GALILEO VIEW OF EARTH AND MOON, DECEMBER 16, 1992—

Eight days after its closest encounter, the Galileo spacecraft looked back and captured this view of the Moon and Earth from about 6.2 million km away. The Moon is in the foreground, moving from left to right. Antarctica is visible through Earth's clouds. The Moon's farside is seen; the shadowy indentation in the dawn terminator is the South Pole/Aitken Basin, one of the largest and oldest lunar impact features.
24th LPSC Conference Information

CONFERENCE INFORMATION

REGISTRATION - LPI OPEN HOUSE

The 24th Lunar and Planetary Science Conference will open with a Registration/Open House on Sunday, March 14 from 6:00 p.m. until 9:30 p.m. at the Lunar and Planetary Institute, 3600 Bay Area Boulevard. Registration will continue in the Gilruth Center, JSC, Monday through Thursday between 8:00 a.m. and 5:00 p.m. A shuttle bus will be available to transport participants between the LPI and local hotels Sunday evening from 5:45 p.m. to 10:00 p.m.

A message center will be open from 8:00 to 5:00, Monday through Thursday (8:00 to noon on Friday) in the registration area in the Gilruth Center. People may contact attendees by calling 713-483-0321. Messages will be posted on a bulletin board near the Registration Desk.

Assistance with arranging airline reservations is available from the Airlines Traffic Office in Room 130 of Building 1 (phone 483-3305). Conference badges must be worn for entrance to this building. This service will be available each day of the conference from 8:00 a.m. to 5:00 p.m.

SHUTTLE BUS SERVICE

A shuttle bus service between JSC, LPI, and the various motels will operate daily from 7:30 a.m. until 9:30 a.m., 11:00 a.m. until 2:00 p.m., and from 5:00 p.m. until 6:30 p.m. Buses will also operate 1/2 hour before and after each official evening function.

During the week of the conference, your conference badge will allow access to the Space Center at all gates, the first floor of Building 1, and the Gilruth Center. Please be reminded that this badge does not allow access to other areas or buildings not open to the general public except those specifically outlined above.

24th LSPC Session Guide

March 15-19, 1993

Monday Morning, 8:30 a.m.
- Basaltic Achondrites
- A Geology of Venus: A Tribute to Valery Barsukov
- Solar System Origins
- Impact Cratering and Shock Metamorphism

Monday Afternoon, 1:30 p.m.
- Solar, Cosmic Ray, and Dynamical Studies (Session honors James R. Arnold)
- Venus Volcanism
- Manson: The Hole and Shocking Story

Monday Evening, 8:00 p.m.
Harold Masursky Lectures, Public Session, Bldg. 2 Auditorium

Tuesday Morning, 8:30 a.m.
- Primitive Achondrites
- Venus Resurfacing and Tectonics
- Chicxulub, K/T Boundary, and Other Impact Ejecta
- Remote Sensing/Space Weathering

Tuesday Afternoon, 1:30 p.m.
- Meteorites and Volatiles: A Session Honoring the Service of Don Bogard as PM & G Discipline Scientist
- Venus Gravity from Magellan and Mars Geophysics
- Large Impact Events: Theory and Observations, and Galileo Earth/Moon Results
- Martian Geomorphology

Tuesday Evening, 7:00-9:00 p.m.
Poster Session I, Lunar and Planetary Institute

Wednesday Morning, 8:30 a.m.
- Interplanetary Dust: Laboratory Studies and Results from Spacecraft
- Martian Surface Mineralogy and Spectroscopy
- Rocks: From the Highlands to the Maria to Antarctica

Wednesday Afternoon, 1:30 p.m.
- Ordinary and Enstatite Chondrites
- Mars: Tectonism and Volcanism
- Lunar Volcanic Glasses and Regolith

5:00 COMPLEX Plenary: Integrated Strategy for Planetary and Lunar Exploration from 1995-2010

Wednesday Evening 6:00-9:30 p.m.
Conference Social, Landolt Pavilion

Thursday Morning, 8:30 a.m.
- Carbonaceous Chondrites and Chondrules
- Mars: Surface and Atmospheric Processes
- Lunar Geology
- Asteroid and Planetary Core Formation and Metal-rich Meteorites

Thursday Afternoon, 1:30 p.m.
- Stars, Stardust, and Isotope Anomalies
- Outer Solar System
- Future Lunar Exploration

5:30 NASA Program Managers' Meeting

Thursday Evening 7:00-9:00 p.m.
Poster Session II - Lunar and Planetary Institute

Friday Morning, 8:30 a.m.
- CAIs and Heat Sources for Chondrule/CAI Melting
- Comets and Asteroids
- Educating Young People in Earth and Planetary Sciences

Meetings and Special Events

As the Conference takes shape in late January, we take this opportunity to list some of the meetings and special events planned for LPSC 24. Some of the details may change and new activities may be added between Bulletin press time and the Conference.

Poster Sessions
Poster Sessions I and II will be held on Tuesday and Thursday evenings from 7:00-9:00 p.m. in the Great Room at LPI. Poster authors will be on hand to discuss
Conference Program and Short Abstracts On Line

The LPSC Program with short abstracts will be accessible electronically on or about February 5 via the NASA Science Internet (NSI) or by direct dial.

- On NSI/DECNET (SPAN), type SET HOST LPI.
- On NSI/Internet, type TELNET LPI.JSC.NASA.GOV or TELNET 192.101.147.11.
- To dial direct, call 713-244-2090 or 713-244-2091. These are new modem numbers and will connect to 2400 or 1200 baud.

For all three methods of access, respond to USERNAME: LPI. No password is necessary. Choose LPSC Conference Program from the menu.

If you have difficulty in accessing the LPI computer, please contact Kinpong Leung at 713-486-2165 (LPI::LEUNG on NSI/DECNET or Leung@lpi.jsc.nasa.gov on NSI/Internet) or Lorraine Willett at 713-486-2194 (LLFISHER on NASAMAIL).

their presentations with other attendees and complimentary keg beer and soft drinks will be served during these sessions.

Displays, Demos, and Exhibits

The on-line and remote access capabilities of the interrelated database systems in use at LPI will be displayed throughout the week at the LPI facility at 3600 Bay Area Boulevard. Shuttle buses will be provided to transport attendees to and from the Gilruth Center; travel time is about 10 minutes.

The Washington University-based Geosciences Node of the Planetary Data System will demonstrate an electronic catalog of Magellan data products. The catalog will allow searches by geographic location, feature, orbit, and product, and will enable the user to place orders for Magellan MIDR, GxDR, ARCDR, and F-BIDR products.

The Combined Publishers Exhibit will be on display at the LPI throughout the week.

Session Chair’s breakfast Meetings will be held in the Club Room, Gilruth Center, 7:45–8:15 a.m., Monday through Friday.

Monday—March 15

The Hal Masursky Lectures will be open to the public at 8:00 p.m. in the Building 2 Auditorium, JSC.

Tuesday—March 16

Poster Session I will be held in the Great Room, LPI, from 7:00–9:00 p.m.

Wednesday—March 17

The JSC Astronomy Seminar will present “Fast Terraforming of Mars” by Jim Oberg at noon in Building 31, Room 129.

The Annual Barbeque Dinner for all registrants will be held at Landolt Pavilion. Guest tickets will be sold at the registration desk.

Thursday—March 18

Poster Session II will be held in the Great Room, LPI, from 7:00–9:00 p.m.

RECYCLING

For the first time, participants who normally discard the bulky abstract volumes after the meeting will have the opportunity to recycle them. Look for notices directing you to the recycling station at the Conference...

LUNAR AND PLANETARY INFORMATION BULLETIN 3
GALILEO:

EARTH-MOON ENCOUNTER

MOON—
This false-color composite (reproduced here in black and white) of 15 images of the Moon was taken through 3 color filters by the Galileo spacecraft Solid State Imaging system during its flyby through the Earth-Moon system on December 7, 1992. This view was obtained while the spacecraft was 425,000 km from the Moon and 69,000 km from Earth.

MOON—
This false-color mosaic (reproduced here in black and white) was constructed from a series of 53 images taken through 3 spectral filters by Galileo’s imaging system as the spacecraft flew over the northern regions of the Moon on December 7, 1992. The lunar nearside is to the left in this view. In color, the mosaic clarifies compositional variations in the Moon’s northern hemisphere.
AFRICA AND ARABIA—
This image (reproduced here in black and white from a color view) of northeast Africa and Arabia was taken from an altitude of about 500,000 km by Galileo on December 9, 1992, as it left the Earth’s vicinity for Jupiter. Most of Egypt (center left) including the Nile Valley, the Red Sea (slightly above center), Israel, Jordan, and the Arabian Peninsula are cloud-free. In the center, below the cloud on the coast, is Khartoum at the confluence of the Blue and White Niles. Somalia (lower right) is mostly cloud-covered.

ANDES, SOUTH AMERICA—
This false-color mosaic (reproduced here in black and white) of the central part of the Andes mountains (70°W, 19°S) is made up of 42 images taken by Galileo from an altitude of 25,000 km. A combination of visible and near-infrared filters was used to distinguish regions with different vegetation and soil types. The mosaic covers the area where Chile, Peru, and Bolivia meet. (North is to the left and the Pacific coast is in the foreground.) Lakes Titicaca and Poopo are the dark patches left and right. A larger lighter area below and left of Poopo is Salar de Uyuni, a dry salt lake 120 km across. The lakes lie in the Altiplano, the region between the eastern and western Andes, which are cloud-covered.
A REVIEW

SOLAR SYSTEM EVOLUTION
A NEW PERSPECTIVE

By Stuart Ross Taylor
Black and white illustrations and photographs. Hardcover, $49.95

This recently published book by S. Ross Taylor, entitled Solar System Evolution and subtitled, A New Perspective, is a thoughtful and informative discourse on the subject. It is written from a perspective that reflects the acknowledged maturation of planetary science, and the merging of research activities in planetary science with research in astronomy and astrophysics on the one hand, and life science on the other (partial motivation for the subtitle for the book). It is also written from a perspective that proclaims the solar system to be unique in the universe, mainly because so many of the specific details of the system are a consequence of "chance events," notably impacts between objects of considerable size (several to thousands of kilometers in diameter) during the evolution of the solar system (also motivation for the subtitle). The book, as with any undertaking of this breadth, has strengths and weaknesses. Many of these are recognized and acknowledged by the author in the Preface.

The literature cited is from pre-April 1990, so students of the subject should not expect, for example, to see discussions of putative planetary systems associated with pulsars. The bibliography is extensive, with emphasis upon relatively recent reviews in many subject areas covered by the book. My only complaint about the bibliography is that it is often difficult, or impossible because the key references are not given, for a reader to discern where the seeds of key concepts first appeared. This is important, as the author himself points out, so that one can judge critically the firmness of the foundation underlying these concepts. This is probably a consequence of the heavy dependence on recent review publications, and on the breadth of the subjects treated in the volume.

The author is to be congratulated for his recognition of the growth of interest and activity directed at placing the solar system in the context of other planetary systems. His emphasis on the role of impacts in shaping the solar system is also to be lauded (this is the first book on solar system evolution that I am aware of that devotes an entire chapter to the role of impacts). The chapter on impacts is readable, and for one not familiar with the topic it provides a sense of why recognition of the significance of this process has had such a profound effect on current thinking not only on the evolution of the solar system, but the past and future evolution of life on this planet.

The story line of the book is reasonably tight. It progresses through the subject in a somewhat unusual, but useful, fashion. There are slight, occasionally awkward, digressions into topics that, while interesting in their own right, seem somewhat out of place here (e.g., discussions on the origins of galaxies and the comparison of galactic collisions with continental drift). Most of these appear in the early chapters where the subject matter is least familiar to the author, and they are minor.

