 2006 Field Experience
- Attendee

"The best way to learn and understand science is to experience it. We always say this to our students but don't always recognize it is also important for teachers ..."

-2005 Field Experience
Attendee

LPI's Education and Public Outreach Department continues to serve as a Support Network Broker Facilitator in the south central region for the Science Mission Directorate. As a Broker, its efforts concentrate on promoting educational interactions between scientists and educators and providing information and resources about Science Mission Directorate missions, research, and educational opportunities and products. LPI provides information to a community of 1400 educators through an electronic newsletter, and to the planetary science community through the *Lunar and Planetary Information Bulletin*. LPI also hosts semi-annual day long community conferences to examine topics of interest to scientists and educators. In March, 54 participants attended the *Public Understanding of Planetary Science* workshop and explored current science misconceptions; research and tools for identifying and altering misconceptions. LPI staff members also are involved in several Support Network Working Groups, including the Planetary Data in Education Initiative and the Community Based Organizations Working Group. LPI co-chairs the Pre-Service Education Working Group, focusing on understanding the needs of pre-service faculty and future educators and identifying opportunities for involvement by the space science community.

Three grants from NASA's Science Mission Directorate and Exploration Systems Mission Directorate supported expansion of the **Explore!** Program beyond its initial four states to include librarians and after-school children's program providers in Alabama, Delaware, Maryland, Mississippi, New Mexico, Oklahoma, and Pennsylvania. Over 200 **Explore!** Trainers currently are sharing space science in their communities. The latest materials are being developed in partnership with after-school educators from the Harris County Department of Education and **Explore!** Trainers. Two modules – *Health in Space* and *To the Moon and Beyond with the Lunar Reconnaissance Orbiter* – bring human and robotic exploration alive in informal learning environments. A third module, *Mars Inside and Out*, will be launched in 2007, with the addition of 120 more **Explore!** Trainers. The Department will continue to pursue funding for supporting expanding the **Explore!** Network.

The **SkyTellers** program was presented in five informal venues, including regional planetarium societies, the International Planetarium Society Annual Meeting, and the National Afterschool Association conference. Over 900 copies of SkyTellers have been requested and received by small planetariums, science centers, schools, and libraries. An electronic survey of SkyTellers users returned a small sample, but the approximately 40 respondents indicated they had presented the program to over 31,000 audience members, over half of whom were ages 8-13. The stories and supporting materials were evaluated strongly by users. LPI currently is investigating several opportunities for presenting SkyTellers for different audiences and for using story more broadly as an entry into science.

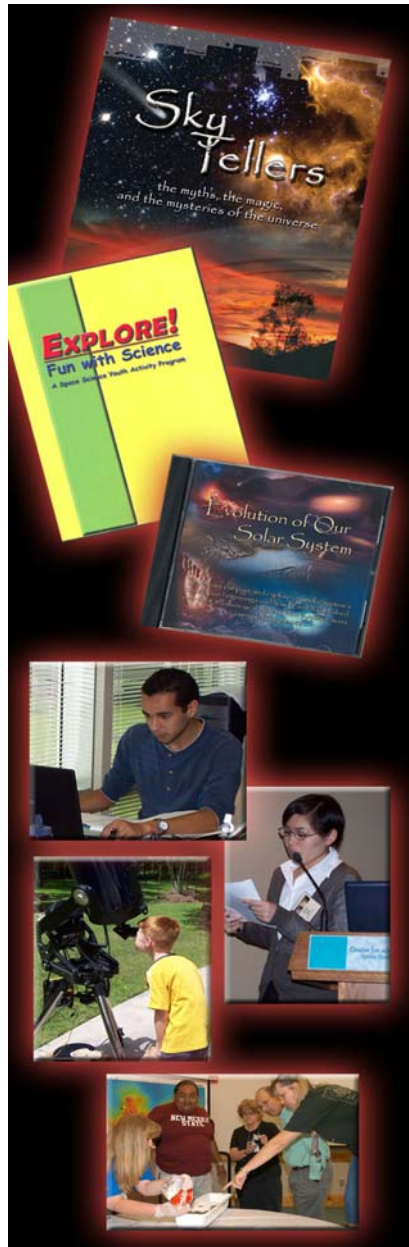
Over 700 parents and children participated in the year's Family Space Day events, held once each month. Topics explored encompassed the inner and outer planets, solar system extremes, Pluto and the outer bodies, living and working in space, staying healthy in space, and a lunar viewing night. A partnership with Clear Creek Independent School District brought in two elementary educators to join the Family Space Day team to design, develop, and implement events. Events commonly integrate the activities and staff of ARES and the JSC Astronomical Society. An advertising campaign, initiated in late summer, focused on face-to-face meetings to promote the events to community groups such as Boys and Girls Clubs, recreation centers, libraries, and elementary schools. In addition to meetings, the events are now advertised in local newspapers; the Institute desires to double attendance.

The Education and Public Outreach Department will continue to pursue external funding for existing and new programs. Plans include programs that design, evaluate, and implement family science learning experiences, and a quarterly public lecture series.

A complete description of the Institute's Education and Public Outreach programs can be found in the Appendices.

Overall, I think the Health in Space Module... "provides an exciting engaging curriculum that can be implemented in a multitude of ways in our system."

-2006 Explore Training Participant



A. SCIENCE

Scientist Programs – The Institute has taken significant strides to improve the already high quantity and quality of the research science pursued under the auspices of the LPI. Many of the successful programs developed over the last four years will continue, including the **Heritage Scholars Program**, the **Urey Fellows**, and the proactive **Postdoctoral Fellowship Program**. The Institute also plans a number of incentive-based programs that will encourage and reward the Staff Scientists for covering more of their salary with soft money. Specifically, the Institute proposes a sabbatical program that will make scientists who are covering more than 50% of their salary eligible for a sabbatical of six months to a year at a major university, NASA center, or research center. This program is designed to build closer ties between NASA and the university community as well as strengthen the ties between the Institute's Staff Scientists and the nation's top planetary science programs. Such interactions will provide growth opportunities for our scientists and encourage collaborations with outside scientists and students. It is also believed that these interactions will result in more visiting scientists coming to the Institute to perform top-quality research.

Lunar Emphasis – We are also looking to refocus the science being undertaken at the Institute. The current research of most of the LPI Staff Scientists is oriented more toward Mars-related science, reflecting the recent focus of NASA and ESA mission activities. The scientists utilize a variety of complementary scientific approaches in order to answer fundamental questions regarding the presence of water on Mars, surface and interior geochemistry, geomorphology, past fluvial and volcanic processes, and interior dynamics. While all these scientific endeavors are valid pursuits and a critical mass of diverse approaches for Mars science has been a recent strength of the Institute, we are looking to diversify research targets to achieve a balance of research interests that maps more closely to current NASA goals, in particular by focusing on building a stronger lunar program and recruiting scientists more actively involved in the study of astromaterials, meteorites, and comets. It is believed that a better balance of science at the Institute will allow the LPI to recruit a broader array of visiting scientists, students, and postdoctoral fellows, as well as participate more broadly in the NASA and planetary science community.

International Collaboration - In addition to broadening the research orientation of the Staff Scientists at the Institute, two other extensions of the visiting scientist programs are also proposed for the five renewal years. The first is a collaboration with EuroPlaNet, a European Union-supported initiative established in 2005 to strengthen and unify the European planetary science community. Much like the objectives of the LPI, this organization supports working groups, fosters scientific exchange, plans meetings, and sponsors education and public outreach programs. In light of the Institute's objectives to encourage participation of eminent scientists from the United States and other countries in solar system exploration programs (objective 1), it is clear that a collaboration between the Institute and this sister organization on the opposite side of the Atlantic would be of benefit to both organizations, working together in planning workshops and conferences, and co-sponsoring exchange programs involving scientists and/or students.

The Institute's initial efforts to codify this collaboration were received with great enthusiasm. A discussion of this collaboration will occur during the First European Planetary Science Congress in September and a vote of support will allow the two parties to work out a timeline for establishing such interactions. It is noteworthy that the Institute already has formal MOUs for collaborative exchange with several universities and institutes in France and Germany.

Visiting Scientists Programs - The second proposed expansion of the visiting scientist program is directed at senior scientists at NASA centers, research institutes or universities. This program will be targeted at mid- to late-career scientists looking for an exciting research environment for periods from three to six months to concentrate on their science. The Institute would provide infrastructure and cover local costs to allow civil servants and professors to bring their knowledge and experience to the Institute.

Sample science issues are of particular interest given our connections to JSC ARES. Where practical the Institute will make every attempt to bring senior visiting scientists to the Institute in distinct groups in which the members share research interests or work on complementary aspects of the same scientific question. This topical approach to the visiting scientist program will allow the Institute to bring critical mass and focus to a specific scientific problem that is a current priority within NASA and the planetary community.

B. EDUCATION AND PUBLIC OUTREACH –

The Education and Public Outreach programs at the Institute have matured significantly over the last four years, resulting in a department that is focused on well-defined areas where the Institute can have the largest impact for the money that is spent, including pre-service and in-service teacher training and maintaining and expanding their established network of educators and scientists across the country. Moving forward, the office will continue to support a majority of their programs with funding beyond that provided in the CAN, focusing on funding opportunities from the NSF as well as other regional and local opportunities. The LPI is also planning on pursuing the new Broker Facilitator contract to ensure the Institute's continued involvement in the broader NASA Education community (objectives 4, 5 and 6). The major focus of our program will remain with SMD education and public outreach themes.

Finally, as NASA prepares to return to the Moon, LPI Education and Public Outreach proposes to utilize the existing education and scientific resources resident at the Institute to identify and provide access to internal and external lunar resources, programs, and products for educators and the public; will develop workshops and activities focusing on lunar themes (formation of the Earth-Moon system, geology and environment, influence on Earth, future exploration, missions, etc.); and will make educational presentations on these same topics available for scientists and educators to use in their communities. In light of the Institute's rich historic lunar activities, its Apollo era heritage, and its geographic juxtaposition to the Manned Space Flight efforts and astromaterials collections at JSC, this lunar focus is a natural fit for the Institute.

C. SERVICE TO NASA AND TO THE PLANETARY COMMUNITY –

Refocused Topical Initiatives – As noted earlier in the proposal, while the **Topical Initiatives** have largely been successful, we have identified ways in which they can be improved. In particular, Initiatives focused in areas with strong current interest from the scientific community, especially involving a broad cross-section of subdisciplines, are most likely to draw larger participation and have higher impact. Thus, individual components of initiatives involving multiple meetings or publications must stand alone as topical and exciting. In addition, the organizers of each component (meeting or publication activity) must be fully engaged and committed to leading the program with excitement and sustained enthusiasm. The active participation of Staff Scientists or visiting scientists from the LPI in these Initiatives can certainly ensure sustained momentum. When selecting proposals for topical science initiatives for future support, we will place significantly more emphasis on the enthusiasm of the organizers, the breadth of support from the larger scientific community, and the implementation plan for completion of the project. We remain fully supportive of this program of activities and wish to ensure its continued success.

Interface with NASA and the Scientific Community – One criticism of the LPI from past reviews and the recent LPI survey of the community concerns our effectiveness in communicating the strength of our programs and our true impact upon NASA, the scientific community, and the public. While most people with a professional or amateur interest in planetary sciences know of the LPI, few know the breadth of our programs or the extent of our support for activities regarded as critical resources. With this concern in mind, the LPI is currently retooling our major interfaces with the community to highlight current Institute scientific excellence and promote NASA science achievements. Our web pages now include brief vignettes that note recent scientific highlights, including work at LPI; these vignettes are changed on a frequent basis as new advances occur. We also make use of this space to highlight changes at NASA, including recent and planned staffing changes at SMD, with associated employment opportunities.

The Institute is evolving the *LPIB* to make it a more dynamic resource for the community, seeking material that may be of interest to the community but is not usually included in the *Bulletin*. Such material might include policy issues from the NASA perspective or editorials from individuals in the community, biographical information on new people at NASA HQ, either in SMD or ESMD, who are in positions of interest to the scientific community, and information on new initiatives at NASA.

Resources – The Institute continues to provide more of the resource materials in the Institute library and RPIF on its website in response to both requests from the professional and amateur communities and on the suggestions of LPI scientists who guide these activities. These resources include the many lunar images in our collection, as well as NASA planning and think-tank documents from our collection and as provided to us by colleagues at NASA, the universities, and other institutes. Many of these documents date from the 1970s to 1990s and are not in electronic form or readily available in print. In a number of cases, materials are provided by individuals who are retiring and wish to ensure that the amazing legacy of past activities is captured for present and future generations.

As the number and diversity of such electronic resources grows, we need to periodically review our web resource structure to ensure ease of access and transparency for external users. This is especially true for our lunar image and document collections, which have grown phenomenally over the past few years.

Meetings Activities and Facilities – The LPI continues to support a broad range of conferences, workshops, and planning meetings, both on-site and in meeting venues around the country and worldwide. These meetings vary in size from groups of 10 people to meetings with thousands of participants. The support the Institute provides ranges from simple logistics to planning and running meetings with full support services. The LPI will continue to provide this support to the community and to NASA. In recent months the Institute has noticed an increase in the number of requests from various NASA entities for logistical support of small meetings, which are often associated with future missions. The LPI is happy to provide support for these activities.