My major difficulty with the tone of the book is that while, as noted above, it recognizes the significance of other planetary systems to students of this planetary system, and it emphasizes the role of impacts in the evolution of the solar system, it then places too much weight on the notion that the solar system is unique and imparts a sense that its counterpart will not be found in nature. What disturbs me about this view is that while it is probably true that an exact replica of the solar system does not exist, the message is that there are no defining prototypical attributes of planetary systems.
that one should seek to discern either in studies of this planetary system or of any other system. For example, the author states on page 288 that the “Division into terrestrial and giant planets is as unlikely to be repeated as is the course of the evolution of life on this planet.” If this view were correct, then the study of the origin of the solar system is removed from the realm of scientific inquiry. I do not believe that such is the case, and one can in fact attempt to identify generic aspects of planetary systems through a study of our own and then test that through observations. It may turn out that the author is correct regarding this view of planetary systems, but there is no firm basis to assume so at this time, and it seems to be inconsistent with his own recognition of the likelihood of planetary systems elsewhere.

I found the book to be a readable and good introduction to most of the key issues and phenomena that are thought to have played an important role in the evolution of the solar system. It should be a useful resource for students and newcomers to the subject.

—David C. Black

*(Dr. Black is Director of the Lunar and Planetary Institute)*

**ELECTRONIC PICTUREBOOKS—A NEW WAY TO LEARN ABOUT ASTRONOMY AND PLANETARY SCIENCE**

As a teacher, would you want to assign your class to read an entire book on a computer screen? Sounds a bit unlikely—until you discover ExInEd’s* new electronic PictureBooks! Intended as educational aids for learning about astronomy and Earth and planetary sciences, ExInEd PictureBooks combine the benefits of traditional books with the flexibility and interactivity of electronic data. They can include full color, audio, and full-motion video. Great educational tools, the PictureBooks are built on Hypercard stacks and designed to run on a Macintosh computer with HyperCard 2.1 and QuickTime 1.5, both of which require system software version 7.0 or above. In the future, they will be available on the PC platform as well.

ExInEd’s electronic PictureBooks are part of a NASA-funded experiment to discover and develop new and better ways to assemble and distribute the results of astronomy and planetary science research, particularly images. Each PictureBook contains a tutorial, text, color images, maps (as appropriate), and a glossary, as well as instructions on how to navigate through the exciting material it contains. For each PictureBook, a teacher’s guide, recommended student activities, background material, and associated fact sheets are also available for classroom use. Because the PictureBooks rely heavily on visual imagery, the reading level for each book is largely determined by which of these associated materials the teacher chooses to use with it.

Two PictureBooks are currently available to the public. *The HST’s Greatest Hits* PictureBook spotlights some of the most spectacular and informative images taken with the scientific instruments of the Hubble Space Telescope (HST) during its first year of operation. Created from an existing slide set distributed by the Space Telescope Science Institute in Baltimore, Maryland, the PictureBook contains a selection of 24 images that represent new data and highlight the new theories about phenomena such as gravitational lenses and black holes now being developed as a consequence of these HST

*ExInEd (Exploration in Education) is a program of the Special Studies Office of the Space Telescope Science Institute.*
images. *Magellan at Venus*, the second PictureBook now being distributed, surveys some of the most exciting results of Magellan, a NASA spacecraft sent to map the surface of Venus with imaging radar. The PictureBook was created from an existing slide set distributed by the Jet Propulsion Laboratory in Pasadena, California. Both PictureBooks are available on GENIE and America On Line (using keyword “ExInEd”). Other distribution means, including CD-ROM and Internet, are also being explored.

Additional ExInEd PictureBooks available soon to the public include:

- **6.5-Meter Mirror Casting**, which describes the successful casting of a 6.5-meter borosilicate honeycomb telescope mirror by the Steward Observatory Mirror Laboratory;
- **Terrestrial Impact Craters**, a presentation of orbital and aerial photographic views of proven or suspected impact structures on Earth from an existing Lunar and Planetary Institute slide set;
- **Science From New Worlds**, a survey of recent planetary exploration from a slide set produced by NASA’s Solar System Exploration Division;
- **Earth from Orbit**, a collection of shuttle pictures of the Earth taken by NASA Astronaut Jay Apt, including his personal interpretations of these Earth views...

...and many more in 1993!

**FROM THE ASTRONOMICAL SOCIETY OF THE PACIFIC**

**“WORLDS IN COMPARISON” SLIDE AND ACTIVITY KIT**

An updated set of 20 slides contrasting the sizes of worlds and geologic features in the solar system is available from the A.S.P. Designed by former NASA Visual Information Specialist Stephan Meszaros, the slides use the best spacecraft and radar images to give the viewer a cosmic sense of scale. They include the Earth projected on (and dwarfed by) Jupiter’s Red Spot and Saturn’s rings; an outline map of the U.S. superimposed on the “Grand Canyon” of Mars; a comparison of volcanos on Earth, Mars, and Jupiter’s moon, Io; and the Earth’s Moon compared to Neptune’s icy satellite, Triton.

The slide set comes in a protective display folder with a 20-page guide that features detailed captions, introductory tables giving the main characteristics of all known planets and moons in the solar system, an up-to-date summary of all U.S. and Soviet planetary missions, several pages of classroom or home activities and projects, and a thorough, nontechnical reading list. $29.95 from A.S.P., Worlds Slide Set Dept., 390 Ashton Avenue, San Francisco CA 94112.
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Researchers Use HST to Examine Ancient Galaxies

A "HUBBLE ATLAS" OF ANCIENT GALAXIES—

Hubble Space Telescope's high resolution allows astronomers to classify galaxies in a cluster (CL 0939+4713) that existed four billion years ago, when the universe was two-thirds of its present age.

The galaxies in this mosaic are arranged according to the well-established system developed by American astronomer Edwin Hubble in the 1920s. The top three rows show familiar types of galaxies found today in nearby clusters: elliptical galaxies and lens-shaped galaxies (S0, or S-zero) that may be transition objects between spiral and elliptical galaxies. Rows 4 through 7 show spiral galaxies categorized by the openness of their pinwheel-shaped arms (Hubble classification Sa, Sb, Sc, Sd). Many of these have since disappeared. In particular the spirals in row 7 (Sd) show peculiar morphologies. The bottom row shows galaxies apparently merging into single systems.

Space Telescope reveals that star-forming galaxies were far more prevalent in the clusters of the younger universe than in modern clusters, a result having important implications for theories of galaxy evolution. The image was taken with HST's Wide Field/Planetary Camera in Wide Field Camera mode, and required a six-hour exposure.

PHOTO CREDIT: ALAN DRESSLER, CARNegie INSTITUTION, AND NASA CO-INVESTIGATORS: AUGUSTUS OESLER (TALE UNIVERSITY), JAMES E. GUNN (PRINCETON UNIVERSITY), HARVEY BUTCHER (THE NETHERLANDS FOUNDATION FOR RESEARCH IN ASTRONOMY).
Looking back in time, the Hubble Space Telescope (HST) has found some suspected ancestors of today's galaxies. The pictures reveal that star-forming galaxies were far more prevalent in the clusters of the younger universe than in modern clusters of galaxies near us today. The results have important implications for theories of how galaxies have evolved since the beginning of the universe 15 billion years ago.

Serendipitously, the Hubble observations might have also discovered the most distant galaxy cluster yet seen. The cluster might be as far away as ten billion light years, at a “look-back” time corresponding to the early epoch of galaxy formation. The research was carried out by Drs. Alan Dressler of Carnegie Institution, Augustus Oemler of Yale University, James E. Gunn of Princeton University, and Harvey Butcher of the Netherlands Foundation for Research in Astronomy.

A principal goal for the Hubble Space Telescope is to trace galaxy evolution through direct observations. This is very difficult to achieve with ground-based telescopes because the tiny images of distant galaxies smear into faint blurs when viewed through Earth’s atmosphere.

Hubble images of a pair of remote clusters of galaxies located four billion light years away allow astronomers to distinguish, for the first time, the shapes of galaxies that existed long ago.

The pictures, taken with the Wide Field/Planetary Camera (in Wide Field Camera mode), are so detailed they show a full range of galaxy types inhabiting the universe of four billion years ago: elliptical, spiral, distorted, and irregular forms. The images also reveal galaxies in collision. Some are tearing material from each other; others are merging into single systems.

Dressler said the pictures are sharp enough to distinguish between various forms of spiral galaxies, whose distinctive swirl patterns are outlined by vigorous star formation. “This shows us that clusters billions of years ago contained not only the elliptical and SO galaxies (S-zero, lens-shaped featureless galaxies that may be the transition between spiral and elliptical) like those dominating their descendant clusters today, but also several times as many spiral galaxies.”

THE CASE OF THE DISAPPEARING GALAXIES

“The new Hubble data are the first unambiguous sign of the influence of environment on the form of a galaxy,” said Dressler. “Clearly, spirals were common in clusters in the distant past, but they have largely disappeared or changed form by now. What has been responsible for their demise?”

Based on the HST pictures and the results of earlier research with ground-based telescopes, the team thinks that the rapid decline in the spiral population can be explained by three mechanisms: merger, disruption, and fading.

HST reveals many examples of strong galaxy interactions or mergers in one of the clusters. This is evident by the presence of “tails” distorting the shapes of some galaxies. The tails are probably caused by tidal effects where the close gravitational pull between bypassing galaxies will stretch and disrupt their stellar distributions.

The result is that many ancient spirals might have merged to form giant elliptical galaxies (as proposed by MIT's Alar Toomre and Carnegie’s Francois.
THE FARTHEST CLUSTER OF GALAXIES EVER SEEN?

This image reveals one of the faintest and probably most distant clusters of galaxies ever seen. The cluster contains about 30 very faint objects that are unusually small and compact in appearance. (The larger objects are foreground galaxies located in a separate galaxy cluster four billion light years away.) These lumpy spots do not appear to resemble the elliptical and spiral galaxies of today. The objects might not be separate galaxies but rather sites of strong star formation embedded within primordial galaxies that are too faint to be seen in this HST exposure.

The colors of these objects (measured with the Mount Palomar 200-inch telescope) place the cluster at a distance of at least seven billion light years (redshift $z > 1$). The cluster may be even farther if it is associated with a quasar (located near the left edge of the frame) that has a measured distance of ten billion light years (redshift $z = 2.055$). Though the superposition of the cluster objects and the quasar could be a coincidence, both are so unusual they probably all are members of the same cluster, at the same distance. If so, then this corresponds to the early epoch of galaxy formation, about ten billion years ago.

The image was taken with HST’s Wide Field/Planetary Camera in Wide Field Camera mode, and required a six-hour exposure.

PHOTO CREDIT: ALAN DRESSLER, CARNEGIE INSTITUTION, AND NASA CO-INVESTIGATORS AUGUSTUS DEMLER (YALE UNIVERSITY), JAMES E. GUNN (PRINCETON UNIVERSITY), AND HARVEY BUTCHER (THE NETHERLANDS FOUNDATION FOR RESEARCH IN ASTRONOMY).