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APPENDIX I

Peer-Reviewed Publications

Published 2006

- 1) Rankenburg, K., A.D. Brandon, and **C.R. Neal** (2006), Neodymium isotope evidence for a chondritic composition of the Moon, *Science* 312, 1369-1372.
- 2) Kinman, W., and **C.R. Neal** (2006), Magma evolution revealed by anorthite-rich plagioclase cumulate xenoliths from the Ontong Java Plateau: Insights into LIP magma dynamics and melt evolution, *J. Volc. Geotherm. Res.* 154, 131-157.
- 3) **Neal, C.R.** (2006), New Views of the Moon, *Reviews in Mineralogy and Geochemistry*, 60, 720, Mineralogical Society of America. ISBN 1529-6466.
- 4) **Demouchy, S.**, S.D. Jacobsen, F. Gaillard, and C.R. Stern (2006), Rapid magma ascent recorded by water diffusion profiles in olivine from Earth's mantle, *Geology* 34: 429-432.
- 5) **Demouchy, S.**, and **S. Mackwell.** (2006), Incorporation and diffusion of Hydrogen in Iron-bearing Olivine, *Phys. Chem. Minerals*, doi: [10.1007/s00269-006-0081-2](https://doi.org/10.1007/s00269-006-0081-2).
- 6) Jolliff, B.L., M.A. Wieczorek, C.K. Shearer, and **C.R. Neal** (2006), New Views of the Moon. *Reviews in Mineralogy and Geochemistry*, Vol 60, 720. P. Mineralogical Society of America. ISBN 1529-6446.
- 7) **Greathouse, T.K.**, J.H. Lacy, B.B. Bézard, **J.I. Moses**, M.J. Richter, and C. Knez (2006), The first detection of propane on Saturn, *Icarus*, 181, 266-271.
- 8) Watters, T.R., and **P.J. McGovern** (2006), Lithospheric flexure and the evolution of the dichotomy boundary on Mars, *Geophys. Res. Lett.*, 33, L08S05.
- 9) Watters, T.R., and **P.J. McGovern** (2006), Introduction to special section: The Hemispheric Dichotomy on Mars, *Geophys. Res. Lett.*, 33, L08S01.
- 10) **Nunes, D.C.**, and R.J. Phillips (2006), Radar Subsurface Mapping of the Polar Layered Deposits on Mars, *J. Geophys. Res.*, 111, E06S21, 10.1029/2005JE002609.
- 11) Bue, B.D., and **T.F. Stepinski** (2006), Automated Classification of Landforms on Mars. *Computers & Geoscience*. 32, 604-614.
- 12) **Stepinski, T.F.**, S. Ghosh, and R. Vilalta (2006), Automatic Recognition of Landforms on Mars Using Terrain Segmentation and Classification. *In Lecture Notes in Artificial Intelligence* 4265, 255-266.
- 13) Ryde, N., G. Harper, M. Richter, **T. Greathouse**, and J. Lacy (2006), Water Vapor on Betelgeuse as Revealed by TEXES High-Resolution 12 μm Spectra, *Ap.J.*, 637, 1040-1055.
- 14) Wilke, M., C. Schmidt, F. Farges, **V. Malavergne**, L. Gautron, A. Simionovici, M. Hahn, and P.E. Petit (2006), Structural environment of Fe in water bearing silicate glass and melt – evidence from X-ray absorption spectroscopy, *Chemical Geology*, 229, 144–161.
- 15) Wieczorek, M.A., B.L. Jolliff, J.J. Gillis, A. Khan, L.L. Hood, **K. Righter**, M.E. Pritchard, B.P. Weiss, **C.R. Neal**, S. Tompkins, and J.G. Williams. (2006), The Constitution and Structure of the Lunar Interior. In (B.L. Jolliff, Wieczorek, M.A., Shearer, C.K., and C.R. Neal, eds.) *New Views of the Moon*, *Rev. Mineral. Geochem.* 60, 221-343.
- 16) **Righter, K.**, M.J. Drake, and E.R.D. Scott (2006), Compositional relationships between meteorites and terrestrial planets, in *Meteorites and the Early Solar System, II* (ed. D. Lauretta and H.Y. McSween, Jr.), Univ. Arizona Press, Tucson, 803-828.
- 17) **Righter, K.**, R.L. Hervig, and W.P. Leeman (2006), Partitioning of Ni, Co, and V between spinel-structured oxides and silicate melts: effects of spinel composition and variable activity, *Chemical Geology* 227, 1-25.
- 18) **Treiman, A.H.**, **D.S. Musselwhite**, **C.D.K. Herd**, and Shearer C.K. Jr. (2006), Light lithophile elements in pyroxenes of NWA817 and other Martian meteorites: Implications for water in Martian magmas, *Geochim. Cosmochim. Acta*, 70, 2919-2934.
- 19) Onstott, T.C., D. McGown, J. Kessler, Lollar B. Sherwood, K.K. Lehmann, and **S.M. Clifford** (2006), Martian CH4: Sources, Flux, and Detection, *Astrobiology*, 6, 377-395.

- 20) Chyba, C., B. Akinwale, J. Alexander, **S.M. Clifford**, A. Delamere, M. Favero, B. Guyot., E. Mathur, J. Niehoff, G. Ori, D. Paige, A. Pearson, J. Priscu, M. Race, M. Sogin, C. Takacs-Vesbach, and P. Whitney (2006), *National Research Council Report of the Committee on Preventing the Forward Contamination of Mars*, 423 pages.
- 21) **Heggy, E., S.M. Clifford**, R.E. Grimm, C.L. Dinwiddie, A.J. Stamatakos, and S.H. Gonzalez (2006), Low-frequency radar sounding investigations of the North Amargosa Desert, Nevada: A potential analog of conductive subsurface environments on Mars, *J. Geophys. Res. (Planets)*, 111, CitelD E06S03, 2006 [DOI: 10.1029/2005JE002523].
- 22) **Heggy, E., S. Clifford**, T. Farr, C. Dinwiddie, and R. Grimm (2006), Radar Investigations of Planetary and Terrestrial Environments, *J. Geophys. Res. (Planets)*, 111, E6, E06S01, DOI: 2006JE002759.
- 23) **Heggy, E., S. Clifford**, C. Dinwiddie, R. Grimm, D. Wyrick, and B. Hill (2006), Ground Penetrating Radar Sounding in Mafic Lava Flows: Assessing Attenuation and Scattering Losses in Mars-Analog Volcanic Terrains, Volume 111, E6, E06S04, *J. Geophys. Res. (Planets)*, DOI2005JE002589.
- 24) Grimm, R., E. **Heggy**, **S. Clifford**, C. Dinwiddie, R. Mcginnis., and D. Farrell (2006), Absorption and Scattering in Ground Penetrating Radar: Analysis of the Bishop Tuff, *J. Geophys. Res. (Planets)*, 111, E6, E06S02, DOI 2005JE002619.
- 25) **Debaille, V.**, R. Doucelance, D. Weis, and P. Schiano (2006), Multi-stage mixing in subduction zones: application to Merapi Volcano (Java, Indonesia), *Geochim. Cosmochim. Acta*, 70, 723-741.
- 26) **Debaille, V.**, J. Blichert-Toft, A. Agranier, R. Doucelance, F. Albarède, and P. Schiano (2006), Geochemical component relationships in MORB from the Mid-Atlantic Ridge, 22-35°N, *Earth Planet. Sci. Lett.* 241, 844–862.
- 27) **Heggy, E.**, and P. Paillou (2006), Mapping Structural Elements of Small Buried Craters Using Ground-Penetrating Radar in the Southwestern Egyptian Desert: Implications for Mars Shallow Sounding, *Geophys. Res. Letter*, L05202, DOI, 10.1029/2005GL024263.
- 28) Paillou, P., Y. Lasne, **E. Heggy**, and J.M. Maleziéux (2006), A study of P-band SAR performances for Mars exploration: Imaging subsurface geology and detecting shallow moisture, *J. Geophys. Res. (Planets)* 111, E6, E06S11, DOI 2005JE002528.
- 29) Grandjean, G., P. Paillou, N. Bahgdadi, **E. Heggy**, T. August, and Y. Lasne (2006), Surface and Subsurface Structures Mapping Using Low Frequency Radar in Mauritania and Egypt. *Journal of African Earth Sciences*, Vol. 44, Issue 2, 220–228.
- 30) **Norman, M.D.**, G.M. Yaxley, V.C. Bennett, and A.D Brandon. (2006), Magnesium isotopic composition of olivine from the Earth, Moon, Mars, and pallasite parent body. *Geophys. Res. Lett.*, 33, L15202, doi:10.1029/2006GL026446.
- 31) **Norman, M.**, M. McCulloch, H. O'Neill, and G Yaxley. (2006), Magnesium isotopes in olivine by laser-ablation multi-collector ICPMS: composition dependent matrix effects and a comparison of the Earth and Moon, *Journal of Analytical Atomic Spectrometry*, 21, 50-54.
- 32) **Norman, M., P. Spudis**, H. Schmitt, and Pieters C. (2006), Why on Earth are We Going Back to the Moon? *The Australian Geologist*, 138, 42-43.
- 33) Ireland, T.R., P. Holden, **M.D. Norman**, and J. Clarke (2006), Isotopic enhancements of ¹⁷O and ¹⁸O from solar wind particles in the lunar regolith, *Nature*, 440, 776-778.
- 34) Nielsen, S.G., M. Rehkämper, **M.D. Norman**, and A.N. Halliday (2006), Thallium isotopic evidence for ferromanganese sediments in the mantle source of Hawaiian basalts, *Nature*, 439, 314-317.
- 35) Wanless, V.D., M.O. Garcia, F.A. Trusdell, J.M. Rhodes, **M.D. Norman**, D. Weis, D.J. Fornari, M.D. Kurz, and H. Guillou (2006), Submarine Radial Vents on Mauna Loa Volcano, Hawai'i. *Geochemistry, Geophysics, Geosystems*, 7, doi:10.1029/2005GC001086, 2 May 2006.
- 36) Wanless, V.D, M.O. Garcia, J.M. Rhodes, D. Weis, and **M.D. Norman** (2006), Shield stage alkalic volcanism on Mauna Loa volcano, Hawai'i, *Journal of Volcanology and Geothermal Research*, 151, 141-155.
- 37) Jackson, J.M., S.V. Sinogeikin, S.D. Jacobsen, H.J. Reichmann, **S.J. Mackwell**, and J.D. Bass (2006), Single-crystal elasticity and sound velocities of (Mg_{0.94}Fe_{0.06})O ferropericlase to 20 GPa, *J. Geophys. Res.*, 111, B09203, doi:10.1029/2005JB004052.

- 38) **Lindsay, J.F.**, and M.D. Brasier (2006), Impact Craters as Biospheric Microenvironments, Lawn Hill Structure, *Northern Australia. Astrobiology*, 6, 348-363.
- 39) **Musselwhite, D.S.**, H.A. Dalton, **W.S. Kiefer**, and **A.H. Treiman** (2006), Experimental Petrology of the Basaltic Shergottite Yamato 980459: Implications for the Thermal Structure of the Martian Mantle, *Meteor. Planet. Sci.* 41.
- 40) **Kiefer, W.S.** (2005), Buried Mass Anomalies Along the Hemispheric Dichotomy in Eastern Mars: Implications for the Origin and Evolution of the Dichotomy, *Geophys. Res. Lett.*, 32, L22201, doi:10.1029/2005GL024260.
- 41) **Moses, J.I.**, and **T.K. Greathouse** (2005), Latitudinal and seasonal models of stratospheric photochemistry on Saturn: Comparison with infrared data from IRTF/TEXES, *J. Geophys. Res.*, 110, E09007, doi:10.1029/2005JE002450.
- 42) Watters, T.R. and **P.J. McGovern** (2005), Hemispheres Apart: the Martian Crustal Dichotomy, article in *EOS Trans. AGU*, 86, 46-47.
- 43) Ghent, R.R., R.J. Phillips, V.L. Hansen, and **D.C. Nunes** (2005), Finite element of short-wavelength contractional deformation on Venus: implications for the hotspot model for crustal plateau formation, *J. Geophys. Res.*, 110, E11006, 10.1029/2005JE002522.
- 44) **Stepinski, T.F.**, and, A.P. Stepinski (2005), Morphology of Drainage Basins as an Indicator of Climate on Early Mars, *J. Geophys. Res.*, 110, E12S12.
- 45) Encrenaz, T., B. Bezard, T., Owen S. Lebonnois, F. Lefevre, **T. Greathouse**, M. Richter, J. Lacy, S. Atreya, A. Wong, and F. Forget (2005), Infrared imaging spectroscopy of Mars: H₂O mapping and determination of CO₂ isotopic ratios, *Icarus*, 179, 43-54.
- 46) Siebert, J., F. Guyot, and **V. Malavergne** (2005), Diamond formation in core segregation experiments, *Earth. Planet. Sci. Lett.*, 229, 205-216.
- 47) **Richter, K.**, S.J. Collins, and, A.D. Brandon (2005), Mineralogy and petrology of the LaPaz Icefield lunar mare basaltic meteorites, *Meteor. Planet. Sci.*, 40, 1703-1722.
- 48) Carrasco-Nunez, G., **K. Richter**, L. Siebert, J.T. Chesley, and J. Aranda-Gomez (2005), Contemporaneous eruption of calc-alkaline and alkaline lavas in a continental arc (eastern Mexican Volcanic Belt): chemically heterogeneous but isotopically homogeneous source, *Contrib.Mineral. Petrol.*, 150, 423-440.
- 49) Meibom, A., **K. Richter**, N.L. Chabot, G. Dehn, A.A. Antignano, T.J. McCoy, A. Krot, M. Zolensky, M.I. Petaev, and K. Keil (2005), Shock melts in QUE 94411, Hammadah al Hamra 237 and Bencubbin: remains of the missing matrix? *Meteoritics and Planetary Science* 40, 1377-1391.
- 50) Dyar, M.D., **A.H. Treiman**, C.M. Pieters, T. Hiroi, M.D. Lane, and V. O'Connor (2005), MIL03346, the most oxidized Martian meteorite: A first look at petrography, mineral chemistry, and spectroscopy, *J. Geophys. Res.*, 110, E09005, doi:10.1029/2005JE002426.
- 51) Beaty, D.W., **S.M. Clifford**, L.E Borg., D. Catling, R.A. Craddock, D.J. Des Marais, J.D. Farmer, H.V. Frey, R.M. Haberle, C.P. McKay, H.E. Newsom, T.J. Parker, T. Segura, and K.L. Tanaka (2005), Key Science Questions from the Second Conference on Early Mars: Geologic, Hydrologic, and Climatic Evolution and the Implications for Life, *Astrobiology*, Vol. 5, No. 6: 663-689.
- 52) Agranier, A., J. Blichert-Toft, J.-G. Schilling, D. Graham, **V. Debaille**, P. Schiano, F. Albarède (2005), Convective refolding of the mantle revealed by isotopic striations along the Mid-Atlantic Ridge, *Earth Planet. Sci. Lett.* 238, 96-109.
- 53) **Norman, M.D.** (2005), Lunar impact breccias: petrology, crater setting, and bombardment history of the Moon. *Australian Journal of Earth Sciences*, 1, 711-723.
- 54) **Norman, M.**, L. Moresi, J. Clarke, C. Caprarelli, M. Walter, and A. Glikson (2005), New plans for planetary science, *The Australian Geologist*, 137, 30-32.
- 55) **Lindsay, J.F.**, M.D. Brasier, N. McLoughlin, O.R. Green, M. Fogel, A. Steele, and S.A. Mertzman (2005), The problem of deep carbon – An Archean paradox, *Precambrian Research*, 142, 1-22.
- 56) **Lindsay, J.F.**, P.D. Kruse, O.R. Green, E. Hawkins, M.D. Brasier, J. Cartledge and R.M. Corfield (2005), The Neoproterozoic-Cambrian Record in Australia: a stable isotope study, *Precambrian Research*, 143, 113-133.
- 57) Brasier, M.D., O.R. Green, **J.F. Lindsay**, N. McLoughlin, A. Steele, and C. Stoakes (2005), Critical testing of Earth's oldest putative fossil assemblage from the ~3.5 Ga Apex chert, Chinaman Creek, Western Australia, *Precambrian Research*, 140, 55-102.

In Press

- 1) Jain, J.C., **C.R. Neal**, and A.I. Kilinc (2006), Potential problems associated with quadrupole ICP-MS analysis of high-field strength elements in tungsten-carbide-milled rock powders. *Can. J. App. Spectroscopy*.
- 2) **Neal, C.R.** and G.Y. Kramer (2006) The petrogenesis of Apollo 14 high-Al mare basalts. *Am. Mineral*.
- 3) Révillon, S., D.A.H. Teagle, P. Boulvais, J. Shafer, and **C.R. Neal** (2006), Geochemical fluxes related to alteration of a subaerially-exposed seamount: Nintoku seamount, ODP Leg 197, Site 1205, *Geochem., Geophys., Geosystems*.
- 4) Walker, A.M., **S. Demouchy**, and K. Wright (2006), Computer Modelling of the Energies and Vibrational Properties of Hydroxyl Groups in α - and β -Mg₂SiO₄, *Eur. J. Mineral*.
- 5) **Kiefer, W.S.** and L.C Swafford (2006), Topographic Analysis of Devana Chasma, Venus: Implications for Rift System Segmentation and Propagation, *J. Structural Geology*.
- 6) Ruiz, J., R. Tejero, and **P.J. McGovern** (2005), Evidence for a differentiated crust at Solis Planum, Mars, from lithospheric strength and heat flow, *Icarus*.
- 7) Phillips, R.J., et al. w/ **Nunes, D.C.** (2006), The SHARAD sounding radar on MRO, *J. Geophys. Res.*
- 8) Vilalta, R., **T.F. Stepinski**, and M. Achari (2006), An Efficient Approach to External Cluster Assessment with an Application to Martian Topography, *Data Mining and Knowledge Discovery*.
- 9) Bue, B.D., and **T.F. Stepinski** (2006), Machine Detection of Martian Impact Craters from Digital Topography Data, *Transactions on Geoscience and Remote Sensing*.
- 10) Luo, W., and **T.F. Stepinski** (2006), Topographically Derived Maps of Valley Networks and Drainage Density in the Mare Tyrrhenum Quadrangle on Mars, *Geophys. Res. Lett.*
- 11) Richter, M.J., J.H. Lacy, D.T. Jaffe, **T.K. Greathouse**, and G.A. Blake (2006), TEXES Observations of Pure Rotational H₂ Emission from T Tau, *ApJ*.
- 12) Burchard, M., S. Kubsky, H. Bureau, A. Somogyi, **V. Malavergne**, B. Menez, and M. Munoz (2006), X-ray transmission properties of intelligent Diamond Anvil Cells (iDACs), *Rev. Sci. Instr.*
- 13) Bouhifd, M.A., L. Gautron, N. Bolfan-Casanova, **V. Malavergne**, T. Hammouda, D. Andrault and A.P. Jephcoat (2006), Potassium Partitioning into molten Iron alloys at high-pressure: Implications for Earth's core, *Phys. Earth Planet. Int.*
- 14) **Richter, K.**, S.R. Sutton, M. Newville, L. Le, **C.S. Schwandt**, H. Uchida, B. Lavina, and R.T. Downs (2006), Oxidation state of vanadium in spinel and silicate melt: implications for planetary basalts and mantle melting, *Am. Mineral*.
- 15) **Treiman, A.H.**, M.D. Dyar, **M. McCanta**, C.M. Pieters, T. Hiroi, M.D. Lane, and J.L. Bishop (2006), Martian dunite NWA 2737: Petrographic constraints on geological history, shock events, and olivine color, *J. Geophys. Res.*
- 16) **Norman, M.D.**, R.A. Duncan, and J.J. Huard (2006), Identifying impact events within the lunar cataclysm from ⁴⁰Ar-³⁹Ar ages and compositions of Apollo 16 impact melt rocks. *Geochimica et Cosmochimica Acta*.
- 17) **Norman, M.**, **P. Spudis**, H. Schmitt, and C. Pieters (2006), Return to the Moon: Scientific and cultural rationales, *6th Australian Space Science Conference* (reviewed conference paper).
- 18) Bystricky, M., F. Heidelbach, and **S. Mackwell** (2005), Large-strain deformation and strain partitioning in polyphase rocks: dislocation creep of olivine-magnesiowüstite aggregates, *Tectonophysics*.
- 19) Mecklenburgh, J., Y. Zhao, F. Heidelbach, and **S. Mackwell** (2005), Deformation of olivine-spinel aggregates in the system (Mg,Ni)₂GeO₄ deformed to high strain in torsion: Implications for upper mantle anisotropy, *J. Geophys. Res.*
- 20) Nimmo, F., and **P. Schenk** (2006), Normal faulting on Europa, *J. Struct. Geol.*
- 21) **Treiman, A.H.**, M.D. Dyar, **M.C. McCanta**, S.K. Noble, and C.M. Pieters (2006), Martian dunite NWA 2737: petrographic constraints of geological history, shock events, and olivine color, *J. Geophys. Res.*

- 22) **McCanta, M.C.**, M.J. Rutherford, and J.E. Hammer (2006), Pre-eruptive and syn-eruptive conditions in the Black Butte, California dacite: insight into crystallization kinetics in a simplified system, *Journal of Volcanology and Geothermal Research*.
- 23) **Treiman A.H.** (2006) Review of "The Rock from Mars: A Detective Story on Two Planets" by K. Sawyer. *Chem. Eng. News*.

Submitted

- 1) O'Neill, C., A. Lenardic, A.M. Jellinek, and **W.S. Kiefer** (2006), Melt Propagation and Volcanism in Mantle Convection Simulations, with Applications for Martian Volcanic and Atmospheric Evolution, *J. Geophys. Res.*
- 2) **McGovern, P.J.**, and J.K. Morgan (2006), Volcanic Spreading and Azimuthal Variations in the Structure of Olympus Mons, Mars, *Geology*.
- 3) Ruiz, J., **P.J. McGovern**, and R. Tejero (2005), The early thermal and magnetic state of the cratered highlands of Mars, *Earth Planet. Sci. Lett.*
- 4) **Nunes, D.C.**, and R.J. Phillips, Effect of initial compensation state on the relaxation of crustal plateaus on Venus (to be submitted September 2006).
- 5) Molloy, I., and **T.F. Stepinski** (2006). Automated Mapping of Valley Networks on Mars, *Computers & Geoscience*.
- 6) Bureau, H., B. Ménez, **V. Malavergne**, A. Somogyi, A. Simionovici, D. Massare, H. Khodja, L. Daudin, J.P. Gallien, C. Shaw, and M. Bonnin-Mosbah (2006), In situ mapping of high pressure fluids : lead partitioning, *J. Geophys. Res.*
- 7) **Malavergne, V.**, M. Tarrida, R. Combes, H. Bureau, J. Jones, **C. Schwandt** (2006), The first terrestrial Pb paradox and the U radioactivity in planetary cores : new high pressure and high temperature insights, *Geochimica. Cosm. Acta*.
- 8) Pieters, C.M, T. Hiroi, M.D. Lane, J.L. Bishop, **A.H. Treiman**, M.D. Dyar, and S.K. Noble (2006), Martian dunite NWA 2737: Electromagnetic spectroscopy and implications for remote sensing, *J. Geophys. Res. (Planets)*.
- 9) Rankenburg, K., A.D. Brandon, and **M.D. Norman** (2006), An integrated Rb-Sr and Sm-Nd isotope and trace element study of lunar meteorite LaPaz 02205: chronology and a possible KREEP connection, *Geochimica et Cosmochimica Acta*.
- 10) Belton, D.X., **M.D. Norman**, T.J. Carter, M. Lorencak, B.P. Kohn, A.J.W. Gleadow, R.W. Brown (2006), Samarium in apatite: contributions to radiogenic helium and implications for helium-based thermochronometry, *Chemical Geology*.
- 11) Friend, C.R.L., A.P. Nutman, V.C. Bennett, and **M.D. Norman** (2006), Seawater trace element signatures (REE+Y) from Eoarchaeon chemical (meta)sedimentary rocks, southern West Greenland, *Contributions to Mineralogy and Petrology*.
- 12) Gingele, F, P. De Deckker, and **M. Norman** (2006), Late Pleistocene and Holocene climate of SE Australia reconstructed from dust and river loads deposited offshore the River Murray Mouth, *Earth Planet. Sci. Lett.*
- 13) Solari, L.A., F. Ortega-Gutiérrez, M. Elías-Herrera, P. Schaaf, **M. Norman**, R.N. Torres de Leó, C. Ortega-Obregón, M. Chiquín, S. Morán Ical (2006), TIMS U-Pb and LA-ICPMS zircon geochronology of Paleozoic units in Western and Central Guatemala: insights into the tectonic evolution of Middle America, *J. Geol. Soc. London, Spec. Publ. on Caribbean Geology*.
- 14) Kohlstedt, D.L., and **S.J. Mackwell** (2005), Strength and deformation of planetary lithospheres, invited for *Planetary Tectonics*, eds. R.A. Schultz and T.R. Watters, Cambridge University Press.
- 15) Aubaud, C., A.C. Withers, M.H. Hirschmann, Y. Guan, L.A. Leshin, **S.J. Mackwell**, and D.R. Bell (2006), Intercalibration of FTIR and SIMS for hydrogen measurements in glasses and nominally anhydrous minerals, *Amer. Mineral.*
- 16) **Musselwhite, D.S.**, J.H. Jones, and M. Wadhwa (2006), Variations in experimentally determined augite/melt partition coefficients for samarium, europium and gadolinium with oxygen fugacity: implications for the oxidation state of the Martian mantle. *Meteor. Planet. Sci.*
- 17) **Musselwhite, D.S.**, and M.J. Drake (2006), Experimentally Determined Halogen and Noble Gas Partition Coefficients with Implications for the Early Outgassing of the Earth. *Geochem. Cosmochem. Acta*.
- 18) **McCanta, M.C.**, M.J. Rutherford, and C. Calvin (2006), Crystallization fO₂ of the cumulate martian meteorites: indications of a wide range of martian fO₂ values, *Meteor. & Planet. Sci.*

- 19) **Demouchy, S., S.J. Mackwell,** and D.L. Kohlstedt (2006), Influence of hydrogen on Fe-Mg interdiffusion in (Mg,Fe)O and implications for the Earth's lower mantle, *Contrib. Mineral. Petrol.*
- 20) **Maloy, A.K. and Treiman A.H.** (2006), Evaluation of multispectral image classification routines for determining the modal mineralogy of rocks in thin section. *Amer. Mineral.*
- 21) **Kring, D.A.,** A.P. Showman, and D.D. Durda (2006), "Global wind storms generated by the Chicxulub impact event," *Science.*
- 22) Patzer, A., **D.A. Kring,** D.H. Goodwin, P.D. Ward, and J.W. Haggart (2006), "A lithological investigation of marine strata from the Triassic-Jurassic boundary interval, Queen Charlotte Islands, British Columbia, including a search for shocked quartz," *Palaeogeography, Palaeoclimatology, Palaeoecology.*
- 23) Wong, S.M., O. Abramov and **D.A. Kring** (2006), "Differential melt scaling for oblique impacts on the Earth, Moon, and Mars," *Meteoritics and Planetary Science.*
- 24) Cohen, B.A., T.D. Swindle, **D.A. Kring,** E.K. Olson, and L.A. Taylor (2006), "Composition and ^{40}Ar - ^{39}Ar ages of impact-melt clasts in lunar meteorites Calalong Creek, Dar al Gani 262, and Dhofar 025," *Geochimica et Cosmochimica Acta.*
- 25) Gleason, J.D., G.E. Gehrels, W.R. Dickinson, P.J. Patchett, and **D.A. Kring** (2006), "Sources of detrital zircon grains in turbidite and deltaic sandstones of the lower to middle Pennsylvanian Haymond Formation, Marathon Assemblage, west Texas," *Journal of Sedimentary Petrology.*