Though the superposition of the cluster objects and the quasar could be a coincidence, both are so unusual that there is good reason to believe that all are members of the same cluster, at the same distance” said Dressler. The bright spots that appear to accompany the quasar do not resemble the elliptical and spiral galaxies of today, according to Dressler. “Conceivably, the objects might not be separate galaxies but rather ‘hot spots’ in galaxies whose full, extended forms are too faint to be seen in the Hubble observations.”

continued on page 20

LUNAR AND PLANETARY INFORMATION BULLETIN 13
TO THE MOON AND GEOGRAPHOS: The SDIO-NASA Clementine Mission

Clementine is a mission designed to test the space-worthiness of a variety of advanced sensors for use on military surveillance satellites. Conducted jointly by the Strategic Defense Initiative Organization and NASA, Clementine will be sent for an extended stay in the vicinity of Earth's Moon and on a flyby of the Apollo asteroid, 1620 Geographos. Thus, we are about to receive an unexpected bounty of planetary data through a serendipitous alignment of disparate technical objectives of both SDIO and NASA.

By Paul D. Spudis

The entire Clementine project, from conception through end-of-mission, will encompass approximately three years. The spacecraft and sensors are being assembled now, aiming for a late January 1994 launch. About two months will be spent mapping the Moon before the spacecraft is sent on an encounter trajectory to Geographos, an S-class near-Earth asteroid. The asteroid flyby will occur in late August 1994.

Clementine is a small (140 kg), 3-axis stabilized spacecraft that will carry a variety of advanced sensors spanning several wavelengths. A UV-VIS camera covers the spectrum from 0.25 to 1.0 micrometers (µm). It is a CCD framing imager that contains a six-position filter wheel; selected filters have bands centered at 0.34, 0.415, 0.75, 0.9, 0.95 and 1.0 µm. A near-IR CCD imager covers the spectrum from 1.0 to 5.5 µm, with six filters at 1.1, 1.25, 1.50, 2.0, 2.6, and 2.78 µm. Collectively, these two instruments make up a 12-channel imaging spectrometer that will map the surface composition of the Moon and Geographos.

In addition to such compositional data, Clementine also carries an imaging LIDAR, which will be operated as both a high-resolution, multicolor imager (typical resolution about 6-10 m/pixel) and as a laser altimeter, if feasible (the Clementine orbit is at the extreme limits of a laser ranging capability). Finally, a broadband, mid-IR imager (5-9 µm) will obtain selected images of the Moon at a resolution of about 20 m/pixel.

Clementine will be launched on a Titan II booster from the Air Force Vandenberg Launch Facility in late January 1994. After a day or so in Earth orbit, its kick motor will send Clementine to the Moon via two highly eccentric "phasing orbits," each having apogee near the lunar orbital distance; this "slow boat" route to the Moon gives Clementine a seven-day launch window, while at the same time lowers total delta-V requirements for lunar orbit insertion. Clementine will go into polar lunar orbit (about 400 by 8300 km) one month after launch. For the first month, perilune occurs near 30°S latitude; a phasing burn moves the perilune point to 30°N latitude for the second month's mapping. In two months of mapping, Clementine will image the entire Moon in 12 spectral bands...
bands and, with luck, obtain laser-ranging altimetric data for the middle latitudes of the Moon, from 30°N to 30°S latitude.

After mapping the Moon, Clementine will depart for a flyby of the asteroid 1620 Geographos on May 3, 1994. After another eccentric “phasing” orbit around the Earth and a lunar gravity assist, Clementine will inject into the Geographos encounter orbit on May 27, 1994. Ninety-six days later, on August 31, 1994, while Clementine is 8.5 million km from Earth, the spacecraft will fly less than 100 km from the asteroid, obtaining multichannel spectral data and high-resolution images (as good as 1 m/pixel for selected areas). End-of-mission occurs after the spacecraft has transmitted its flyby data.

The pressing need for global mapping of the Moon, by a variety of remote-sensing techniques, has been stressed repeatedly in every lunar science report for the last 20 years. The Clementine mission begins this task. The Clementine mission will allow us to construct a global digital image model (DIM) of the Moon. These data are augmented by (1) a set of topographic profiles (depending upon the efficacy of the ranging laser, topographic coverage may be nearly complete for the middle latitude band (± 60°) of the Moon); and (2) a geodetic control net for the whole Moon that, when tied to the Apollo data, should permit knowledge of the true positions of lunar surface features in inertial space to within a few hundred meters. Maps of the Moon made from Clementine data will enable studies of regional history and permit us to decipher the processes of volcanism, tectonism, and impact that have shaped lunar history. In a supporting mode, the global DIM will serve as a base to overlay other data; the geological context of the multispectral data must be understood to interpret such data properly.

From the combined visible and near-IR cameras, we will have a global color map that we can interpret in terms of the distribution of rock types. At a minimum, we will be able to recognize and discriminate between the absence of mafic minerals (pure feldspar) and the presence of orthopyroxene, clinopyroxene, and olivine, as has been done for the nearside of the Moon from Earth-based data.

Thus, we can distinguish, on a global basis, the distribution of anorthosite, “noritic” rocks, olivine-bearing rocks (dunites and troctolites), and gabbros. For mafic deposits, visible color mapping can classify the mare in terms of Ti abundance, an element that can be used to estimate the distribution of solar wind hydrogen, an important lunar resource.

Combined with our knowledge of cratering and the use of basins as probes of the crust, these data will permit us to reconstruct the composition and petrologic structure of the crust in three dimensions. We can address the question of the existence of a magma ocean, the nature of Mg-suite magmatism, the history and extent of ancient KREEP and mare volcanism, the compositional diversity of mare units, and the effects of cratering on the composition of the lunar surface. Topographic data from the LIDAR ranger combined with spectral information will allow us to model and understand the dynamics of large impacts, e.g., the problem of depth of excavation for basin-sized impacts.

With high-resolution data from the LIDAR imager, we can study surface processes and compositions in greater detail. Many mare units display significant heterogeneity, and color imaging from the Clementine LIDAR can map different color units, some of which are perhaps related to individual mare flows. Images of crater walls and central peaks can not only provide high-resolution compositional data, but permit us to better understand the geological setting and processes that have affected given regions, information that may prove critical to the proper interpretation of the regional compositional information. Finally, the high-resolution imaging can be used to make detailed geological studies of areas of high scientific interest.

The Clementine mission will provide us with an abundance of information about the surface morphology, topography, and composition of both the Moon and Geographos, permitting us to infer their history and the processes that have shaped that history. This information can be used to address fundamental questions in lunar science and allow us to make significant advances toward deciphering the complex story of the Moon. The Clementine mission will also permit a first-order global assessment of the resources of the Moon and provide a strategic base of knowledge upon which future robotic and human missions to the Moon can build.

(Dr. Spudis is a staff scientist at Lunar and Planetary Institute, Houston)
DANTE DEMONSTRATES THE DIFFICULTY OF ROBOTIC EXPLORATION

At 5:10 p.m. EST Saturday, January 2, the Erebus project team located on the ice at the foot of the Mt. Erebus volcano in Antarctica called off any further exploration by the 8-legged rappelling robot Dante because of a physical break in the fiber optical cable that connects the robot with the computers providing its machine intelligence.

The team reported the results of a day's troubleshooting during a video conference that included their colleagues located at the remote robot control site at the Goddard Space Flight Center. The conference was called following a series of seemingly minor problems that had cropped up during two days of attempts to deploy the robot down the 750-foot, nearly vertical incline, from the rim of the continuously active volcano to the lava lake below.

When the team called off further mission operations, the robot Dante remained suspended approximately 21 feet below the rim of the crater. Having been successfully launched on January 1, Dante had moved the 21 feet on its own during initial testing of the robot control mechanisms and had been halted by what, at the time, seemed to be computer network problems.

The team reported that further troubleshooting of the computer network problem disclosed kinks in the fiber optical cable connecting sensors and motor mechanisms of the robot with the computer systems that provide Dante with depth perception and a self-navigating capability. While examining the fiber optical cable kinks, the team caused a break that severed all communications between the robot and the controlling computers. Dave Lavery, project supervisor and NASA telerobotic program manager, reported, "By late in the afternoon, the problem had been isolated to the fiber optic cable, which stretches between the robot and the control station two kilometers away. It was found that the passive deployment system which releases the fiber from the robot as it walks had formed multiple kinks in the fiber which had reduced data communications to the robot. At 1955 hours, while the team was removing the fiber optic cable from the deployment mechanism, the fiber was severed entirely, cutting off all communications with the robot. Without integrity in this cable, the robot cannot operate."

One of the considerations in the decision to call off the demonstration project was the time period remaining until they must leave the side of the volcano. By January 15 the team must be back at McMurdo Station because of impending ice-up of the Ross Sea and a worsening of general weather conditions. This time constraint had existed all along but became of higher importance when the break in the fiber optical cable occurred.

The team indicated they had contacted McMurdo Station and determined that a replacement fiber cable was not available, nor were connectors for this type of cable that might have allowed for a repair operation of this cable. The supporting team at the Goddard payload operations control center was able to find a supplier for identical cable but could not guarantee delivery of that cable to the Antarctic in time to make the repair, perform the rest of the descent down into the volcano, and still get the robot back up to the top and pack everything up in time to depart on January 15.

Lavery said that the team considered the project an "unqualified success" in one of the three primary objectives, that of testing the remote control of a robot. The Carnegie-Mellon University team located at Goddard had successfully commanded the Dante robot the previous day while the robot was poised at the rim awaiting its deployment into the volcano crater.
The robot demonstration project had three objectives: to test telerobotic capabilities, to test the use of such sophisticated hardware in a very harsh and demanding environment, and to test the use of advanced computer programs that would enable machines such as the Dante robot to act under a form of machine intelligence. According to Lavery, the first two objectives of this experiment were met. The robot never got to a point where it was under operation of its own autonomous control systems.

NASA and the National Science Foundation undertook this demonstration project to develop technology and telecommunications capabilities that NASA could use in future explorations of the Moon or Mars and that NSF might apply to its ongoing research activities in the Antarctic. Part of the project involved transferring control of the robot from the Mt. Erebus team to team members located at the Goddard payload control center. This portion tested the "telepresence" capabilities of such robots and was called an unqualified success.

Carnegie-Mellon University and the New Mexico Institute of Mining and Technology are partners with NASA and the NSF as robotics and volcano experimenters for this project. Team members from Carnegie-Mellon were located both in the Antarctic and at Goddard. New Mexico Tech members were at Mt. Erebus. The robot included six different sensors that were to have provided significant and new data about the physical and chemical composition of gases and aerosols being released into the atmosphere by the Mt. Erebus volcano.

JAN HENDRIK OORT, APRIL 28, 1900–NOVEMBER 5, 1992

The Leiden Observatory announced the death of longtime staff member and former director Jan Oort in November. "Jan Oort played a crucial role in twentieth century astronomy. His name is forever linked to the Oort cloud of comets and to the Oort constants of galactic rotation. Not only did he make fundamental contributions to science, but he was one of the fathers of radio astronomy, which, as he foresaw, has indeed turned out to be essential for probing the universe. He was the founder and first director (1949–1970) of the Netherlands Foundation for Radio Astronomy (now Astron) and instigated construction of the Dwingeloo 25-meter telescope and the Westerbork Synthesis Radio Telescope.

His strong inner conviction of the need for international collaboration is reflected in his career: he was General Secretary of the International Astronomical Union (IAU) from 1935–1948, during the difficult period when the Netherlands were occupied territory during the Second World War. From 1958–1961 he was president of the IAU. In 1953–1954, he was one of the founders of the European Southern Observatory. In addition he strongly advocated the merging of national astronomical journals into the European journal, *Astronomy and Astrophysics*.

Jan Oort was the recipient of many honors and prestigious prizes. Yet, with all his achievements, he remained an essentially modest man, driven by an intense curiosity about how the universe functions and why.”
FEBRUARY

28-Mar 5

MARCH

9-10

15-19

APRIL

1-3
Fractals and Dynamic Systems in Geosciences international meeting, Frankfurt/Main, Germany. Contact: Jorn H. Kruhl, Geology-Paleontology Institute, JW Goethe-University, Senckenberganlage 32, D-6000 Frankfurt/Main, Germany. Phone: 0049-69-7982695; FAX: 0049-69-7988383.

1-4

4-8
25th International Symposium on Remote Sensing and Global Environmental Change, Graz, Austria. Contact: Nancy Wallman, ERIM Symposium, P.O. Box 134001, Ann Arbor MI 48113-4001. Phone: 313-994-1200, ext. 3234; FAX: 313-994-5123.

5-8

15-16
Science and Technology Policy Meeting, Washington, DC. Contact: American Association for the Advancement of Science, 1333 H Street NW, Washington DC 20005. Phone: 202-326-6400.

APRIL (CONTINUED)

21-25
Geoscience Education and Training, Southampton, UK. Contact: Esther Johnson, GEOED Conference Secretariat, University of Southampton, Southampton S09 5NH, UK. Phone: (0703) 593049; FAX: (0703) 593052; telex: 47662 SOTONU G.

23-26

28-30
Advanced Technologies for Planetary Instruments, Fairfax, Virginia. Contact: Program Services Department, LPI, 3600 Bay Area Boulevard, Houston TX 77058-1113. Phone 713-486-2150; FAX: 713-486-2160.

MAY

15-17
Workshop on the Analysis of Interplanetary Dust Particles, Houston, Texas. Contact: Program Services Department, LPI, 3600 Bay Area Boulevard, Houston TX 77058-1113. Phone: 713-486-2150; FAX: 713-486-2160.

17-19

JUNE

6-9

8-10

14-18
Asteroids, Comets, Meteors 1993, Beligrar (Novara), Italy. Contact: Vincenzo Zappala, Astronomical Observatory, Strada Observatorio 20, 10025 Pino Torinese (70), Italy, or Program Services Department, LPI,
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<th>JUNE (CONTINUED)</th>
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<td>MSATI Workshop on Atmospheric Transport on Mars, Corvallis, Oregon. Contact: Program Services Department, LPI, 3600 Bay Area Boulevard, Houston TX 77058-1113. Phone: 713-486-2150; FAX: 713-486-2160.</td>
<td>56th Meteoritical Society Meeting, Vail, Colorado. Contact: Program Services Department, LPI, 3600 Bay Area Boulevard, Houston TX 77058-1113. Phone: 713-486-2150; FAX: 713-486-2160.</td>
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<td>The Universe in the Classroom: A Workshop on Teaching Astronomy in Grades 3-12, San Diego, California. Contact: Meeting Information,</td>
<td>25-Oct 1 International Association of Volcanology and Chemistry of the Earth's Interior General Assembly, Canberra, Australia. Contact: IAVCEI ACTS, GPO Box 2200, Canberra ACT 2601, Australia. Phone: 61-6-257-3299; FAX: 61-6-257-3256.</td>
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**CALENDAR**

**OCTOBER**

18-22

25-28

**NOVEMBER**

15-17
MSATT Conference—Mars: Past, Present, and Future Results from the MSATT Program, Houston, Texas. Contact: Program Services Department, LPI, 3600 Bay Area Boulevard, Houston TX 77058-1113. Phone: 713-486-2150; FAX: 713-486-2160.

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Continued from page 13

Dressler suggested that the small spots seen in the more distant cluster could be sites of vigorous star formation. This would explain their blue colors, because young, massive stars are brightest in blue and ultraviolet light. "If the cluster is as far as the quasar, then it will offer an unprecedented opportunity to learn how galaxies formed. With so many objects, it seems likely that among them are the ancestors of common galaxies like our own Milky Way."

The team believes that the further study of this cluster and similar ones could be a major breakthrough in seeing galaxies in the very act of formation. When HST's full optical capabilities are restored during a Space Shuttle servicing mission in late 1993, HST will be able to resolve the morphology of these very young galaxies. Hubble will be capable of showing the evolution of galaxy form over a wide range of environments and in even earlier epochs. This will greatly aid astronomers in their efforts to understand this key piece of the cosmological puzzle.

**THE MYSTERY OF GALAXY EVOLUTION**

Astronomers have long sought to understand the origins of the different forms of galaxies, from the disk-shaped spiral galaxies with their lacy pattern of newborn stars, to the bulbous elliptical galaxies, which seem to have completed star formation long ago.

In the 1770s French astronomer Charles Messier first included galaxies in his sky catalog of "fuzzy-looking" objects. Their true nature wasn't known, however, until the 1920s. Edwin Hubble, using a telescope of comparable size to HST, was able to measure the vast distances to nearby "spiral nebulae." This proved they were "island universes" far separated in time and space. Edwin Hubble first attempted to classify galaxies according to their spiral and elliptical shapes and look for an evolutionary track.

In the 1960s a number of remarkable discoveries—quasars, active galaxies, and confirmation of the Big Bang by the detection of the cosmic microwave background—all converged to reinforce the notion that galaxies simply weren't made the way we see them today, but must have evolved into their present shapes.

In 1978 H. Butcher and A. Oemler surprised the astronomical community when they discovered that distant clusters contained a high percentage of blue galaxies, the color associated with the birth of new stars in spiral galaxies. In contrast, nearby "modern" clusters of galaxies are dominated by elliptical and S0 galaxies, objects whose red colors indicate a long absence of star formation.

Were there more spiral galaxies in clusters billions of years ago? Dressler and Gunn pursued this question in a ten-year program with the 200-inch telescope at Caltech's Palomar Observatory, California. They took spectra of the faint blue galaxies and showed that most did show signs of vigorous star formation. The Hubble Space Telescope now provides an unprecedented opportunity to directly observe the birth of galaxies.
Twenty-Fourth
Lunar and Planetary
Science Conference

Preliminary Program
March 15-19
Monday, March 15, 1993

THE GEOLOGY OF VENUS: A TRIBUTE TO ACADEMICIAN
VALERY LEONIDOVICH BARSUKOV
8:30 a.m. Room B

Co-sponsored by:
International Union of Geological Sciences
Commission on Comparative Planetology

The field of planetary science and solar system exploration lost a dear friend and invaluable colleague with the untimely death of Academician Valery Leonidovich Barsukov in July 1992. Academician Barsukov had achieved many of the highest scientific honors in the Soviet Union and Russia, and he was truly dedicated to international cooperation in scientific research and planetary exploration. During his career, Academician Barsukov's professional interests underwent a metamorphosis from the geochemistry of ore deposits, to the study of the metallogenic aspects of the Earth's mantle, and then to the geochemistry and geology of the planets and their satellites. As director of the V.I. Vernadsky Institute of Geochemistry and Analytical Chemistry in Moscow he actively participated in Soviet Union missions to the Moon, Venus, and Mars. In the latter part of his career, he developed another of his passionate interests, international cooperation in scientific research and planetary exploration. He was Vice-President of the International Union of Geological Sciences and was a well-known figure at the annual Lunar and Planetary Science Conference in Houston, where he often gave keynote papers on the latest Soviet planetary exploration achievements. Upon the renegotiation of a joint agreement between the United States and the Soviet Union in the mid 1980s he was named the Soviet Chair of the Joint Working Group on Solar System Exploration. Close friends of Academician Barsukov knew that the passion and intensity of his work extended into his personal life. His significant activities in international cooperation and his legendary guitar playing and singing of Russian folk songs made each of us who came in contact with him a little bit more Russian and a significantly better citizen of the scientific world. We will miss him greatly.

Chairs: J. W. Head III and R. S. Saunders

Saunders R. S.* Stefan E. R. Plaut J. J. Senske D. A.
Magellan at Venus: Summary of Science Findings

Senske D. A.* Stefan E. R. Bindschadler D. L. Smrekar S. E.
Volcanic Rises on Venus: Geology, Formation, and Sequence of Evolution

Turcotte D. L.*
Is There Uniformitarian or Catastrophic Tectonics on Venus?

Phillips R. J.* Hansen V. L.
Venus Magmatic and Tectonic Evolution

Hansen V. L.* Phillips R. J.
Ishar Deformed Belts: Evidence for Deformation from Below?

Marchenko K. I.* Saunders R. S. Banerdt W. B.
Geophysical Models of Western Aphrodite-Niobe Region: Venus
Grosfils E. B.* Head J. W. III
Spatially Extensive Uniform Stress Fields on Venus Inferred from Radial Dike Swarm Geometries: The Aphrodite Terra Example

Stefan E. R.* Hamilton V. E. Cotugno K.
*Parga and Hecate Chasmata, Venus: Structure, Volcanism and Models of Formation

Basilevsky A. T.*
Estimation of Age of Dali-Ganis Rifting and Associated Volcanic Activity, Venus

Robinson C. A.*
Subduction on the Margins of Coronae on Venus: Evidence from Radiothermal Emissivity Measurements

Brown C. D.* Grimm R. E.
Flexure and the Role of Inplane Force Around Coronae on Venus

Burt J. D.* Head J. W. III
Buoyant Subduction on Venus: Implications for Subduction Around Coronae

Monday, March 15, 1993
SOLAR SYSTEM ORIGINS
8:30 a.m. Room C

Chairs: E. H. Levy and T. Stepinski

Moore M. Ferrante R. Hudson R. Tanabe T. Nath J.*
Catalytic Crystallization of Ices by Small Silicate Smokes at Temperatures Less Than 20K

Cameron A. G. W.*
The Giant Impact Produced a Precipitated Moon

Humayun M.* Clayton R. N.
Potassium Isotope Cosmochemistry, Volatile Depletion and the Origin of the Earth

Stevenson D. J.*
Volatile Loss from Accreting Icy Protoplanets

Wasilewski P. J.* Faris J. L. O'Bryan M. V.
Magnetic Record in Chondrite Meteorites

Stepinski T. F. Reyes-Ruiz M.*
Magnetically Controlled Solar Nebula

Dolginov A. Z. Stepinski T. F.*
Are Cosmic Rays Effective for Ionization of the Solar Nebula?