APPENDIX II

Published Abstracts

2006

- 1) **Neal, C.R.**, C.-Y. Shih, Y. Reese, and L.E. Nyquist (2006), Derivation of Apollo 14 high-Al basalts from distinct source regions at discrete times: New constraints, *Lunar Planet. Sci. Conf. XXXVII* [CD-ROM] #2003.
- 2) Kramer, G.Y., B.L. Jolliff, and **C.R. Neal** (2006), Searching for high-Al mare basalts: Mare Fecunditatis and Luna 16. *Lunar Planet. Sci. Conf. XXXVII* [CD-ROM] #2227.
- 3) Kramer, G.Y., B.L. Jolliff, and **C.R. Neal** (2006), Searching for high-Al mare basalts: Mare Imbrium and Apollo 14, *Lunar Planet. Sci. Conf. XXXVII* [CD-ROM] #2221.
- 4) Rankenburg, K., A.D. Brandon, and **C.R. Neal** (2006), Constraints on the formation of the Moon from high-precision Nd-isotopic measurements of Lunar basalts, *Lunar Planet. Sci. Conf., XXXVII* [CD-ROM] #1348.
- 5) **Neal, C.R.**, and C.K. Shearer (2006), High-Ti volcanic glasses: Derivation from a garnet-bearing source coupled with late-stage assimilation of LMO cumulates, *Lunar Planet. Sci. Conf., XXXVII* [CD-ROM] #2086.
- 6) **Becker, H.**, A.D. Brandon, and R.J. Walker (2006), Geochemical tracing of core-mantle interaction: A trial for high-precision W isotopic data on komatiites using TIMS, *Eur. J. Mineral.* 18, Beih. 1, 15.
- 7) **Berthet, S., V. Malavergne, K. Righter**, A. Corgne, and R. Combes (2006), The Evolution of the EH4 Chondrite Indarch at High Pressure and Temperature: The First Experimental Results, *Lunar Planet. Sci. Conf., XXXVII*, Abstract #2026.
- 8) **Mackwell, S.J., W.S. Kiefer**, and **D. Nunes** (2006), The Interior of Venus, *Chapman Conference on Exploring Venus as a Terrestrial Planet*, 9-10.
- 9) **Kiefer, W.S.** (2006), Gravity Observations of Structure in Valles Marineris, Mars, *Lunar Planet. Sci. Conf. XXXVII*, abstract 1458.
- 10) Anderson, R.B., **W.S. Kiefer**, H.V. Frey, and J.H. Roark (2006), Morphometry of Large Martian Impact Structures and Implications for Resurfacing Processes on Mars, *Lunar Planet. Sci. Conf. XXXVII*, abstract 2018.
- 11) Wong, A.-S., M. Liang, Y.L. Yung, **J.I. Moses**, and K.A. Boering (2006), Hydrocarbon Photochemistry: Evaluation Of Chemical Kinetics Using Laboratory Measurements, *Bull. Am. Astron. Soc.*, 38, #27.07.
- 12) **Moses, J.**, and R.J. Vervack, Jr. (2006), Saturn's Upper Atmospheric Structure: Forward Modeling and Comparison with a Reanalysis of the Voyager UVS Occultation Data, *Bull. Am. Astron. Soc.*, 38, #11.25.
- 13) **Strong, S.B., T. Greathouse**, and **J. Moses** (2006), A Radiative Seasonal Climate Model of Saturn's Atmosphere, *Bull. Am. Astron. Soc.*, 38, #11.20.
- 14) **Moses, J.I.**, and R.J. Vervack, Jr. (2006), The structure of the upper atmosphere of Saturn, *Lunar Planet. Sci. Conf., XXXVII*, #1803.
- 15) **Strong, S.B., T. Greathouse, and, J.I. Moses** (2006), A radiative seasonal climate model for the Saturnian atmosphere, *Lunar Planet. Sci. Conf., XXXVII*, #1742.
- 16) **McGovern, P.J.**, J.K. Morgan, and **M.A. Higgie** (2006), Structure and Evolution of the Olympus Mons Volcanic Edifice and Basal Escarpment, Mars, *Lunar Planet. Sci. Conf., XXXVII*, abstract 2329.
- 17) **Nunes, D.C.**, R.J. Phillips, G. Picardi, J.J. Plaut, A. Safaeinili, R. Seu, and A. Egan (2006) Resolving stratigraphy of the Polar Layered Deposits with MARSIS and SHARAD, *Lunar Planet. Science Conf. XXXVII*, 1450.
- 18) Bue, B.D., and **T.F. Stepinski** (2006), Machine Detection of Martian Craters from Digital Topography, *Lunar Planet. Sci. Conf. XXXVII*, Abstract # 1178.
- 19) Molloy, I., and **T.F. Stepinski** (2006,) Automated Mapping of Valley Networks on Mars, *Lunar Planet. Sci. Conf. XXXVII*, Abstract # 1743.

- 20) **Stepinski T.F.**, M. Carriere, and I. Molloy (2006), Properties of Martian Highlands Drainage from THEMIS Images and MOLA Topography, *Lunar Planet. Sci. Conf. XXXVII*, Abstract # 1118.
- 21) Gregoire-Mazzocco, H., **T.F. Stepinski**, **P.J. McGovern**, S. Lanzoni, A. Frascati, and A. Rinaldo (2006), Martian Meanders: Wavelength-Width Scaling and Flow Duration, *Lunar Planet. Sci. Conf. XXXVII*, Abstract # 1185.
- 22) Lacy, J.H., D.T. Jaffe, M.J. Richter, **T.K. Greathouse**, M. Bitner, P. Segura, W. Moller, T.R. Geballe, and K. Volk (2006), TEXES on Gemini, *Proceedings of the SPIE*, 6269.
- 23) Richter, M.J., J.H. Lacy, D.T. Jaffe, D.J. Mar, J Goertz., W. Moller, **S. Strong**, and **T.K. Greathouse** (2006), Development and future use of the echelon-cross-echelle spectrograph on SOFIA, *Proceedings of the SPIE*, 6269.
- 24) **Greathouse, T.K.**, **S.B. Strong**, and M.J. Richter (2006), Saturn: The Observed Seasonal Variations of Stratospheric Temperature and Hydrocarbon Abundances Since 2002, *Lunar Planet. Sci. Conf. XXXVII*, abstract #1737.
- 25) Encrenaz, T., B. Bezard, **T. Greathouse**, S. Holmes, M. Richter, D. Nuccitelli, J. Lacy, S. Lebonnois, F. Lefevre, S. Atreya, A.S. Wong, T. Owen, and F. Forget (2006), Ground-based high-resolution IR spectroscopy of Mars: H₂O and H₂O₂ mapping, search for CH₄, and determination of CO₂ isotopic ratios. *Second workshop on Mars atmosphere modelling and observations*, held February 27 - March 3, 2006, p. 510.
- 26) **Malavergne, V.**, M. Tarrida; J. Siebert, R. Combes; H. Bureau, and **S. Berthet** (2006), Partitioning of trace elements between silicate, sulfide and metal at high pressure and high temperature: investigation of dopant influence on partition behavior, *Lunar Planet. Sci. Conf. XXXVII*, Abstract #1951, 2006.
- 27) **Malavergne, V.**, J.H. Jones, A.J. Campbell, and M. Perronet (2006), Pt, Au, Pd and Ru partitioning between olivine and silicate liquid, *Lunar Planet. Sci. Conf. XXXVII*, Abstract #1974, 2006.
- 28) **Righter, K.** and B. Bussey (2006), Mineralogy and Petrology of the Mare Basalt-rich Breccia MET 01210, *Meteor. & Planet. Sci.*, 41, #5364.
- 29) **Righter, K.**, R.P. Harvey, J.W. Schutt, C. Satterwhite, K.M. McBride, T.J. McCoy, and L. Welzenbach (2006), The Great Diversity of Planetary Materials Returned from the Queen Alexandra Range, Antarctica, *Meteor. & Planet. Sci.*, 41, #5363.
- 30) **Malavergne, V.**, **Berthet S.**, and **K. Righter** (2006), CaS Formation from a CI Composition at High Pressure and Temperature Under Low Oxygen Fugacity, *Meteor. & Planet. Sci.*, 41, #5356.
- 31) **Righter, K.** (2006), Depletion of Vanadium in Planetary Mantles: Controlled by Metal, Oxide, or Silicate? *Lunar Planet. Sci. Conf.*, XXXVII, no. 2259.
- 32) **Righter, K.** (2006), The role of Antarctic meteorites in defining new chondrite groups and enhancing our understanding of the early solar system, *30th NIPR Symposium on Antarctic meteorites*. (submitted).
- 33) Neff, K.E., and **K. Righter** (2006), Opaque Assemblages in CK and CV Carbonaceous Chondrites, *Lunar Planet. Sci. Conf.*, XXXVII, no.1320.
- 34) **Danielson, L.R.**, M. Humayun, and **K Righter** (2006), Highly Siderophile Elements in Pallasites and Diogenites, including the New Pallasite, CMS 04071, *Lunar Planet. Sci. Conf.*, XXXVII, no.2304.
- 35) Chabot, N.L. and **K. Righter** (2006), Sulfur in Earth's Mantle and Its Behavior During Core Formation, *Lunar Planet. Sci. XXXVII*, no.1062.
- 36) Campbell, A.J., **L. Danielson**, **K. Righter**, Y. Wang, and G. Davidson (2006), Oxygen fugacity at high pressure: equations of state of metal-oxide pairs, *Lunar Planet. Sci. Conf.*, XXXVII, 1977.
- 37) **Treiman, A.H.**, **M. McCanta**, M.D. Dyar, C.M. Pieters, T. Hiroi, M.D. Lane, and J.L. Bishop (2006), Brown and clear olivine in Chassignite NWA 2737: Water and deformation, *Lunar Planet. Sci. Conf.*, XXXVII, [Abstract #1314](#). Lunar and Planetary Institute, Houston (CD-ROM).
- 38) Morgan, R.S. and **A.H. Treiman** (2006), Geographic settings of gullies in the Newton-Copernicus region of Mars: Implications for groundwater, snow, and dust, *Lunar Planet. Sci. Conf.*, XXXVII, [Abstract #1304](#). Lunar and Planetary Institute, Houston (CD-ROM).
- 39) Pieters, C.M., M.D. Dyar, T. Hiroi, M.D. Lane, A.H. Treiman, M. McCanta, J.L. Bishop, and J. Sunshine (2006), Optical properties of Martian dunite NWA 2737: A record of Martian processes, *Lunar Planet. Sci. Conf.*, XXXVII, [Abstract #1634](#). Lunar and Planetary Institute, Houston (CD-ROM).

- 40) **McCanta, M.C.**, M.D. Dyar, **A.H. Treiman**, C.M. Pieters, T. Hiroi, M.D. Lane, and J.L. Bishop (2006), Mössbauer and synchrotron MicroXANES analysis of NWA2737, *Lunar Planet. Sci. Conf., XXXVII*, [Abstract #1751](#). Lunar and Planetary Institute, Houston (CD-ROM).
- 41) Burgess, K.A., **D.S. Musselwhite**, and **A.H. Treiman** (2006), Experimental petrology of olivine-phyric shergottite NWA 1068: Toward defining a parental melt, *Lunar Planet. Sci. Conf., XXXVII*, [Abstract #1972](#). Lunar and Planetary Institute, Houston (CD-ROM).
- 42) Golden, D.C., D.W. Ming, H.V. Lauer Jr., R.V. Morris, **A.H. Treiman**, and G.A. McKay (2006), Formation of “chemically pure” magnetite from Mg-Fe-carbonates: Implications for the exclusively inorganic origin of magnetite and sulfides in Martian meteorite ALH84001, *Lunar Planet. Sci. Conf., XXXVII*, [Abstract #1199](#). Lunar and Planetary Institute, Houston (CD-ROM).
- 43) **Heggy, E.**, **S.M. Clifford**, and Card D. (2006), Understanding ambiguities in backscattered orbital radar sounding data from the Martian polar layered deposits using Finite Difference Time Domain simulations, *Fourth International Conference on Mars Polar Science and Exploration*, abstract no. 8107.
- 44) **Heggy, E.**, **S.M. Clifford**, A. Younsi, J.L. Miane, R. Carley, and R.V. Morris (2006), On the dielectric properties of dust and ice-dust mixtures: Experimental characterization of the Martian polar layered deposits analog materials, *Fourth International Conference on Mars Polar Science and Exploration*, abstract no. 8105.
- 45) Plaut, J.J., G. Picardi, A. Cicchetti, **S. Clifford**, P. Edenhofer, W. Farrell, C. Federico, A. Frigeri, **E. Heggy**, A. Herique, A. Ivanov, R. Jordan, W. Kofman, C. Leuschen, S. Milkovich, J. Mouginot, E. Nielsen, R. Orosei, E. Pettinelli, R. Phillips, D. Plettemeier, A. Safaeinili, R. Seu, E. Stofan, G. Vannaroni, T. Watters, and I. Williams (2006), MARSIS subsurface sounding observations of the South Polar Region of Mars, *Fourth International Conference on Mars Polar Science and Exploration*, abstract no. 8100.
- 46) **Clifford, S.M.**, **E. Heggy**, M. Ali, V. Ciarletti, C. Corbel, F. Dolon, A. Le Gall, R. Grimm, R. Ney, and S. Sandberg (2006), Multi-frequency GPR and other electromagnetic investigations of two Mars analog environments in the West Egyptian Desert, *EGU General Assembly 2006, Geophysical Research Abstracts, Vol. 8*, 05442.
- 47) **Heggy, E.**, and **S.M. Clifford** (2006), Experimental approach in understanding the dielectric properties of the Martian polar-layered deposits, *EGU General Assembly 2006, Geophysical Research Abstracts, Vol. 8*, 05508.
- 48) **Heggy, E.**, P. Paillou, and, **S. Clifford** (2006), Potential of Ground Penetrating Radar in Sounding Cratonic Fill in Small Buried Craters: analog study to the Martian case, *EGU General Assembly 2006, Geophysical Research Abstracts, Vol. 8*, 05476.
- 49) **Heggy, E.**, and **S. Clifford** (2006), Experimental approach in understanding the dielectric properties of the Martian polar-layered deposits, *EGU General Assembly 2006, Geophysical Research Abstracts, Vol. 8*, 05508.
- 50) Plaut, J., G. Picardi, A. Cicchetti, **S. Clifford**, P. Edenhofer, W. Farrell, C. Federico, A. Frigeri, **E. Heggy**, and Herique A. (2006), MARSIS Subsurface Sounding Observations of the South Polar Layered Deposits of Mars, *EGU General Assembly 2006, Geophysical Research Abstracts, Vol. 8*.
- 51) **Clifford, S.M.**, **E. Heggy**, M. Ali, V. Ciarletti, C. Corbel, C.L. Dinwiddie, F. Dolon, A. Le Gall, R.E. Grimm, R.N. McGinnis, R. Ney, and S.K. Sandberg (2006), Mars analog investigations of the West Egyptian Desert utilizing multi-frequency GPR and other electromagnetic sounding techniques, *Lunar Planet. Sci. Conf., XXXVII*, abstract no. 2442, March 13-17, 2006, League City, Texas.
- 52) **Heggy, E.**, R.A. Carley, A. Pommerol, **S.M. Clifford**, and R.V. Morris (2006), Density, temperature and Frequency dependent model of the Dielectric Map of the Martian Surface, Density, Temperature and Frequency Dependent Model of the Dielectric Map of Martian Surface, *Lunar Planet. Sci. Conf., XXXVII*, abstract no. 2140. March 13-17, 2006, League City, Texas
- 53) Watters, T.R., C.J. Leuschen, J.J. Plaut, G. Picardi, A. Safaeinili, **S.M. Clifford**, W.M. Farrell, A.B. Ivanov, R.J. Phillips, E.R. Stofan, and the MARSIS Science Team (2006), Evidence of buried basins in the northern lowlands of Mars from the MARSIS radar sounder., *Lunar Planet. Sci. Conf., XXXVII*, abstract no.1693, March 13-17, 2006, League City, Texas.
- 54) Onstott, T.C., Lisa M. Pratt, **S.M. Clifford**, B. Lollar Sherwood, T.J. Phelps (2006), Martian subsurface biotomes: A fanciful speculation (*submitted to the 2006 Astrobiology Conference*).