Levy E. H.* Ruzmaikina T. V.
Possible Dust Contamination of the Early Solar System

Cassen P.*
Why Convection Heat Transport in the Solar Nebula was Inefficient

Boss A. P.*
Midplane Temperatures in the Solar Nebula

Weidenschilling S. J. Ruzmaikina T. V.*
Coagulation of Grains in Static and Collapsing Protostellar Clouds

Malhotra R.*
On the Delivery of Planetesimals to a Protoplanet in the Solar Nebula

Wetherill G. W.*
Variety in Planetary Systems
Monday, March 15, 1993
IMPACT CRATERING AND SHOCK METAMORPHISM
8:30 a.m. Room D

Chairs: M. B. Boslough and R. Bottomley

Holsapple K. A.*
The Size of Complex Craters

Takata T.* Aten T. J.
SPH Modelling of Energy Partitioning During Impacts on Venus

Schmidt R. M.*
Pressure Versus Drag Effects on Crater Site

Barnouin O. S.* Schultz P. H.
Behavior of Vortices Generated by an Advancing Ejecta Curtain in Theory, in the Laboratory, and on Mars

Crawford D. A.* Schultz P. H.
Macroscopic Electric Charge Separation During Hypervelocity Impacts: Potential Implications for Planetary Paleomagnetism

Fiske P. S.* Gratz A. J. Nellis W. J.
NMR Spectroscopy of Experimentally Shocked Single Crystal Quartz: A Reexamination of the NMR Shock Barometer

Boslough M. B.* Cygan R. T. Kirkpatrick R. J.
$^{29}$Si NMR Spectroscopy of Naturally Shocked Quartz from Meteor Crater, Arizona: Correlation to Kieffer's Classification Scheme

Spray J. G.*
Delimitation of Terrestrial Impact Craters via Pseudotachylitic Rock Distribution

Schultz P. H.* Bunch T. E. Koeberl C. Collins W.
Further Analyses of Rio Cuarto Impact Glass

Bottomley R. J.* York D. Grieve R. A. F.
Age of Popigai Impact Event Using the $^{40}$Ar-$^{39}$Ar Method

Brandt D.* Reimold W. U.
A Structural and Petrographic Investigation of the Pretoria Salt Pan Impact Structure

Koeberl C.* Shikes S. B.
Osmium Isotopes in Ivory Coast Tekittes: Confirmation of a Meteoric Component and Rhenium Depletion

Monday, March 15, 1993
SOLAR, COSMIC RAY, AND DYNAMICAL STUDIES

Session is dedicated to Professor James R. Arnold
in honor of his seventieth birthday.
1:30 p.m. Room A

Chairs: D. Black and R. C. Reedy

SCR $^{21}$Ne and $^{39}$Ar in Lunar Rock 68815: The Solar Proton Energy Spectrum over the Past 2 Myr

Rao M. N.* Garrison D. H. Bogard D. D.
SCR Neon and Argon in Kappa Feldspar: Evidence for an Active Ancient Sun

Wieter R.* Baur H. Signer P.
A Long-Term Change of the Arikrie Fracation in the Solar Corpuscular Radiation

Juli A. J. T. Donahue D. J.
Cosmogenic-Radiocarbon Profiles in Knyalynthia: New Measurements and Models

Measurements of Cosmic Nucleides in Lunar Rock 64455

Graf Th.* Niedermann S. Mari K.
A Calibration of the Production Rate Ratio $P_{P_{1}}/P_{S}$ by Low Energy Secondary Neutrons: Identification of Ne Spallation Components at the $10^{9}$ Atoms/g Level in Terrestrial Samples

Loeken Th.* Scherer P. Schultz L.
Noble Gases in Twenty Yamato H-Chondrites: Comparison with Allan Hills Chondrites and Modern Falls

Imamura M. Kobayashi K. Shanna P.
Exposure Ages of Carbonaceous Chondrites

Dodd R. T.* Lipschutz M. E.
A CM Chondrite Cluster and CM Streams

Herzig G. F.* Souzis A. E. Xue S. Klein J. Juennemann D. Middleton R.
$^{40}$Ar-$^{36}$Ar Ages of Iron Meteorites

Asphaug E.* Melosh H. J. Ryan E.
Ejecting Basaltic Achondrites from Vesta: Hydrodynamical Impact Models

Williams D. R.* Wetherill G.
Equilibrium Models of Mass Distribution and Collisional Lifetimes of Asteroids

On Dust Emissions from the Jovian System
Monday, March 15, 1993
VENUS VOLCANISM
1:30 p.m. Room B

Chairs: B. Campbell and J. B. Garvin

Kuahnen K.*
Tectonics of Neystekob Corona on Venus

Garvin J. B.* Williams R. S. Jr.
Morphometric Comparison of Icelandic Lava Shield Volcanoes Versus Selected Venusian Edifices

Wilson L.* Pinkerton H. Head J. W. Magee Roberts K.
A Classification Scheme for the Morphology of Lava Flow Fields

Campbell B. A.* Zimbelman J. R.
Lava Flows on Venus: Analysis of Motion and Cooling

Zimbelman J. R.* Campbell B. A. Kousoum J. Lampkin D. J.
Numerical Simulation of Lava Flows: Applications to the Terrestrial Planets

Sakimoto S. E. H.* Zuber M. T.
Venus Pancake Dome Formation: Morphologic Effects of a Cooling-induced Variable Viscosity During Emplacement

Bulmer M. H.* Guest J. E. Michaels G. Saunders S.
Scalloped Margin Domes: What are the Processes Responsible and How do they Operate?

Bussey D. B. J.* Sørensen S. A. Guest J. E.
The Origin of Venusian Channels: Modelling of Thermal Erosion by Lava

Komatsu G.* Baker V. R.
Meander Properties of Venusian Channels

Weitz C. M.* Basilevsky A. T.
Geology and Radiophysical Properties of the Venera and Vega Landing Sites

Fegley B. Jr.* Lodders K.
The Rate of Chemical Weathering of Pyrite on the Surface of Venus

Straub D. W.*
The Role of CO₂ in Weathering Reactions and the Presence of S₂ on Venus: Implications for the Pyrite Stability Field

Monday, March 15, 1993
MANSON: THE HOLE AND SHOCKING STORY
1:30 p.m. Room C

Chairs: R. Anderson and E. M. Shoemaker

Shoemaker E. M. Roddy D. J.* Anderson R. R.
Research Program on the Manson Impact Crater, Iowa

Anderson R. R.* Witzke B. J. Hartung J. B. Shoemaker E. M. Roddy D. J.
Descriptions and Preliminary Interpretations of Cores Recovered from the Manson Impact Structure (Iowa)

Roddy D. J.* Shoemaker E. M. Anderson R. R.
The Manson Impact Crater: Estimation of the Energy of Formation, Possible Size of the Impacting Asteroid or Comet, and Ejecta Volume and Mass

Keiswetter D. A.* Black R. Steeples D. W. Anderson R. R.
High-Resolution Seismic Reflection Survey at the Manson Crater, Iowa

Plescia J. B.*
Gravity Investigation of the Manson Impact Structure, Iowa

Steiner M. B.* Shoemaker E. M.
Two-Polarity Magnetization in the Manson Impact Breccia

Zeiler P. K.* Kunk M. J.
Age and Thermochronology of K-Feldspars from the Manson Impact Structure

Kunk M. J.* Sneé L. W. French B. M. Harlan S. S. McGee J. J.
Preliminary ⁴⁰Ar/³⁹Ar Age Spectrum and Laser Probe Dating of the M1 Core of the Manson Impact Structure, Iowa: A K-T Boundary Crater Candidate

A Discontinuous Melt Sheet in the Manson Impact Structure

Petrography and Preliminary Interpretations of the Crystalline Breccias from the Manson M-1 Core

Short N. M.* Gold D. P.
Petrography of Shock Features in the 1953 Manson 2-A Drill Core

Crossey L. J.* McCarville P.
Post-Impact Alteration of the Manson Impact Structure

Koeberl C.* Anderson R. R. Hartung J. B. Reimold W. U.
Manson Impact Structure, Iowa: First Geochemical Results for Drill Core M-1

Blum J. D.* Chamberlain C. P. Hingston M. J. Koeberl C.
Strontium and Oxygen Isotope Study of M-1, M-3 and M-4 Drill Core Samples from the Manson Impact Structure, Iowa: Comparison with Haitian K-T Impact Glasses
Monday, March 15, 1993
PUBLIC SESSION
HAROLD MASURSKY LECTURES
8:00 p.m. Building 2, Auditorium

Chairs: To be announced
Speakers to be announced

Tuesday, March 16, 1993
PRIMITIVE ACHONDRITES
8:30 a.m. Room A

Chairs: D. Bogard and O. Eugster
McClure T. J.* Keil K., Clayton R. N., Mayeda T. K.
Classificational Parameters for Acapulcoites and Lodranites: The Cases of FRO 90011,
EET 84302 and ALH 87184/190
Davis A. M.* Prinz M., Weisberg M. K.
Trace Element Distributions in Primitive Achondrites
Bogard D. D.* Garrison D. H., McClure T. J., Keil K.
³⁹Ar-²²⁶Rb Ages of Acapulcoites and Lodranites: Evidence for Early Parent
Body Heating
Kim Y.* Marti K.
Isotopic Signatures and Distribution of Nitrogen and Trapped and Radiogenic Xenon in
the Acapulco and FRO90011 Meteorites
Eugster O.* Weigel A.
Xe-Q in Lodranites and a Hint for Xe-L. FRO90011 Another Lodranite?
Boynton W. V.* Hill D. H.
Trace-Element Abundances in Several New Ureilites
Goodrich C. A.* Lugmair G. W.
Stalking the LREE-enriched Component in Ureilites
Russell S. S.* Arden J. W., Franchi I. A., Pillinger C. T.
A Carbon and Nitrogen Isotope Study of Carbonaceous Vein Material in
Ureilite Meteorites
Casanova I.* McCoy T. J., Keil K.
Metal-rich Meteorites from the Aubrite Parent Body
Takeda H.* Salki K., Otsuki M., Hiroi T.
A New Antarctic Meteorite With Chromite, Orthopyroxene and Metal With Reference to
a Formation Model of S Asteroids
Petitv M. I.*
Opaque-rich Lithology in the D Vince Achondrite: Petrology and Origin

Tuesday, March 16, 1993
VENUS RESURFACING AND TECTONICS
8:30 a.m. Room B

Chairs: R. R. Herrick and E. M. Parmentier
Thompson T. W.* Magellan Flight Team
Magellan Mission Progress Report
Simpson R. A.* Tyler G. L., Maurer M. J., Holmman E., Wong P. B.
Scattering by Venus' Surface
Izenberg N. R.* Arvidson R. E., Phillips R. J.
A First-Order Model for Impact Crater Degradation on Venus
Strom R. G.*
Parabolic Features and the Erosion Rate on Venus
Kaula W. M.*
Implications of Crater Distributions on Venus
Malin M. C., Grimm R. E.* Herrick R. R.
Tectonic Resurfacing of Venus
Solomon S. C.*
A Tectonic Resurfacing Model for Venus
Solomatov V. S.* Stevenson D. J.
Differentiation of Magma Oceans and the Thickness of the Depleted Layer on Venus
Partenier E. M.* Hess P. C., Sotin C.
Mixing of a Chemically Buoyant Layer at the Top of a Thermally Conveeting Fluid:
Implications for Mantle Dynamics with Application to Venus
Gilmore M. S.* Head J. W., III
The Formation and Evolution of Alpha and Tellus Tesserae on Venus
Raitala J.*
Chocolate Tablet Aspects of Cytherean Meshkenet Tessera
Tuesday, March 16, 1993

CHICXULUB, KT BOUNDARY, AND OTHER IMPACT EJECTA
8:30 a.m.  Room C

Chairs:  B. Schuraytz and B. Bohor

Hildebrand A. R.* Grégoire D. C. Atreya M. Jr. Claeys P. Thompson C. M. Boynton W. V.
Trace-Element Composition of Chicxulub Crater Melt Rock, K/T Tektites and Yucatan Basement

Urrutia-Fucugauchi J.* Martin L. E. Sharpton V. L. Quezada-Muñeton J. M.
Reverse Polarity Magnetized Melt Rocks from the Chicxulub Impact Structure, Yucatan Peninsula, Mexico

Sharpton V. L.* Burke K. Hall S. Lee S. Martin L. E. Suarez G. Quezada J. M.
Urrutia-Fucugauchi J.
Chicxulub Impact Basin: Gravity Characteristics and Implications for Basin Morphology and Deep Structure

Carey S.* Sigurdsson H. D'Hondt S. Espindola J. M.
Stratigraphy and Sedimentology of the K/T Boundary Deposit in Haiti

Bohor B. F.* Glass B. P. Betterton W. J.
K/T Spherules from Haiti and Wyoming: Origin, Diagenesis, and Similarity to Some Microtektites

Glass B. P.* Bohor B. F. Betterton W. J.
Cretaceous-Tertiary Boundary Spherules and Cenozoic Microtektites: Similarities and Differences

Premo W. R.* Irett G. A.
U-Pb Provenance Ages of Shocked Zircons from the K-T Boundary, Raton Basin, Colorado

Espindola J. M.* Carey S. Sigurdsson H.
Modelling of Dispersal and Deposition of Impact Glass Spherules from the Cretaceous-Tertiary Boundary Deposit

Bostwick J. A.* Kyte F. T.
Impact Mineralogy and Chemistry of the Cretaceous-Tertiary Boundary at DSDP Site 576

Chamberlain C. P.* Blum J. D. Koebel C.
Oxygen Isotopes as Tracers of Tektite Source Rocks: An Example From the Ivory Coast Tektites and Lake Bosumtwi Crater

Claeys P.* Casier J.-G.
Microtektite-like Glass Spherules in Late Devonian (367 Ma) Shales

Mittlefehldt D. W.* See T. H. Scott E. R. D.
Siderophile Element Fractionation in Meteor Crater Impact Glasses and Metallic Spherules

Tuesday, March 16, 1993

REMOTE SENSING/SPACE WEATHERING
8:30 a.m.  Room D

Chairs:  B. Clark and B. W. Hapke

Goguen J. D.*
A Test of the Applicability of Independent Scattering to High Albedo Planetary Regoliths

Nelson R. M.* Hapke B. W. Smythe W. D. Gharakhanian V. Henota P.
The Coherent Backscattering Opposition Effect

Shepard M. K.* Guinness E. A. Arvidson R. E.
The Roughness of the Martian Surface: A Scale Dependent Model

Brackett R. A.* Arvidson R. E.
Compositional and Textural Information from the Dual Inversion of Visible, Near and Thermal Infrared Remotely Sensed Data

Salisbury J. W. Wald A.* D'Aria D. M.
Thermal Infrared Remote Sensing and Kirchoff's Law: I Laboratory Measurements

Henderson B. G.* Jakosky B. M.
Near-Surface Temperature Gradients and Their Effects on Thermal-Infrared Emission Spectra of Particulate Planetary Surfaces

Lucy P. G. Domergue-Schmidt N.* Henderson B. G. Jakosky B.
First Results from a Laboratory Facility for the Measurement of Emission Spectra Under Simulated Planetary Conditions

Hapke B.*
Why is the Moon Dark?

Effects of Microscopic Iron Metal on the Reflectance Spectra of Glass and Minerals

Pieters C. M.* Fischer E. M. Rode O. D. Basu A.
Optical Effects of Space Weathering on Lunar Soils and the Role of the Finest Fraction

Fasale F. P.* Clark B. E.
Chondrites, S Asteroids, and "Space Weathering": Thumping Noises from the Coffin?

Spectral Evidence of Size Dependent Space Weathering Processes on Asteroid Surfaces
MARTIAN METEORITES AND VOLATILES: A SESSION HONORING THE SERVICE OF DON BOGARD AS PM&G DISCIPLINE SCIENTIST

1:30 p.m. Room A

Dedication: L. Nyquist
Chairs: D. S. Burnett and J. Longhi

Jagoutz E.* Luck J. M. Ben Ohman D. Wänke H. Ols仁on Isotopes in SNC Meteorites and Their Implications to the Early Evolution of Mars and Earth


Ford D. J.* Rutherford M. J. Primitive SNC Parent Magmas and Crystallization: Low P Experiments

Treiman A. H.* The Parent Magma of the Nakhla (SNC) Meteorite: Reconciliation of Composition Estimates from Magmatic Inclusions and Element Partitioning

McKay G.* Le L. Wagtstaff J. The Nakhla Parent Melt: REE Partition Coefficients and Clues to Major Element Composition

Wadhwa M.* Crozaz G. Rare Earth Elements in Individual Minerals in Shergottites

McCoy T. J.* Keil K. Taylor G. J. The Dregs of Crystallization in Zagami

Chen J. H.* Wasserburg G. J. LEW88516 and SNC Meteorites

Becker R. H.* Pepin R. O. Nitrogen and Noble Gases in a Glass Sample from LEW88516


Wright I. P.* Douglas C. Pillinger C. T. The Carbon Components in SNC Meteorites of Feldspathic Harzburgite Composition


Watson L. L.* Hutchison I. D. Epstein S. Stolper E. M. High D/H Ratios of Water in Magmatic Amphiboles in Chassigny: Possible Constraints on the Isotopic Composition of Magmatic Water on Mars

Wasserburg G. T. Remarks and Observations

VENUS GRAVITY FROM MAGELLAN AND MARS GEOPHYSICS

1:30 p.m. Room B

Chairs: W. Sjogren and B. Bills

Sjogren W. L.* Konopliv A. S. Borderies N. Batchelder M. Heirath J. Wimberly R. N. Venus Gravity: New Magellan Low Altitude Data

Smrekar S. E.* Parmentier E. M. Response of the Topography and Gravity Field on Venus to Mantle Upwelling Beneath a Chemical Boundary Layer

Buck W. R.* Can Weak Crust Explain the Correlation of Geoid and Topography on Venus?

Moresi L.* Effective Elastic Thickness of the Venussian Lithosphere with Lateral Viscosity Variations in the Mantle

Simons M.* Hager B. H. Solomon S. C. Geoid, Topography, and Convection-driven Crustal Deformation on Venus


Kiefer W.* Bills B. Frey H. Nerem S. Roark J. Zuber M. An Inversion of Geoid and Topography for Mantle and Crustal Structure on Mars


Lemoine F. G.* Smith D. E. Fricke S. K. McCarthy J. J. A Simultaneous Estimation of the Mass of Mars and Its Natural Satellites, Phobos and Deimos, from the Orbital Perturbations on the Mariner 9, Viking 1, and Viking 2 Orbiters

Stevenson D. J.* Expectations for the Martian Core Magnetic Field

Dolginov A. Z.* Magnetic Fields and Nonuniform Structures of the Moon
Tuesday, March 16, 1993
LARGE IMPACT EVENTS: THEORY AND OBSERVATIONS
1:30 p.m. Room C

Chair: P. H. Warren

O'Keefe J. D.* Ahrens T. J.
Dynamics of Large-scale Impacts on Venus and Earths

Ivanov B. A.* Ford P. G.
The Depths of the Largest Impact Craters on Venus

Chadwick D. J.* Schaber G. G.
A Two-Stage (Turbulent-Drainage) Mechanism for the Emplacement of Impact Crater Outflows on Venus

Ahrens T. J.*
Giant Impact-induced Atmospheric Blow-off

Vickery A. M.*
Numerical Modeling of Impact Erosion of Atmospheres: Preliminary Results

Warren P. H.*
Limits on Differentiation of Melt "Sheets" from Basin-scale Lunar Impacts

Therriault A. M.* Reid A. M. Reimold W. U.
Origin of the Vredefort Structure, South Africa: Impact Model

Tuesday, March 16, 1993
GALILEO EARTH/MOON RESULTS
3:15 p.m. Room C

Chair: A. S. McEwen

Greeley R.* Belton M. J. S. Head J. W. McEwen A. S. Pieters C. M. Neukum G.
Becker T. L. Fischer E. M. Kadel S. D. Robinson M. S. Sullivan R. J. Sunshine J. M.
Williams D. A.
Galileo Imaging Results from the Second Earth-Moon Flyby: Lunar Maria and Related Units

Head J. W.* Belton M. Greeley R. Pieters C. Fischer E. Sunshine J. Klaasen K.
McEwen A. Becker T. Neukum G. Oberst J. Pietsch C. Plutchak J. Robinson M.
Johnson T. Williams D. Kadel S. Sullivan R. Antonenko I. Bridges N.
Galileo Imaging Team
Lunar Impact Basins: New Data for the Nearside Northern High Latitudes and Eastern Limb from the Second Galileo Flyby

Soderblom L. A. Smythe W. D. Torson J. Weissman P. R.
Preliminary Report of Lunar Observations by the Near-Infrared Mapping Spectrometer (NIMS) During the Second Galileo Earth-Moon Encounter

Pieters C. M.* Belton M. Head J. W. Greeley R. McEwen A. Fischer E. M. Sunshine J. M.
Klaasen K. Plutchak J. Neukum G. Johnson T. V. SSI Team
Compositional Diversity of the Lunar North Pole: Preliminary Analyses of Galileo SSI Data

McEwen A. S.* Greeley R. Head J. W. Pieters C. M. Fischer E. M. Johnson T. V.
Neukum G. Galileo SSI team
Galileo SSI Lunar Observations: Cretaceous Craters and Soils

Thompson W. R. Galileo Imaging Team
Earth Imaging Results from Galileo's Second Encounter
Tuesday, March 16, 1993
MARTIAN GEOMORPHOLOGY
1:30 p.m. Room D

Chairs: R.A. Craddock and J. Grant

Leonard G. J.* Tanaka K. L.
Hellas Basin, Mars: Formation by Oblique Impact

Fractal Dimensions of Rampart Impact Craters on Mars

Barlow N. G.*
Increased Depth-Diameter Ratios in the Medusae Fossae Formation Deposits of Mars

Grant J. A.* Schultz P. H.
Maritan Crater Degradation by Eolian Processes: Analogy with the Rio Cuarto Crater Field, Argentina

Greeley R.* Anderson F. S. Blumberg D. Lo E. Xu P.
Sand Transport on Mars: Preliminary Results from Models

Christensen P. R. Malin M. C.*
A Simple Model of Clastic Sediments on Mars

Craddock R. A.* Crumpler L. S. Aubele J. C.
Geologic History of Central Chryse Planitia and the Viking 1 Landing Site, Mars

Wednesday, March 17, 1993
INTERPLANETARY DUST: LABORATORY STUDIES AND
RESULTS FROM SPACECRAFT
8:30 a.m. Room A

Chairs: J. A. M. McDonnell and G. Blanford

Multielement Analysis of Interplanetary Dust Particles Using TOF-SIMS

Clemett S. J.* Macchioni C. R. Zare R. N. Swan P. D. Walker R. M.
Measurement of Polycyclic Aromatic Hydrocarbon (PAHs) in Interplanetary Dust Particles

Keller L. P.* Thomas K. L. McKay D. S.
Carbon Abundances, Major Element Chemistry, and Mineralogy of Hydrated Interplanetary Dust Particles

Thomas K. L.* Keller L. P. Blanford G. E. McKay D. S.
Cometary Interplanetary Dust Particles? An Update on Carbon in Anhydrous IDPs

Bradley J. P.*
Unequilibrated, Equilibrated, and Reduced Aggregates in Anhydrous Interplanetary Dust Particles

Flynn G. J.* Sutton S. R. Bajt S.
Trace Element Content of Chondritic Cosmic Dust: Volatile Enrichments, Thermal Alterations, and the Possibility of Contamination

Rietmeijer F. J. M.*
Micrometeorite Dynamic Pyrometamorphism: Observation of a Thermal Gradient in Iron-Nickel Sulfide

Nier A. O.* Schlutter D. J.
Helium in Interplanetary Dust Particles

Identification of Cometary and Asteroidal Particles in Stratospheric IDP Collections

Presper T.* Kurat G. Koebel C. Palme H. Maurer M.
Elemental Depletions in Antarctic Micrometeorites and Arctic Cosmic Spherules: Comparison and Relationships

Barrett R. A.* Zolensky M. E. Bernhard R.
Mineralogy of Chondritic Interplanetary Dust Particle Impact Residues from LDEF

Bernhard R. P.* See T. H. Hörz F.
Composition and Modal Frequencies of Hypervelocity Particles < 1 mm in Diameter in Low-Earth Orbit