- 55) **Clifford, S.M.** (2006), Assessing the distribution and state of subsurface water on Mars: Theoretical expectations, the geologic evidence, and potential geophysical approaches (*submitted to the Fall AGU meeting in San Francisco, December 2006*).
- 56) **Debaille, V.**, R.G. Tronnes, A.D. Brandon, and C.-T.A. Lee (2006), Origin of the Jan Mayen hotspot: An 187Os/188Os and PGE perspective, *16th Goldschmidt Conference*, Melbourne, 2006.
- 57) **Heggy, E.**, E. Asphaug, R. Carley, A. Safaeinili, and **K. Righter** (2006), Dielectric Properties of Chondrites and Their Implication in Radar Sounding of Asteroid Interiors, *Spacecraft Reconnaissance of Asteroid and Comet Interiors*, held Oct. 5-6, 2006, Santa Cruz, California, abstract #3043.
- 58) **Heggy, E.**, R. Carley, W. Kofman, **S.M. Clifford**, A. Herique, I.P. Williams, and A.C. Levasseur-Regourd (2006), Dielectric Properties of Dirty-Ice and FDTD Simulation of Radar Propagation Through Comet Nuclei Geoelectrical Models to Support Radar-probing Investigation of the Comet 67P/Churyumov-Gerasimenko, *Spacecraft Reconnaissance of Asteroid and Comet Interiors*, held Oct. 5-6, 2006, Santa Cruz, California, abstract #3044.
- 59) **Heggy, E.**, and P. Paillou (2006), Counting and Exploring Small-buried Craters in the Sahara Using Radar Sounding and Imaging Radar: Lessons to be Learned for the Martian Case, *Workshop on Surface Ages and Histories: Issues in Planetary Chronology* LPI Contribution No. 1320, held May 23-23, 2006, Lunar and Planetary Institute, Houston, Texas.
- 60) **Heggy, E.**, and P. Paillou (2006), Sounding Cratonic Fill in Small Buried Craters Using ground Penetrating radar: Analog Study to the Martian Case, *Lunar Planet. Sci. Conf., XXXVII*, Houston Texas.
- 61) **Clifford, S.**, **E. Heggy**, M. Ali, V. Ciarletti, C. Corbel, F. Dolon, A. Le Gall, R. Grimm, R. Ney, and S. Sandberg (2006), Multi-frequency GPR and other electromagnetic investigations of two Mars analog environments in the West Egyptian Desert, *EGU 2006 meeting*, paper A-05508, Vienna, Austria.
- 62) Anderson, F.S., T. Whitaker, G. Miller, D. Young, J. Mahoney, **M. Norman**, and L. French (2006) A Laser RIMS Instrument to date igneous rocks using Rb-Sr and measure elemental chemistry. LPI Contributions 1320, 10-11.
- 63) Day, J.M.D., G.M. Nowell, **M.D. Norman**, D.G. Pearson, D.G. Chertkoff, and L.A. Taylor (2006) Evidence for age-progressive melting of increasingly incompatible-element-enriched mantle reservoirs on the Moon? *Lunar Planet. Sci. Conf., XXXVII*, Abstract #2235.
- 64) **Norman, M.D.**, and V.C. Bennett (2006) Impactor populations and lunar crustal compositions inferred from highly siderophile element compositions of Apollo 16 and 17 melt breccias. *Lunar Planet. Sci. Conf., XXXVII*, Abstract #1526.
- 65) Schnare, D.W., **M.D. Norman**, J.M.D. Day, and L.A. Taylor (2006) Origin of Apollo 15 olivine- and quartz-normative basalts. *Lunar Planet. Sci. Conf., XXXVII*, Abstract #2212.
- 66) **Lindsay, J.F.** and V.C. Bennett (2006), The late Archean biospheric explosion, *Lunar Planet. Sci. Conf., XXXVII*, Abstract No. 1174, Houston, Texas, 12-17 March, 2006.
- 67) **Lindsay, J.F.**, and V.C. Bennett (2006), Evidence for Global Biomass Expansion in the Late Archean, Hamersley Basin, WA. *Annual Goldschmidt Conference* (Abstract) Melbourne, Australia.
- 68) **Kirkland, L.E.**, K.C. Herr, and P.M. Adams (2006), Craters as Drills on Mars: Results from a Manmade, 260 Meter Diameter Crater in Layered Terrain. *Lunar Planet. Sci. Conf., XXXVII*, Abstract 1864.
- 69) **Kirkland, L.E.**, K.C. Herr, and P.M. Adams (2006), The Primary Uncertainties in Infrared Spectral Studies of Mars, *Lunar Planet. Sci. Conf., XXXVII*, abstract 1885.
- 70) **Kirkland, L.E.**, K.C. Herr, N. Schulenburg, and P. Adams (2006), Spectral Libraries in the Real World, *ITIC Reference Signatures Technical Exchange Meeting*, May 23-24, 2006.
- 71) **Thomson, B.J.** (2006), Cut craters on Mars: A study of impact craters exposed in cross section, *Lunar Planet. Sci. Conf., XXXVII*, abstract #1906. [Oral presentation]
- 72) Stone, A.S., N.T. Bridges, and **B.J. Thomson** (2006). A catalog of rock abrasion features at the MER Landing Sites: Preliminary results from Spirit and comparisons with orbital wind direction indicators, *Lunar Planet. Sci. Conf., XXXVII*, abstract #2080. [Poster presentation].

- 73) **Thomson, B.J.** (2006), Surface age conundrum in the northern plains of Mars: Ground truth at the Viking 2 Lander Site, *Workshop on Surface Ages and Histories: Issues in Planetary Chronology*, May 21–23, 2006, Houston, Texas. [Oral presentation].
- 74) **Schenk, P.**, and S. Seddio (2006), Geologic and Cratering History of Enceladus, *Bull. Am. Astron. Soc.*, abstract no. 18.01.
- 75) **Schenk, P.** (2006), Impact crater morphology on Saturnian satellites – First Results, *Lunar Planet. Sci. Conf.*, XXXVII, abstract no. 2339.
- 76) **McCanta, M.C., A.H. Treiman**, and E Essene (2006) LAP 04840: An amphibole bearing R-chondrite, *Meteor. Planet. Sci.* A5376.
- 77) **McCanta, M.C.**, M.D. Dyar, and F.P. Hörz (2006) Shock oxidation of pyroxene: effects on redox ratio, *Lunar Planet. Sci. Conf.*, XXXVII, Abstract 1903 (CD-ROM).

2005

- 1) **Neal, C.R.** (2005), The Lunar Seismic Network (LuSeN) Mission: The Need for Compact, Robust, Long-Lived Power Supplies, *EOS Trans. AGU 86(52)*, Fall Meet. Supp. abstract # P51C-0933 [CD-ROM].
- 2) Shafer, J.T., **C.R. Neal**, and J.J. Mahoney (2005), Crustal Xenoliths From Malaita, Solomon Islands: A Window to the Lower Crust of the Ontong Java Plateau, *EOS Trans. AGU 86(52)*, Fall Meet. Supp. abstract # T11C-0397 [CD-ROM].
- 3) Kinman, W.S. and **C.R. Neal** (2005), A textural and microanalytical evaluation of magma mixing in Detroit Seamount Lavas, *EOS Trans. AGU 86(52)*, Fall Meet. Supp. abstract # V13B-0543 [CD-ROM].
- 4) **Demouchy, S., S.J. Mackwell**, and D.L. Kohlstedt (2005), Effect of Hydrogen on Mg-Fe Interdiffusion in Ferro-periclase. *AGU Fall Meet. Suppl.*, Abstract MR41A-0902.
- 5) **Kiefer, W.S.** (2005), Gravity Models of the Argyre and Isidis Impact Basins, Mars: The Relative Importance of Surface Loading and Mantle Uplift, *AGU Joint Assembly*, abstract P23A-04.
- 6) **Kiefer, W.S.** (2005), Mantle Convection and the Uplift History of Tharsis, Mars: The Importance of Time-dependent Loading, *AGU Fall Meeting*, abstract P51B-0925.
- 7) Morgan, J.K. and **P.J. McGovern** (2005), Particle Dynamics Simulations of Gravitational Volcanic Deformation, *AGU Fall Meeting 2005*, abstract # V13F-08.
- 8) **McGovern, P.J.** and J.K. Morgan (2005), Spreading of the Olympus Mons volcanic edifice, Mars, *Lunar Planet. Sci.*, XXXVI, abstract 2258.
- 9) Cull, S.C. and **P.J. McGovern** (2005), Evidence for Extensive Fluvial Erosion around Olympus Mons: A Multi-Resolution Survey, *Lunar Planet. Sci.*, XXXVI, abstract 1154.
- 10) Bue, B.D. and **T.F. Stepinski** (2005), Machine Identification of Martian Craters Using Digital Elevation Data, *AGU Fall Meeting 2005*, abstract #P23A-0184.
- 11) Penteado, P., C. Griffith, **T. Greathouse**, H. Roe, and R. Yelle (2005), Measuring Titan's mesospheric temperatures by infrared spectroscopy, *Am. Astron. Soc.*, DPS meeting #37, #45.23; *Bull. Am. Astron. Soc.*, 37, 721.
- 12) **Treiman, A.H.** (2005), Li, Cl, and Br in Martian (Shergottite) basalts: No evidence of water loss, *Goldschmidt Conference 2005*, A751.
- 13) Steele, A., H.E.F. Amundsen, M. Fries, **A.H. Treiman**, M. Vogel, E.P. Vicenzi, J. Maule, J. Toporski, and M. Schweizer (2005), A morphological and chemical study of carbonate globules contained within mantle xenoliths of the Sverrefjell Volcano, Spitsbergen, *Astrobiology*, 5, 319, Abstract 1010.
- 14) **Heggy, E.** and **S.M. Clifford** (2005), Dielectric properties of mafic dust-ice mixtures: Case study of the Martian polar layered deposits, *AGU, Fall Meeting 2005*, abstract #P31C-0214.
- 15) Plaut, J.J., G. Picardi, D. Calabrese, A. Cicchetti, **S. Clifford**, W. Farrell, C. Federico, A. Frigeri, D. Gurnett, R. Huff, A. Ivanov, W. Johnson, R. Jordan, D. Kirchner, C. Leuschen, A. Masdea, R. Orosei, R. Phillips, A. Safaeinili, R. Seu, E. Stofan, and T. Watters (2005), First science results from MARSIS subsurface sounding, *AGU, Fall Meeting 2005*, abstract #P13C-02.
- 16) **Heggy, E.** and **S.M. Clifford** (2005), Dielectric Properties of Mafic Dust-Ice Mixtures: Case Study of the Martian Polar Layered Deposits, *AGU Fall Meeting Abstracts*, 31, 0214.

- 17) Osterloo, M.M., F.S. Anderson, T. Whitaker, G. Miller, D. Young, J. Mahoney, and **M. Norman** (2005), A LASER RIMS instrument to date igneous rocks using Rb-Sr and measure elemental chemistry, *EOS Trans. AGU*, 86(52), Fall Meet. Suppl., Abstract #P41A-0918
- 18) Aubaud, C., A.C. Withers, M.M. Hirschmann, Y. Guan, L.A. Leshin, **S.J. Mackwell**, and D.R. Bell (2005), A new calibration of H measurements by SIMS in glasses and nominally anhydrous minerals: application to experimental determinations of H partitioning, *EOS Trans. AGU*, 86, V41A-1419.
- 19) **Lindsay, J.F.**, V.C. Bennett and M.D. Brasier (2005), The Late Archean Biospheric Explosion (Abstract) *Geological Society of America*, Salt Lake City, November, 2005.
- 20) **Higbie, M.A.**, **S. Shipp**, and L. Lowes (2005), Bringing Planetary Data into Learning Environments: A Community Effort, *Eos Trans. AGU*, 86(52), Fall Meet. Suppl., Abstract ED34A-07.