McDonnell J. A. M.*
Resolving LDEF's Flux Distribution: Orbital (Debris?) and Natural Meteoroid Populations
Wednesday, March 17, 1993
MARTIAN SURFACE MINERALOGY AND SPECTROSCOPY
8:30 a.m. Room B

Chairs: J. Bishop and R. V. Morris

Bell J. F. III* Mustard J. F.
A Comparison of Telescopic and Phobos-2 ISM Spectra of Mars in the Short-Wave Near-Infrared (0.75-1.02 µm)

Mustard J. F.* Murchie S. L. Erard S.
Composition of Weakly Altered Martian Crust

Miller J. S.* Singer R. B.
Analysis of Pyroxene Absorptions Observed in Martian Dark Regions

Sabol D. E. Jr.* Bell J. F. III Adams J. B.
Detectability of Crystalline Ferric and Ferrous Minerals on Mars

Murchie S.* Mustard J. Erard S. Geissler P. Singer R.
Variations in the Fe Mineralogy of Bright Martian Soil

Farrand W. H.* Singer R. B.
A Comparison of the Visible and Near Infrared Reflectance of Hydrovolcanic Palagonite Tuffs and Martian Weathered Soils

Bishop J. L.* Pieters C. M. Burns R. G.
Reflectance Spectra of Sulfate- and Carbonate-bearing Fe*-doped Monmorillonites as Mars Soil Analogs

Morris R. V.* Lauer H. V. Jr. Golden D.C.
Terrestrial Impact Melts as Analogues for the Hematization of Mariner Surface Materials

Mérényi E.* Edgett K. S. Singer R. B.
Deucalionis Regio, Mars: Evidence for a Unique Mineralogic Endmember and a Crusted Surface

Burns R.G.*
Chemical Weathering on Mars: Rate of Oxidation of Iron Dissolved in Brines

Moore J. M.* Bullock M. A. Stoker C. R.
Mars Brine Formation Experiment

Wenrich M. L.* Christensen P. R.
A Study of Carbonates, Sulfates, and Phosphates Using Thermal Emission Spectroscopy

Christensen P. R.* Harrison S. T. Barbera P. Ruff S.
Thermal-Infrared Emission Spectroscopy of Natural Surfaces: Application to Coated Surfaces

Presley M. A.* Christensen P. R.
Thermal Conductivity Measurements of Particulate Materials Under Martian Conditions

Wednesday, March 17, 1993
MOON ROCKS: FROM THE HIGHLANDS TO THE MARIA TO ANTARCTICA
8:30 a.m. Room C

Chairs: O. B. James and H. Takeda

Taylor S. R.* Norman M. D. Esat T. M.
The Mg-Suite and the Highland Crust: An Unsolved Enigma

Jolliff B. L.* Bishop K. M.
Apollo 17 Materials Viewed from 2-4 mm Soil Particles: Pre-Serrenitatis Highlands Components

Cushing J. A.* Taylor G. J. Norman M. D. Keil K.
The Granulite Suite: Impact Melts and Metamorphic Breccias of the Early Lunar Crust

Norman M. D.* Albert C. McCulloch M. T.
Fragments of Ancient Lunar Crust: Ferroan Noritic Anorthosites from the Descartes Region of the Moon

Preme W. R.* Tatsumoto M.
U-Pb Isotopic Systematics of Ferroan Anorthosite 60025

Snyder G. A.* Taylor L. A. Halliday A. N.
Geochronology and Petrogenesis of the Western Highlands Alkali Suite: Radiogenic Isotopic Evidence from Apollo 14

Shih C.-Y.* Wiesmann H. Garrison D. H. Nyquist L. E. Bogard D. D.
Chronology of Lunar Granite 12033.516: Resetting of Rb-Sr and K-Ca Isochrons

Consoritium Reports on Lunar Meteorites Yamato 793169 and Asuka 881757, a New Type of Mare Basalt

Takeda H.* Arai T. Saiki K.
Ti-bearing OXide Minerals in Lunar Meteorite Y793169 with the VLT Affinity

Warren P. H.* Lindstrum M. M.
Consoritium Study of Lunar Meteorites Yamato-793169 and Asuka-881757: Geochronological Evidence of Mutual Similarity, and Dissimilarity vs. Other Mare Basalts

Torigoe N. Misawa K. Dalrymple G. B. Tatsumoto M.
U-Th-Pb, Sm-Nd, and Ar-Ar Isotopic Systematics of Lunar Meteorite Yamato 793169

Nyquist L. E.* Shih C.-Y. Wiesmann H. Bansal B. M.
144*Sm-142Nd Formation Interval for the Lunar Mantle and Implications for Lunar Evolution

Neal C. R.* Taylor L. A.
Petrogenesis of Apollo 12 Mare Basalts, Part I: Multiple Melts and Fractional Crystallization to Explain Olivine and Ilmenite Basalt Compositions

Jerde E. A.* Snyder G. A. Taylor L. A.
On the Composition of newKREEP: QMD Contamination at Apollo 117
Wednesday, March 17, 1993
ORDINARY ENSTATITE CHONDRITES
1:30 p.m. Room A

Chairs: K. Kell and M. Prinz

Rubin A. E.*
Euhedral Metallic-Fe-Ni Grains in Extraterrestrial Samples

Yang C. W.* Williams D. B. Goldstein J. I.
Preliminary AEM Study of the Microstructure and Composition of Metal Particles in Ordinary Chondrites

Podosek F. A.* Brannon J. C. Perron C. Pellas P.
Elevated Initial \(^{87}\)Sr/\(^{86}\)Sr in Ordinary Chondrite Metal

Burkland M. K.* Swindle T. D. Baldwin S. L.
Studies of the Release of Radiogenic \(^{136}\)Xe from Bjurböle: Evidence Against Simple Diffusion Models

Kehn K.* Nichols R. H. Jr. Hohenberg C. M. McCoy T. J. Keil K.
\(^{136}\)Xe Structure of Hafug 009 and Shallowater: Evidence for Early Formation and Rapid Cooling of Impact-derived Enstatite Meteorites

Scott E. R. D.* McCoy T. J. Keil K.
Post-Metamorphic Brecciation in Type 3 Ordinary Chondrites

Crozaz G.* Hsu W.
Anomalous REE Patterns in Unequilibrated Enstatite Chondrites: Evidence and Implications

Weisberg M. K.* Prinz M. Fogel R. A. Shimizu N.
The Formation of FeO-rich Pyroxene and Enstatite in Unequilibrated Enstatite Chondrites: A Petrologic-Trace-Element (SIMS) Study

Zhang Y.* Benoit P. H. Sears D. W. G.
Lewis Cliff 87057: A New Metal-rich E3 Chondrite with Similarities to Mt. Egerton, Shallowater and Happy Canyon

Brearley A. J.* Jones R. H.
Chondrite Thermal Histories from Low-Ca Pyroxene Microstructures: Autometamorphism vs Prograde Metamorphism Revisited

Benoit P. H.* Sears D. W. G.
The Great 8 Ma Event and the Structure of the H-Chondrite Parent Body

Wolf S. F. Lipschutz M. E.*
Multivariate Statistical Analysis: Principles and Applications to Coorbital Streams of Meteorite Falls

Yanai K.* Kojima H.
Regolith Breccia Consisting of H and LL Chondrite Mixture

Wednesday, March 17, 1993
MARS: TECTONISM AND VOLCANISM
1:30 p.m. Room B

Chairs: W. B. Banerdt and J. Plescia

Zuber M. T.*
Wrinkle Ridges, Reverse Faulting, and the Depth Penetration of Lithospheric Stress in Lunae Planae, Mars

Banerdt W. B.*
Horizontal Stresses Induced by Vertical Processes in Planetary Lithospheres

Tanaka K. L.* Chadwick D. J.
Extensional History of Mars' Tharsis Region

Chadwick D. J.* Lucchitta B. K.
Fault Geometries and Extension in the Valles Marineris, Mars

Watters T. R.* Zimbelman J. R. Scott D. H.
Arcuate and Circular Structures in the Tharsis Region: Evidence of Coronae on Mars

Balog S. M.* Spudis P. D.
Reconstruction of the Dynamics of the 1800-1801 Hualalai Eruption: Implications for Planetary Lava Flows

Bruno B. C.* Taylor G. J. Lopes-Gautier R. M. C.
Quantifying the Effect of Rheology on Plan-View Shapes of Lava Flows

Martian Lavas: Three Complementary Remote Sensing Techniques to Derive Flow Properties

Mouginis-Mark P.*
The Influence of Oceans on Martian Volcanism

Gregg T. K. P.* Williams S. N.
Explosive Mafic Volcanism on Earth and Mars

Plescia J. B.*
Geology of Biblis Patera, Ulysses Patera, and Jovis Tholus, Mars

Robinson M. S.* Mouginis-Mark P. J. Zimbelman J. R. Wu S. S. C.
Chronology, Eruption Duration, and Atmospheric Contribution of Apollinaris Patera, Mars
Wednesday, March 17, 1993
LUNAR VOLCANIC GLASSES AND REGOLITH
1:30 p.m. Room C

Chairs: J. Delano and D. S. McKay

Delano J. W.* Compositional Heterogeneity Within a Dumbbell-shaped Apollo 15 Green Glass: Evidence for Simultaneous Eruption of Different Magmas

Shearer C. K.* Papke J. J. Basaltic Magmatism on the Moon. A Perspective from Volcanic Picritic Glasses


McKay D. S.* Wentworth S. J. Grain Surface Features of Apollo 17 Orange and Black Glass

Rutherford M. J. Fogel R. A.* C-O Volatiles in Apollo 15 and Apollo 17 Picritic Glasses

Colson R. O.* Graphite "Solubility" and CO Vesiculation in Basalt-like Melts at One-Atm

Hess P. C.* The Ilmenite Liquidus and Depths of Segregation for High-Ti Picrite Glasses

Longhi J.* Liquidus Equilibria of Lunar Analogs at High Pressure

Wagner T. P.* Grove T. L. Origin of High-Ti Lunar Ultramafic Glasses

Norris J. A.* Keller L. P. McKay D. S. Impact Glasses from the Ultrafine Fraction of Lunar Soils

Korotev R. L.* Morris R. V. Lauer H. V. Jr. Composition and Maturity of the 60013/14 Core

Kerridge J. F.* Kim Y. Kim J. S. Muri K. Nitrogen Isotopic Signatures in Agglutinates from Breccia 79035

Brilliant D. R.* Franchi I. A. Pillinger C. T. Multiple Nitrogen Components in Lunar Soil Sample 12023

Wednesday, March 17, 1993
COMPLEX PLENARY
"Integrated Strategy for Planetary and Lunar Exploration from 1995 to 2010"
5:30 p.m. Room C

Discussion Leader: J. A. Burns

Open Discussion

Members of COMPLEX (The Committee on Planetary and Lunar Exploration; Space Studies Board of the National Academy of Sciences/National Research Council) will discuss the above report which is being prepared for NASA. This document (a) summarizes our current understanding of the solar system, (b) identifies the most significant scientific questions that remain; and (c) establishes priorities for study and scientific exploration of the solar system over the next 15 years. A formal presentation will describe the study so far and will then seek community input on key scientific questions and on future scientific priorities.
Thursday, March 18, 1993
CARBONACEOUS CHONDRITES AND CHONDRULES
8:30 a.m. Room A

Chairs: J. Gooding and L. Grossman

Prinz M.* Weinberg M. K. Clayton R. N. Mayeda T. K.
Oxygen Isotopic Relationships Between the LEW85332 Carbonaceous Chondrite and CR Chondrites

Kallemeyn G. W.*
The Al Rais Meteorite: A CR Chondrite or Close Relative?