APPENDIX III

Research Grants

Awarded

- 1) **W.S. Kiefer**
Modeling the Gravity Field of Mars: Constraints on Subsurface Structure and Lithospheric Properties at Large Highland Volcanos, Valles Marineris, and Large Impact Basins
NASA Mars Data Analysis Program
04/2003 – 04/2006
- 2) **W.S. Kiefer**
Improved Models of Mantle Convection and Magma Production on Present-day Mars
NASA Mars Fundamental Research Program
07/2005 – 06/2008
- 3) **J.I. Moses**
Chemistry in the Outer Solar System and Beyond
NASA Planetary Atmospheres Program
11/2004 – 10/2007
- 4) **J.I. Moses**
An Investigation of the Chemical-Dynamical Balance in the Methane Homopause Region of the Giant Planets
NASA Outer Planet Research Program
4/2005 – 03/2007
- 5) **P.J. McGovern**
The Influence of Flexural Stresses in Planetary Lithospheres on Magma Ascent and Volcano-Tectonic Surface Structures
NASA Planetary Geology and Geophysics Program
2005 – 2008
- 6) **P.J. McGovern**
Studies of Volcanic Spreading and Deformation on Mars
NASA Mars Data Analysis Program
2005 – 2008
- 7) **P.J. McGovern**
Studies of Tectonic Features on Mars
NASA Mars Data Analysis Program
2005 – 2008
- 8) **T.F. Stepinski**
Collaborative Research: A Statistical-Learning Tool for the Analysis and Characterization of Mars Topography
NSF Science and Engineering Information, Integration and Informatics

9/01/04 – 08/31/07

- 9) **T.F. Stepinski**
Origin of Martian Valley Networks – A Computational Approach
NASA Mars Fundamental Research
07/01/05 – 06/30/08

- 10) **T.F. Stepinski**
Automated Identification and Characterization of Landforms on Mars
NASA Applied Information Systems Research
01/01/06 – 12/31/08

- 11) **T.K. Greathouse**
Evolution of Giant Anticyclonic Storms in Jupiter
NASA Planetary Astronomy
10/2006 – 9/2009

- 12) **T.K. Greathouse**
A Complete Radiative Seasonal Climate Model Applied to Saturn's Stratosphere
NASA Planetary Atmospheres
10/2006 – 9/2009

- 13) **T.K. Greathouse**
Extra funding was received from the Gemini observatory for instrument support
Gemini
2006

- 14) **V. Malavergne**
Délégation CNRS
The Granting Agency is the C.N.R.S. (French national agency for fundamental research)
02/2004 to 08/2006

- 15) **K. Righter**
Cosmochemistry of the Highly Siderophile Elements
NASA Cosmochemistry
10/2003 to 9/2006

- 16) **A.H. Treiman**
Antarctic Mars Analogue Svalbard Expeditions (AMASE)
NASA Astrobiology Science and Technology for Exploring Planets (ASTEP) Program
01/2006 – 12/2008

- 17) **A.H. Treiman**
CheMin: An X-ray Diffraction/X-ray Fluorescence (XRD/XRF) Instrument for Definitive Mineralogical Analysis in the Analytical Laboratory of MSL
NASA Mars Science Laboratory '09 Mission

6/2005 - 2011

- 18) **A.H. Treiman**
Linking Our Origins to Our Future
NASA/Ames node of NASA Astrobiology Institute (NAI)
01/2003 - 12/2007
- 19) **A.H. Treiman**
Acid Fog on Mars
NASA Mars Fundamental Research Program
01/2006 - 12/2008
- 20) **A.H. Treiman**
Enhancing LPI Field/Lab Workshops for Professional Development
NASA Code S education supplement to MRF proposal
06/2004 – 05/2007
- 21) **S.M. Clifford**
MARSIS Investigations of the Nature and Evolution of the Martian Hydrosphere and Polar Layered Deposits
MARSIS NASA/JPL
04/2003-09/2008
- 22) **S.M. Clifford**
Broadband GPR Field and Laboratory Investigations of Remote Hyper-Arid Desert and Cold-Climate Analogs of Mars
NASA Mars Fundamental Research Program
07/2005 – 06/2007
- 23) **S.M. Clifford**
Early Climate & Geologic Evolution of Mars
NASA Planetary Geology and Geophysics
12/2003 – 11/2006
- 24) **S.M. Clifford**
NASA Astrobiology Institute, Indiana-Princeton-Tennessee Astrobiology Center for Detection of Biosustainable Energy and Nutrient Cycling in the Deep-Subsurface of Earth and Mars
NASA NAI
11/03 – 11/08
- 25) **S.M. Clifford**
GPR Field and Laboratory Investigations of Mars Analogs: Calibration and Blind Studies of Well-Characterized Sites in the Western United States
NASA Mars Fundamental Research Program
07/2005 – 06/2007

- 26) **E. Heggy, S. Clifford**
Electromagnetic Characterization of Planetary Analog and Extraterrestrial Materials in Support of Radar Investigations of Planetary Surfaces
NASA Planetary Geology and Geophysics
7/2005 – 07/2008
- 27) **E.S. Heggy**
Rock Electromagnetic Characterization in Support of Radar Sounding and Imaging Investigations of Planetary Surfaces
NASA Planetary Geology and Geophysics
07/2005 – 07/2008
- 28) **E.S. Heggy**
Broadband GPR Field and Laboratory Investigations of Mars Analogs: Calibration and Blind Studies of Well-Characterized Sites in the Western United States
NASA Mars Fundamental Program Research
06/2005 – 06/2007
- 29) **E.S. Heggy, S. Clifford**
Broadband GPR Investigation: Remote Hyper-Arid Desert and Cold Climate Analogs of Mars
NASA Mars Fundamental Program Research
06/2005 – 06/2007
- 30) **E.S. Heggy**
Radar Mosaic in Band L of Africa and Arabic Peninsula: Mapping Subsurface Paleo-Hydrological Structures
Submitted to the French Space Agency CNES
09/2006 – 09/2008
- 31) **S.J. Mackwell**
Skytellers: A Resource for Smaller Community and School Planetariums
National Science Foundation: Education
09/2002 – 08/2006
- 32) **S.J. Mackwell**
Hydrous Defects and Diffusion in Mantle Minerals
National Science Foundation: Geochemistry
01/2004 – 12/2006
- 33) **S.J. Mackwell**
Lunar and Planetary Institute (LPI-CAN)
NASA, Science Mission Directorate: Planetary Sciences
01/2003 – 12/2007
- 34) **S.J. Mackwell**
Collaborative Research: Field and modeling-based tests of the role of water in nominally anhydrous minerals in controlling the strength/stability of continental lithospheric mantle
National Science Foundation: Geochemistry

01/2007 – 12/2009

- 35) **L.E. Kirkland**
ChemCam — Laser-Induced Remote Sensing for Chemistry and Micro-Imaging
NASA-2009 Mars Rover
USRA Proposal #04-333
11/2004-10/2013
- 36) **L.E. Kirkland**
Field and Airborne Infrared Spectral Studies
Non-NASA U.S Government agencies
Covers 80% of my salary, yearly airborne missions, field work, and equipment
- 37) **P.M. Schenk**
NASA Planetary Geology and Geophysics
1/01/04 – 12/31/07
- 38) **P.M. Schenk**
NASA Outer Planets Research
8/15/05 – 8/14/07
- 39) **P.M. Schenk**
NASA Outer Planets Research
8/15/05 – 8/14/07
- 40) **P.M. Schenk**
NASA Outer Planets Research
8/15/05 – 8/14/07
- 41) **P.M. Schenk**
NASA Planetary Geology and Geophysics
8/15/05 – 8/14/07
- 42) **D. A. Kring**
Petrological and Geochemical Studies of Impact Melts and Impact Breccias
NASA Cosmochemistry Program
2006 - 2009
- 43) **D. A. Kring**
Modeling of the Thermal Evolution of Impact-Generated Hydrothermal Systems on Mars
NASA Mars Fundamental Research Program
2006-2009

Pending

- 1) **D. A. Kring**
Sampling Ancient Mars (SAM) Mission
Science Team Member
NASA Mars Scout Program
2007-2015

- 2) **D. A. Kring**
Lunar Communication for Exploration Activities Inside Craters: Non-line of Sight Communication
on the Moon without a Lunar Relay Satellite
NASA Innovative Partnership Program
2007

- 3) **D.A. Kring**
Cold Tolerant Tracks for Lunar Polar Crater Exploration
NASA Innovative Partnership Program
2007

- 4) **W.S. Kiefer**
Lunar Prospector Gravity Observations as Constraints on Lunar Volcanic Processes
NASA Discovery Data Analysis Program
12/2006-11/2009

- 5) **W.S. Kiefer**
Improved Models of Mantle Convection and Magma Production on Present-Day Mars
NASA Mars Fundamental Research Program
07/2005 – 06/2008

- 6) **W.S. Kiefer**
Understanding Mercury's Early Volcanic Evolution
NASA Messenger Mission Participating Scientists Program
04/2007 – 03/2013

- 7) **W.S. Kiefer**
*Modeling the Gravity Field of Mars: Constraints on Subsurface Structure and Lithospheric
Properties in Ancient Tharsis and along the Hemispheric Dichotomy*
NASA Mars Data Analysis Program
04/2007 – 04/2010

- 8) **T.F. Stepinski**
Building a New Global Martian Valley Networks Database and Inferring Past Climatic History
NASA Mars Data Analysis
08/16/07 – 08/15/10

- 9) **T.K. Greathouse**

Cassini Investigation of Jovian Chemistry, Energetics and Dynamics.
NASA Cassini Data Analysis Program
10/2006 – 9/2008

- 10) **T.K. Greathouse**
General Circulation and Photochemistry of Saturn's Stratosphere
NASA Cassini Data Analysis Program
10/2006 – 9/2008
- 11) **E.S. Heggy**
Electromagnetic Characterization of Planetary Analog and Extraterrestrial Materials in Support of Radar Investigations of Planetary Surfaces — Equipment Support
NASA Planetary Geology and Geophysics
06/2007
- 12) **E.S. Heggy**
Multi-Frequency GPR and Other Electromagnetic Field and Laboratory Investigations of Hyper-Arid and Cold-Climate Analogs of Mars
NASA Mars Fundamental Research Program
06/2007-06/2010
- 13) **E.S. Heggy**
Unique Egyptian Lacustrine Impact Facies: Key Analog of the Martian Sedimentary Record
NASA Mars Fundamental Research Program
06/2007 – 06/2010
- 14) **E.S. Heggy**
Geophysical Field and Electromagnetic Laboratory Investigations of Mars Analogs: Characterization Studies in the Western United States
NASA Mars Fundamental Research Program
06/2007 – 06/2010
- 15) **E.S. Heggy**
GPR Scattering & EM Induction Signatures from Buried Targets in the Presence of Antennas or Induction Sources
NASA Mars Fundamental Research Program
06/2007 – 06/2010
- 16) **E.S. Heggy**
Radar Laboratory, Field and Numerical Investigations in Support of the Geologic, Hydrologic, and Polar Interpretation of the SHARAD Orbital Sounding Data
NASA Mars Reconnaissance Orbiter, participating scientist, SHARAD Instrument
06/2007 – 06/2010
- 17) **E.S. Heggy**
Development of Mars Surface Simulator for testing ExoMars Rover Geophysical package
CNES (French Space Agency)

01/2007 – 01/2010

- 18) **D.S. Musselwhite**
Experimental Investigations of the Mantle Source of Martian Basalts
NASA Mars Fundamental Research Program
01/2007 – 12/2009 (pending)
- 19) **J.F. Lindsay**
Martian biospheric limits: Evidence from late Archean Earth
NASA Mars Fundamental Research Program
1/2007 – 12/2009
- 20) **J.F. Lindsay**
Understanding the Martian Glacial Record
NASA Mars Fundamental Research Program
1/2007 – 12/2009
- 21) **J.F. Lindsay**
The Road to Mars: Understanding Prebiotic Earth as a Mars Analog
NASA Mars Fundamental Research Program
1/2007 – 12/2009
- 22) **J.F. Lindsay**
Biogenesis – Deciphering the Ancient Rock Record
NSF – Geobiology and Low-Temperature Geochemistry
1/2007 – 12/2009
- 23) **J.F. Lindsay**
The Martian Glacial Record: Searching for Earth Analogs
NASA Mars Fundamental Research Program
1/2007 – 12/2009
- 24) **J.F. Lindsay**
The Road to Mars — Defining Robust Biosignatures
JSC Center Directors Discretionary Fund
1/2007 – 12/2008
- 25) **P.M. Schenk**
MESSENGER Participating Scientist
01/08 – 01/13
- 26) **P.M. Schenk**
Cassini Data Analysis
01/07 – 12/08
- 27) **C.R. Neal**

Development of a Lunar Geophysical Instrument Package
NASA Planetary Instrument Definition and Development Program
01/07 – 12/08

APPENDIX IV

Support of NASA and Other Federal Agencies

S.M. Clifford

- Fourth International Conference on Mars Polar Science and Exploration (October 2006)
- Committee for Planetary and Terrestrial Analogs, U.S. Subglacial Antarctic Lake Environment (SALE) Program (2005 – present)
- National Research Council Committee on Preventing the Forward Contamination of Mars (2004 – 2006)
- Participant, Mars Exploration Program and Advisory Group (2000 – present)

W.S. Kiefer

- Venus Exploration and Analysis Group (VEXAG) (2005, 2006)

L.E. Kirkland

- NASA Astrobiology Institute – CAN review (2006)

D.A. Kring

- Science Team Member, Mars Scout Program submission entitled, “Sampling Ancient Mars (SAM)”
- Lunar Surface Explorer (LSE): Continued to collaborate with General Dynamics and Foster-Miller to refine this rover design. Assembled a partial team to provide science instrument payload.
- Polar Express (PE): Continued to collaborate with General Dynamics to refine subsystem trades for this lander, which is designed to land safely on the shadowed floor of Shackleton Crater and determine how much H and H₂O is present and to provide the first major and minor element chemical analysis of South-Pole Aitken lithologies.
- Lunar Surface Reconnaissance Lander (LSRL): Initiated a new design study for a lander to carry LSE and to provide a generic spacecraft capable of landing anywhere on the lunar surface. Involves several subsystem trades that are being run in parallel with subsystem trades for LSE and PE.
- Responded to two IPP opportunities sponsored by NASA Headquarters. My LSE team joined NASA Glenn Research Center for these efforts (see section regarding pending proposals).
- Responded to a NASA-GRC Request for Information (RFI): “In Situ Resources Utilization (ISRU) Test Facilities.” Response to RFI submitted with General Dynamics 24 July 2006.
- Invited briefing to the Manager of the Lunar Precursor Robotic Program at the NASA Marshall Space Flight Center; briefing is coordinated with additional meetings with the Manager of MSFC Science Programs and Projects Office and the science staff in the radiation hazards division. (October 2006).
- Continued to participate in an effort to develop an *in situ* K-Ar geochronology capability (called AGE) for the surface of Mars. I am providing petrological and geochemical expertise; Tim Swindle is the PI.

S.J. Mackwell

- Panel Chair for Planetary Geology and Geophysics, NASA, Washington DC, 2005 – present
- Member, Management and Operations Working Group, Planetary Geology and Geophysics, NASA, Washington DC, 2003 – present
- Executive Committee, Lunar Exploration Analysis Group, NASA, Washington DC, 2005 – present
- Executive Committee, Venus Exploration Analysis Group, NASA, Washington DC, 2005 – present
- Panelist for “Exploration Strategy Workshop”, NASA, Washington DC, April 25–28, 2006

P.J. McGovern

- Reviewer for NASA Postdoctoral Program (NPP) proposals (2006)

J.I. Moses

- Steering Committee, NASA Outer Planet Assessment Group (2005 – present)
- Committee Member, Giant Planets Panel
- PDS Atmospheres Node Advisory Group (1996 – present)
- NASA Planetary Atmospheres Program Review Panel (2006)
- NASA Cassini Data Analysis Program Review Panel (2006)

P.M. Schenk

- Team Member - New Horizons Jupiter Encounter Sequencing Team
- Chair, NASA Planetary Cartography and Geologic Mapping Working Group (2006)
- Lead, Planetary Cartography Ten-Year Strategic Outlook

T.F. Stepinski

- NSF Science and Engineering Information, Integration and Informatics Review Panel (2006)

A.H. Treiman

- VEXAG (Venus Exploration Analysis Group) (2005 – present)
- Review Panel member, NASA Exobiology Program (Jan. 2006)
- LPI/JSC Liaison committee (2003 – 2006)

E.S. Heggy

- MARSIS (NASA-ESA 2004, Mars Express mission): Participating in MARSIS American work team, providing expertise in quantifying attenuation, scattering losses and data comparison from earth based analog study
- WISDOM (ESA-2011, ExoMars program): Participating in instrument design and setting field tests experiments using the updated GPR of the Netlander flight model. Collaborative work with the CETP (Velizy, France) and The Southwest research Institute (San Antonio, USA)
- CONSERT (ESA-2004, Rosetta mission): Perform dielectric measurements and field tests with the instrument flight model. Collaborative work with the LPG (Grenoble, France)
- P-band SAR group (CNES-ONERA, RAMSES experimental SAR): Preparing an air-ported field survey on the Western Sahara: evaluating the potential of polarimetric sub-metric resolution imaging of shallow subsurface geology

D.C. Nunes

- Review Panel — NASA Data Analysis Program (2006)

J.F. Lindsay

- Support of NASA's Advanced EVA Program and their Desert RATS Field Program at Meteor Crater in Arizona (2004 – present)
- Lunar Airborne Dust Toxicity Advisory Group (LADTAG) (2005 – present)
- NASA's In Situ Resource Utilization Program (ISRU) (2005 – present)
- Marshall Space Flight Center Lunar Simulant Development Project (2005 – present)

APPENDIX V

Education Activities

W.S. Keifer

- Instructor for Summer Planetary Geology Workshops for Science Teachers: (2003-2006)
- Content Development and Scientific Reviewing for LPI Education Products
 - Mars Geology Education Modules (2005 – 2008)
- Speakers Bureau Contributor (2003 – 2006)

D.A. Kring

- Science Expert, film documentary “Asteroid Apocalypse,” The History Channel; aired 6 June.
- Science Expert, film documentary about Tunguska and Barringer impact events, The History Channel; interviewed at Barringer Crater and producer is editing the film for release later in year.
- Science Expert, film documentary about impact cratering on Moon, National Geographic Channel; in pre-production phase with filming scheduled for November.
- Science Expert, film documentary about the formation and collisional evolution of Earth, including the consequences of the inner solar system cataclysm and Chicxulub impact, BBC Television; currently in a pre-production phase with filming anticipated later in year.
- Responded to email inquiries about planetary sciences from general public.
- Assisting LPI Education Department with design of 3 E/PO posters about the Moon.

S.J. Mackwell

- Adjunct Professor: Rice University (2005-present)

J.I. Moses

- Coordinator, LPI Summer Intern Program (2004 – present)

P.M. Schenk

- Development of Star Parties and lectures for Bolivar Peninsula School District, (Fall semester 2006)
- Attend Annual Space Day activities Little Elementary, Dickenson ISD, (May 2003-2006)

T.F. Stepinski

- Assisted in developing learning modules with the LPI education department (2005)
- Co-I: educational grant (2005)

A.H. Treiman

- Organizer/Presenter:
 - Teacher Training Workshops (2003 – 2006)
- Presenter: Multiple public lectures and demonstrations (2003 – 2006)

E.S. Heggy

- Advisor: in coordination with the Houston Museum of Natural Sciences, developed planetarium movie as part of Education and Public Outreach NASA project (2005 – 2008)

M.A. Higbie

- Assistant Director of the South Central Organization of Researchers and Educators (SCORE) (2003 – 2006)
- Co-Lead of the Planetary Data in Education Initiative (2004 – 2006)
- Assisted with Coordination of LPI Summer Educator Fieldtrips (2003 – 2006)
- Lead and supported numerous educator workshops at state, regional, and national level science teacher conferences (2003 – 2006)
- Reviews and contributions made to several LPI Educational Products (2003 – 2006)
- Guest Lecturer: 2006

A.K. Maloy

- Teaching Assistant: Rice University (2006)

D.S. Musselwhite

- Adjunct Professor: University of Houston Clear Lake (2005 – 2006)

D.C. Nunes

- Workshop Coordinator: (2006)
- Lecturer: (2005 – 2006)

K. Righter

- Presenter: Brownsville, Texas Middle School Students (2006)

B.S. Thomson

- Judge of a local intermediate school science fair (2006)
- Instructor: Rice University (2006)
- Judge: Geological Society of America Stephen E. Dworkin Student Awards (poster presentations) at the 37th Lunar and Planetary Science Conference

APPENDIX VI

Support of the Planetary Community

S.M. Clifford

- Associate Editor:
 - International Journal of Astrobiology (2000 – present)
 - Astrobiology, Mary Ann Liebert, Inc. (2000 – present)
- Member, American Geophysical Union (1982 – present)
- Organizer:
 - Special Section on Radar Investigations of Planetary and Terrestrial Environments JGR-Planets (Spring 2006)

W.S. Keifer

- Scientific Organizing Committee for Workshop on Early Planetary Differentiation: A Multi-Planetary and Multi-Disciplinary Perspective (Dec. 8–10, 2006)
- Member: Mission Planning Team for the Lunar Seismic Network Mission (LuSeN) (2004 – 2006)

S.J. Mackwell

- Member, Review Panel for Schwerpunktprogramm “Internationales Kontinentales Bohrprogramm (ICDP)”, Deutsche Forschungsgemeinschaft (2001 – present)
- Member of Gilbert Award Committee, Geological Society of America (2003 – present)
- Member, Advisory Committee, Winchell School of Earth Sciences, University of Minnesota, Minneapolis, MN (2005 – present)
- Co-chair, Lunar and Planetary Science Conference Organizing Committee (2002 to present)
- Editorial Board Member:
 - Physics and Chemistry of Minerals, Springer (1996 – present)
 - Tectonophysics, Elsevier (2002 – present)

P.J. McGovern

- Judge, GSA Dwornik Student Paper Award (2003, 2004, and 2006)
- Guest Editor, GRL (2006)

J.I. Moses

- Editor, Journal of Geophysical Research – Planets (2003 – present)

P.M. Schenk

- Scientific Editor, Lunar and Planetary Institute Bulletin (2003 – present)
- Director, Regional Planetary Image Facility, Lunar and Planetary Institute (2002 to present)
- Convener: Surface Ages and Histories: Issues in Planetary Chronology (2006)
- Advisor, LPI Summer Intern Program (1992 – 1999, 2006)

E. Heggy

- Associate Editor, JGR Special Review on Radar Investigations of Planetary and Terrestrial Environments (2006)

D.A. Kring

- Chair, Barringer Family Fund for Meteorite Impact Research
- Chair, Eugene Shoemaker Impact Crater Award
- Co-Chair, impact cratering session at the 2006 Meteoritical Society meeting
- Leader, Union-level special session about the Chicxulub Crater and K/T boundary for the 2007 AGU spring meeting in Mexico
- Leader, 2007 Meteoritical Society field trip to Barringer Meteorite Crater and Northern Arizona (currently drafting field guide and making logistical arrangements)

- Attended JOI/IODP/ICDP workshop to prepare a 2-borehole drilling plan for the Chicxulub Crater; input already used to augment IODP plans; input being assembled for a new ICDP proposal.
- Program Committee, 2007 DPS meeting

D.C. Nunes

- Judge, GSA Stephen E. Dornik Student Research Paper Award (2006)
- Planning Committee Member, LPSC (2006)
- Session Chair, LPSC (2006)

M.D. Norman

- Steering Committee and Chair, Planetary Sciences Working Group Australian National Committee for Space Sciences Decadal Plan (2006)
- Chair:
 - Planetary Geochemistry Task Group, Science Program Committee, Goldschmidt Conference, Melbourne, 2004 – 2006).
 - Specialist Group in Planetary Geosciences, Geological Society of Australia (2004 – present)
- Session Chair: Planetary Geochemistry at the 6th Australian Space Science Conference, Canberra (2006)
- Hosted NASA-supported student visitors to Research School of Earth Sciences, Australian National University to conduct geochemical studies of lunar samples and martian meteorites (2005 – 2006)

B.S. Thomson

- Program Committee Member, LPSC (2006)

APPENDIX VII

Invited Scientific Presentations

- Demouchy S.** "Mobilité et solubilité de l'hydrogene dans le manteau terrestre", Seminar at laboratoire de tectonophysiques, Montpellier, France. (February 7, 2006).
- Demouchy S.** "Mobilité et solubilité de l'hydrogene dans le manteau terrestre." Seminar at laboratoire des transferts géologiques, Toulouse, France. (February 10, 2006).
- Demouchy S.** "Effect de l'eau sur l'interdiffusion dans le ferro-periclase", Seminar at laboratoire magma et volcans, Clermont-Ferrand, France. (February 14, 2006).
- Demouchy S.** "Diffusivity of Water in the Deep Earth: Reports from the Lab, Rumors from Patagonia", Carnegie Inst. Geophysical Lab. Washington D.C. (April 10, 2006).
- Mackwell S.J., W.S. Kiefer, and D. Nunes,** "The Interior of Venus", Chapman Conference on Exploring Venus as a Terrestrial Planet (Invited Review talk, presentation given by Mackwell), (February 13, 2006).
- Nunes D.C.** "Radar Sounding and Mars Polar Science", USGS Astrogeology Branch - Flagstaff, AZ. (2006).
- Berthet S., V. Malavergne, and K. Righter** "The evolution of the EH4 chondrite indarch at high pressure and temperature: the first experimental results", Johann Wolfgang Goethe University, Institute of mineralogy, Franckfurt, Germany. (July 2006).
- Treiman A.H.** "ALH84001: A Synthesis of What Happened, Current Thinking Relative to Life on Mars, and What We (Should) Have Learned." National Research Council's Committee on the Origins and Evolution of Life. (January 2006).
- Clifford S.M.** "Mars: The Effect of Stratigraphic Variations in Regolith Diffusive Properties on the Evolution and Vertical Distribution of Equatorial Ground Ice", ISSI International Team Workshop on the Water Content of the Upper Martian Surface, Bern Switzerland. (June 19 - 23, 2006).
- Heggy E.** Speaker at the National Program of Planetary Science in France. (September 11, 2006).
- Heggy E.** Invited speaker at Institute de Physique de Globe de Paris, France (June 4, 2006).
- Heggy E.** Invited Speaker at the Centre d'Etude terrestre et Planitaire, Velizy, France. (February 3, 2006).
- Norman M.D.** Invited keynote presentation: "Asteroids: Their origins and significance", Australian Institute of Physics Congress, Brisbane. (2006).
- Schenk P.M.** "Frozen Holes: Impact Craters in Icy Targets and What They Tell us", 1st Int'l Conference on Impact Cratering, Noordwijk, NL. (May 9, 2006)
- Kring D.A.** "Accretion and Collisional Evolution of Our Solar System and Other Young Planetary Systems," invited keynote lecture for a 2-day workshop about Mars and The Terrestrial Planets that was sponsored by the German Science Foundation, Max Planck Institut für Chemie, Mainz, Germany, (August 14, 2006)
- Kring D.A.** "The Chicxulub Crater and Impact-generated Environmental Effects at the K/T Boundary." Lunar and Planetary Institute, Houston, Texas, (October 4, 2006)

APPENDIX VIII

Mentoring

S. M. Clifford

- Visiting Graduate Fellow from Centre d'étude des Environnements Terrestre et Planétaires, Paris, France (2006)
- LPI/NASA Summer Intern Program (2006)
- Graduate Student from University of Houston-Clear Lake (1998 – present)
- Postdoctoral Fellow (2003 – 2006)

W. S. Keifer

- LPI/NASA Summer Intern Program (2003 – 2006)
- Post-doctoral Fellow (2006)

L. E. Kirkland

- Masters Student from University of Houston (2003 – 2006)

S. J. Mackwell

- Postdoctoral Fellow from University of Minnesota (2004 – present)

P. J. McGovern

- LPI/NASA Summer Intern Program

J. I. Moses

- Ph.D. student from University of Texas – Austin (2004 – present)

P. M. Schenk

- LPI/NASA Summer Intern Program (2006)
- Postdoctoral Fellow (2006)

T. F. Stepinski

- LPI/NASA Summer Intern Program
- Graduate student from Purdue University (2002 – 2006)
- Masters student from University of Houston (2006)
- Masters student from University College London, UK (2006)

A. H. Treiman

- Postdoctoral Fellow (Sept. 2006 to present)
- Masters student from Rice University (Sept. 2004 – present)

E. Heggy

- LPI/NASA Summer Intern Program
- Master student from Cambridge University, UK (June 2005 – May 2006)

T. K. Greathouse

- LPI/NASA Summer Intern Program
- Ph.D. student from University of Texas – Austin (2004 – present)

V. Malavergne

- Ph.D. student from Laboratoire des Géomatériaux de l'Université de Marne La Vallée, France (2004 – 2007)

K. Righter

- LPI/NASA Summer Intern Program

- Ph.D.student from Laboratoire des Géomatériaux de l'Université de Marne La Vallée, France (2004 – 2007)

APPENDIX IX

Other Conferences, Meetings, and Workshops

Upcoming Conferences and Workshops (2007– 2010)

38th Lunar and Planetary Science Conference; March 12-16, 2007; League City, Texas; Stephen Mackwell (Lunar and Planetary Institute) and Eileen Stansbery (NASA Johnson Space Center).

Seventh International Mars Conference; July 9-13, 2007; Pasadena, California; Dan McCleese (Jet Propulsion Laboratory) and David Beatty (Jet Propulsion Laboratory).

70th Meeting of the Meteoritical Society; August 19-24, 2007; Tucson, Arizona; Timothy Jull (University of Arizona) and Timothy Swindle (University of Arizona).

Workshop on Impact Cratering: Bridging the Gap between Modeling and Observations II; September 24-26, 2007; Montreal, Canada; Robert Herrick (University of Alaska Fairbanks) and Elisabetta Pierazzo (Planetary Science Institute).

Workshop on the Lunar Reconnaissance Orbiter High Resolution Image Targeting Selection; TBD, 2007; TBD; Jeffrey Plescia (Johns Hopkins University, Applied Physics Laboratory).

Conference on Large Meteorite Impacts and Planetary Evolution IV; August, 2008; South Africa; Wolf Uwe Reimold (Humboldt-Universität zu Berlin); Roger Gibson (University of the Witwatersrand); C. Cockell (Open University); Christian Koeberl (University of Vienna); J. Morgan (Imperial College); J. Mungall (University of Toronto); Elisabetta Pierazzo (Planetary Science Institute); and U. Riller (Humboldt-Universität zu Berlin).

73rd Meeting of the Meteoritical Society; July 25-30, 2010; Manhattan, New York; Denton Ebel (American Museum of Natural History); Harold Connolly (City University of New York); Cyrena Goodrich (City University of New York); C.E. Nehru (Brooklyn College); and Michael Weisberg (City University of New York).

2006

Stardust Educator Conference; January 18-21, 2006; Lunar and Planetary Institute; Aimee Whalen (NASA Jet Propulsion Laboratory) and Jackie Allan (NASA John Space Center).

37th Lunar and Planetary Science Conference; March 13-17, 2006; League City, Texas; Attendance: 1582; Stephen Mackwell (Lunar and Planetary Institute) and Eileen Stansbery, NASA Johnson Space Center.

Workshop on Surface Ages and Histories: Issues in Planetary Chronology; May 21-23, 2006; Lunar and Planetary Institute; Attendance: 43; Paul Schenk (Lunar and Planetary Institute); Nadine Barlow (Northern Arizona University); Beau Bierhaus (Lockheed Martin, Denver).

Workshop on Desert Meteorites: Recovery, Documentation of Meteorite Finds, and Future Prospects of Cooperation in Research (Workshop to be held in partnership with the 69th Annual Meeting of the Meteoritical Society, August 7-11, 2006); August 3-4, 2006; Casablanca, Morocco; Hasnaa Chennaoui Aoudjehane (Casablanca Hassan II University, Chair).

69th Annual Meeting of the Meteoritical Society; August 7-11, 2006; Zurich, Switzerland; Rainer Wieler (ETH Zurich, Chair); Addi Bischoff (University of Münster); Marc Chaussidon (CRPG Nancy); Alex Deutsch (University of Münster); Beda Hofmann (Natural History Museum, Bern); Peter Hoppe, (MPI Mainz); Ingo Leya (University of Bern); Sara Russell (Natural History

Museum, London); Nadia Vogel (University of Bern); and Jutta Zipfel (Forschungsinstitut Senckenberg, Frankfurt a/M).

Fourth International Conference on Mars Polar Science and Exploration; October 2-6, 2006; Davos, Switzerland; Steve Clifford (Lunar and Planetary Institute); Walter Ammann (Swiss Federal Institute for Snow and Avalanche Research); Kathryn Fishbaugh (International Space Science Institute); and David Fisher (Geological Survey).

Scheduled in 2006:

Workshop on Spacecraft Reconnaissance of Asteroid Interiors; October 5-6, 2006; University of California Santa Cruz Inn and Conference Center; Erik Asphaug (University of California, Santa Cruz) and Louise Procktor (Johns Hopkins University, Applied Physics Laboratory).

Workshop on Lunar Crater Observation and Sensing Satellite (LCROSS) Site Selection; October 16, 2006; NASA Ames Research Center, Moffett Field, California; Jennifer Heldmann (NASA Ames Research Center/SETI Institute, Chair); Geoff Briggs (NASA Ames Research Center); Tony Colaprete (NASA Ames Research Center), Don Korycansky (University of California, Santa Cruz); and Pete Schultz (Brown University).

Workshop on Martian Sulfates as Recorders of Surficial-Atmospheric-Fluid Rock Interactions; October 22-24, 2006; Lunar and Planetary Institute, Houston, Texas; James Papike (University of New Mexico).

Space Resources Roundtable VIII; October 31-November 2, 2006; Colorado School of Mines, Golden, Colorado; G. Jeffrey Taylor (University of Hawai'i); Michael Duke (Colorado School of Mines); and Leslie Gertsch (University of Missouri-Rolla).

Workshop on Early Planetary Differentiation; December 8-10, 2006; Sonoma County, California; Charles Shearer (University of New Mexico); Lars Borg (Lawrence Livermore National Laboratory); and Kevin Righter (NASA Johnson Space Center).

All announcements, preliminary programs, and abstracts for each meeting were published on the LPI website and are available upon request.

APPENDIX X

Education and Public Outreach Programs

The programs of the Institute's Education and Public Outreach Department are primarily focused on training formal and informal educators (teachers, librarians, and after-school program providers), providing them with materials designed to engage, inspire, and educate students in the field of lunar and planetary science.

A. Informal Education

Evolution of the Solar System Timeline

www.lpi.usra.edu/education/timeline/

The Evolution of Our Solar System resulted from the close collaboration of artists, scientists, programmers, image researchers, and educators at the Institute. The timeline is a 40-foot-long illustration of 4.56 billion years of solar system history depicting the major geologic and biologic events that have occurred from formation of the solar nebula to accretion of the planets to the floods on Mars and the evolution of Earth's biosphere. Originally funded by the Institute, the timeline is being offered in partnership with the Houston Museum of Natural Science as a kiosk version available to museums and science centers.

Explore! Fun with Science

www.lpi.usra.edu/explore

Explore! brings space science resources and after-school activities to the informal educational settings of library and after-school programs. Ten topics, each accompanied by hands-on activities, imagery, and additional resources, investigate rockets, comets, living and working in space, space health, our solar system, and more. Two hundred librarians and after-school youth program providers have been trained in nine states. An additional three modules will be added and training is pending in ten additional states. Librarians are not only continuing to present *Explore!* in their own settings, but also are offering staff development in their library systems, at state library conferences, and, in one case, through online training. LPI continues to support the *Explore!* trainers and broader community through updates of the Web page, electronic communication of news and events, and periodic phone surveys. Originally funded by the National Science Foundation, funds have been successfully acquired from NASA's Exploration Science Mission Directorate (ESMD) and an E/PO supplemental grant from the Science Mission Directorate (SMD) to expand the program to additional states. Additional funding is pending from ESMD and through the Lunar Reconnaissance Orbiter (LRO), New Horizons, and MESSENGER missions to expand the program even further.

Planetarium Shows

Through an education supplement from SMD, the Institute is partnering with the Houston Museum of Natural Science to produce a series of full-dome digital planetarium show clips that explore the dramatic geologic features hidden beneath the sands of the Sahara, investigate the processes that created these features, and determine the processes that obscured them through the evolution of the desert. This geologic story on Earth will be compared with the search for water at the Moon's poles and the features hidden under the Mars surface as revealed by new NASA missions. The program will emphasize remote-sensing tools, techniques, and results from research undertaken by Institute scientists. The Education Department will produce supporting educational materials and will evaluate the impact of the clips.

B. Training the Future Workforce

Educator Field Trips

www.lpi.usra.edu/education/fieldtrips/index.shtml

Each summer the Institute provides a week-long field experience for fifth- through eighth-grade educators. These educators often are responsible for teaching science content, but only about a third of them hold a major or minor in science or science education. Covering such topics as planetary volcanism and Mars geology, these field trips provide teachers with hands-on, real-world experiences and classroom resources to enhance their teaching about Earth and space science and the connections between these exciting fields of research. While primarily supported by the Institute, the facilitators have successfully proposed for an SMD E/PO supplemental grant and have acquired supporting funds from Sandia National Laboratories; results of a second round of funding requests are pending.

Pre- and In-Service Educator Training

In partnership with ARES and the Harris County Department of Education, as well as a number of local school districts, the Institute supports and provides training in Earth and planetary science content and classroom-appropriate resources for K–12 educators and future teachers. Earth and space science content is a focus of fifth- and eighth-grade assessment tests in Texas, and science teachers at these levels often have not been prepared to educate their students in this content. These programs will be expanded in the future to week-long institutes for district science specialists and advertised nationally.

The Education Department leads a Texas Pre-Service Educator Collaborative, a small working group of primarily university-based space science and education faculty who train future teachers. Through periodic meetings and telecons, the group explores avenues for bringing Earth and planetary science content, best teaching strategies, and experiences to pre-service teachers. Efforts currently focus on developing a Web-based interface that assists pre-service faculty and teachers in accessing standards-targeted content, activities, and resources.

Summer Intern Program

www.lpi.usra.edu/lpiintern/

The Institute provides undergraduates with an opportunity to experience cutting-edge research in the planetary sciences through its Summer Intern Program. Interns work one-on-one with scientists at the Institute or at the NASA Johnson Space Center to complete a research project of current interest in planetary science. The program allows participants to experience a real research environment, to learn from top-notch planetary scientists, and to preview careers in research. Currently funded solely by the Institute, funds are being sought from the National Science Foundation.

C. Family and Community Engagement

Family Space Day

www.lpi.usra.edu/education/space_days/

A monthly free event held at the Institute shares SMD (and other directorates') research and missions with parents and children ages 5 through 8 in the local area. The program is designed to engage and excite young children about Earth and planetary science. We frequently partner with ARES and the JSC Astronomical Society in planning and implementing these events, and have recently partnered with a local school district to provide two elementary-school teachers to be involved with the program.

Public Lectures and Speakers' Bureau

www.lpi.usra.edu/education/lectures/

The Institute invites the public to join us for lectures and discussions of current space science events, learning about NASA research and missions directly from the scientists involved. Scientists and staff of the Institute also make themselves available upon request for presentations to schools, civic groups, and other organizations.

SkyTellers: The Myths, the Magic, and the Mysteries of the Universe

www.lpi.usra.edu/education/skytellers

SkyTellers is a multimedia project that combines Native American myths and legends created to explain the mysteries of our universe with factual scientific information detailing the actual causes of these phenomena. The stories, told by Native American master storytellers and a Native American astronaut, cover such topics as day and night, the phases of the Moon, constellations, and our solar system. Presented in DVD format, *SkyTellers* is designed for use in small planetariums, museums, libraries, and other educational environments. A resource guide containing more detailed information and related activities is also provided with the DVD. Funding for this project was provided by the National Science Foundation (NSF).

D. NASA Support Programs

Broker Facilitator Program

www.lpi.usra.edu/education/score/about.shtml

The Institute serves as one of seven Broker Facilitators for NASA's Science Mission Directorate Space Science Support Network. As the South Central Organization of Researchers and Educators (SCORE), the Institute's E/PO staff members facilitate development of long-term partnerships between educators and SMD researchers across the six-state region of Arizona, Kansas, Louisiana, New Mexico, Oklahoma, and Texas. SCORE activities include providing electronic newsletters containing space science information and opportunities to educators and education specialists in the region; hosting booths and space science workshops at state science educator conferences; participating and presenting at conferences identified as strategically important for sharing SMD science, missions, and educational products and programs with an educator or scientist audience (e.g., the National Afterschool Association, AGU, AAS, ASP); and offering small grants for scientist-educator partnerships that involve development of educator workshops or special projects.

SCORE is involved as a co-chair on the **Pre-Service Educator Working Group**. This working group is helping to facilitate preparation of teachers in Earth and space science content by (1) developing a deeper understanding of pre-service programs and needs and (2) identifying diverse ways to meet those needs. The working group is gathering information from pre-service faculty and future teachers about challenges and needs, identifying models of best practices, and articulating this information to the SMD community. SCORE has initiated partnerships with organizations involved in the preparation of educators such as the Association for Science Teacher Education (ASTE).

SCORE also is a lead on the **Planetary Data in Education Initiative** with the Solar System Exploration Education Forum (SSE-EF). The initiative involves developing an understanding of the issues in bringing data successfully into the classroom and working to bring the necessary communities together.

Working Relationship with SMD (and ESMD) Missions

The Institute has established partnerships to develop educational materials for several missions. Mission E/PO funds support the Institute's role.

Juno — Educational materials will be incorporated into the *Explore!* program to present mission-related research, activities, and resource materials.

Moon Mineralogy Mapper Instrument Onboard Chandrayaan — ALTA spectrometer activities and an additional SkyTellers story will be developed.

ChemCam Project for Mars Science Laboratory — ChemCam is a remote-sensing instrument that uses laser interrogation to determine the composition of rocks and perform elemental analyses. The Institute will serve as E/PO lead for this project, in collaboration with AMNH and TERC. Specifically, we will develop an interactive Web environment, provide standards-based investigations, educator training, and public interactions with a nationally distributed team.

Lunar Reconnaissance Orbiter, New Horizons, and MESSENGER — *Explore!* modules are being proposed in conjunction with each of these missions. Funding is pending.