Brandstätter F.* Kurat G. Ivanov A. V. Palme H. Spettel B.
Mineralogy Versus Bulk Composition of the Carbonaceous Chondrite Clast Kaidun II

Steele I M.*
Fe/Mn in Olivine of Carbonaceous Meteorites

Hua X.* Buseck P. R.
Olivines in the Koba Carbonaceous Chondrite and Constraints on Their Formation

Determining the Relative Extent of Alteration in CM Chondrites

Woolam D. S.* Poelstra K. Alexander C. Ireland T.
LREE Variability in CM Matrices: Another Look at Meteorite “Compaction Ages”

Gilmour I.* Pillinger C. T.
Extraction and Isotopic Analysis of Medium Molecular Weight Hydrocarbons from Murchison Using Supercritical Carbon Dioxide

Misawa K.* Fujita T. Kitamura M. Nakamura N.
Refractory Precursor Components in an Allende Ferromagnesian Chondrule

Jones R. H.*
Complex Zoning Behavior in Pyroxene in FeO-rich Chondrules in the Semarkona Ordinary Chondrite

Krot A. N.* Rubin A. E.
Chromite-rich Mafic Silicate Chondrules in Ordinary Chondrites: Formation by Impact Melting

Huang S.* Benoît P. H. Sears D. W. G.
The Group A3 Chondrules of Krymka: Further Evidence for Major Evaporative Loss During the Formation of Chondrules

Lofgren G. E.* DeHart J. M. Dickinson T. L.
Experimentally Reproduced Relict Enstatite in Porphyritic Chondrules of Enstatite Chondrite Composition

Thursday, March 18, 1993
MARS: SURFACE AND ATMOSPHERIC PROCESSES
8:30 a.m. Room B

Chairs: V. Gulick and K. Herkenhoff

Gulick V. C.* Baker V. R.
Fluvial Erosion on Mars: Implications for Paleoclimatic Change

Leyva l. A.* Clifford S. M.
The Seismic Response of an Aquifer to the Propagation of an Impact Generated Shock Wave: A Possible Trigger of the Martian Outflow Channels?

Parker T. J.* Gorsline D. S.
Constraints on the Rate of Discharge and Duration of the Mangala Valles Flood

Betts B. H.* Murray B. C.
Thermal Studies of Maritian Channels and Valleys Using Thermoskan Data

Lucchita B. K.* Isbell N. K. Howington-Kraus A.
Sedimentation, Volcanism, and Ancestral Lakes in the Valles Marineris: Clues from Topography

De Hon R. A.*
Classification of Martian Deltas

Herkenhoff K. E.*
Thermal Inertia and Radar Reflectivity of the Maritian North Polar Erg: Low-Density Aggregates

Zent A. P.* Roush T. L.
Spectral Analysis of Chemisorbed CO$_2$ on Marss Analog Materials

Crisp D.* Bell J. F. III
Near-Infrared Spectra of the Maritian Surface: Reading Between the Lines

Altitude Profile of Aerosols on Mars from Measurements of Its Thermal Radiation on Limb

Murphy J. R.* Pollack J. B.
Dust-Dynamic Feedbacks in the Maritian Atmosphere: Surface Dust Lifting

Dollfus A.* Ebisawa S.
Dust in the Maritian Atmosphere: Polarimetric Sensing

Mellon M. T.* Jakosky B. M.
The Effects of Orbital and Climatic Variations on Maritian Surface Heat Flow

Bell J. F. III* Calvin W. M. Pollack J. B. Crisp D.
An Observational Search for CO$_2$ Ice Clouds on Mars
Thursday, March 18, 1993
LUNAR GEOLOGY
8:30 a.m. Room C

Chairs: J. Granahan and P. Spudis

Stacy N. J. S. Campbell D. B.*
Earth-based Measurement of Lunar Topography Using Delayed Radar Interferometry

Bahar E.* Haugland M.
Interpretation of Lunar and Planetary Electromagnetic Scattering Using the Full Wave Solutions

Cooper B. L.* Carter J. L.
Using Lunar Sounder Imagery to Distinguish Surface from Subsurface Reflectors in Lunar Highlands Areas

Mendell W. W.* Wieczorek M. A.
Thermogeologic Mapping of the Moon from Lunar Orbit

Tompkins S.* Pieters C. M. Mustard J. F.
Distribution and Geologic History of Materials Excavated by the Lunar Crater Bullialdus

Kadel S. D.* Greeley R. Neukum G. Wagner R.
The History of Mare Volcanism in the Orientale Basin: More Deposit Ages, Compositions and Morphologies

Hiesinger H.* Jaumann R. Neukum G. GLL Imaging Team
Earth-based and Galileo SSI Multispectral Observations of Eastern Mare Serenitatis and the Apollo 17 Landing Site

Spudis P. D.* Hawke B. R. Lucey P. G.
Geology and Deposits of the Serenitatis Basin

Remote Sensing Studies of the Northeastern Portion of the Lunar Nearside

Spectral and Multispectral Imaging Studies of Lunar Mantled Mare Deposits

Head J. W.* Wilson L.
Mode of Emplacement of Lunar Mare Volcanic Deposits: Graben Formation Due to Near Surface Deformation Accompanying Dike Emplacement at Rima Parry V

Kneeler U.* Jaumann R. Neukum G.
Age Determinations and Earth-based Multispectral Observations of Lunar Light Plains

Galileo Photometry of Apollo Landing Sites

Thursday, March 18, 1993
ASTEROID AND PLANETARY CORE FORMATION AND METAL-RICH METEORITES
8:30 a.m. Room D

Chairs: G. W. Lugmair and H. Newsom

Keil K. Wilson L.*
Explosive Volcanism and the Compositions of the Cores of Differentiated Asteroids

Jurewicz S. R.* Jones J. H.
Experimental Segregation of Iron-Nickel Metal, Iron-Sulfide, and Olivine in a Thermal Gradient: Preliminary Results

Zhou Y.* Steele I. M.
Chemical Zoning and Diffusion of Ca, Al, Mn, and Cr in Olivine of Springwater Pallasia

Holzheid A.* Borisov A. Palme H.
Siderophile Elements in the Upper Mantle of the Earth: New Clues from Metal-Silicate Partition Coefficients

Newsom H. E.* Mahr S.
Core Formation in the Moon: The Mystery of the Excess Depletion of Mo, W and P

Systematic Chemical Variations in Large HIIAB Iron Meteorites: Clues to Core Crystallization

Rhenium-Osmium Isotope Systematics of Ordinary Chondrites and Iron Meteorites

Esat T.* Bennett V.
Re-Os Dating of HIIAB Iron Meteorites

Creaser R. A.* Papanastassiou D. A. Wasselburg G. J.
Rhenium-Osmium Isotope Systematics of Group IIA and Group IVA Iron Meteorites

Eisenhour D. D. Buseck P. R. Palme H.* Zipfel J.
Micro-Zoning in Minerals of a Landes Silicate Inclusion

Stewart B. W.* Papanastassiou D. A. Wasselburg G. J.
Sm-Nd Systematics of Silicate Inclusions in Iron Meteorites: Results from Caddo (IAB)

Constraints on the Differentiation of the Earth from the Coupled 16O/18O Sm/142Nd Systematics

Harper C. L. Jr.* Jacobsen S. B.
142Nd/144Nd in Bulk Planetary Reservoirs, the Problem of Incomplete Mising of Interstellar Components and Significance of Very High Precision

141Nd/144Nd Measurements
### Thursday, March 18, 1993
**STARS, STARDUST, AND ISOTOPE ANOMALIES**
1:30 p.m. Room A

**Chairs:** D. Papanastassiou and A. M. Davis

1. Dong Q. W. Thiemens M. H.*
   Development of a Molecular Beam Technique to Study Early Solar System Silicon Reactions

2. Yurimoto H.* Nagasawa H. Mori Y.
   Inter- and Intra-Crystalline Oxygen Isotope Distribution of Fassaites in Allende CAI

   Identification of an Interstellar Oxide Grain from the Murchison Meteorite by Ion Imaging

4. Lewis R. S.* Srinivasan B.
   A Search for Noble-Gas Evidence for Presolar Oxide Grains

5. Amari S.* Zinner E. Lewis R. S.
   Interstellar Graphite in Murchison: Continued Search for Isotopically Distinct Components

   Do SiC Grains in Orgueil Differ from Those in Murchison?

7. Yates P. D.*
   Micrometeorite Presolar Diamonds from Greenland Cryoconite?

   Are the C₂ Light Nitrogen and Noble Gases Located in the Same Carrier?

   Carbon and Nitrogen in Type II Supernova Diamonds

10. Sharp C. M.* Wasserburg G. J.
    Molecular Equilibria and Condensation Sequences in Carbon Rich Gases

11. Wasserburg G. J. Gallino R.* Busso M. Raiteri C. M.
    AGB Stars as a Source of Short-lived Radioactive Nuclei in the Solar Nebula

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### Thursday, March 18, 1993
**OUTER SOLAR SYSTEM**
1:30 p.m. Room B

**Chairs:** L. J. Horn and R. Malhotra

   A Decade's Overview of Io's Volcanic Activity

2. Kargel J. S.*
   Crustal Structure and Igneous Processes in a Clondrite Io

   Phase Equilibria of the Magnesium Sulfate-Water System to 4 Kbars

   Rheology of Water and Ammonia-Water Ices

5. Croft S. K.*
   Porosity and the Ecology of Icy Satellites

6. Pappalardo R.* Greeley R.
   Structural Evidence for Reorientation of Miranda About a Paleo-Pole

7. Denk T.* Jaumann R. Neukum G.
   Disk-resolved Spectral Characteristics of Saturn's Medium-sized Satellites

8. Horn L. J.* Russell C. T.
   Mass of Saturn's A Ring

9. Strom R. G.* Croft S. K.
   Triton's Cratering Record and Its Time of Capture

10. Boyce J. M.*
    A Structural Origin for the Canoloupe Terrain of Triton

11. Schenk P.* Jackson M. P. A.
    Diapirs and Canoloupes: Layering and Overturn of Triton's Crust

12. Hansen C. J.* Paige D. A.
    A Pluto Thermal Model

13. Levison H. F.* Stern S. A.
    Mapping the Stability Region of the 3:2 Neptune-Pluto Resonance
Thursday, March 18, 1993
FUTURE LUNAR EXPLORATION
1:30 p.m. Room C

Chairs: M. B. Duke and D. A. Morrison

Head J. W.* Belton M. Greeley R. Pieters C. McEwen A. Neukum G. McCord T.
Lunar Scout Missions: Galileo Encounter Results and Application to Scientific
Problems and Exploration Requirements

Pieters C. M.* Head J. W. McCord T. B. MinMap Team
MinMap: An Imaging Spectrometer for High Resolution Compositional Mapping
of the Moon

Neukum G.*
The High Resolution Stereo Camera (HRSC) for the Lunar Scout-I Mission

Gamma-Ray Spectrometer for Lunar Scout II

Auchampaugh G.* Barraclough B. Byrd R. Drake D. Feldman W. Moss C. Reedy R.
The Los Alamos Neutron Spectrometer for the Lunar Scout-I Mission

Clark P. E. Evans L. G. Trombka J. I.*
Remote Sensing X-Ray Fluorescence Spectrometry for Future Lunar
Exploration Missions

Cheng A. F.*
Lunar Scout Two Spacecraft Gravity Experiment

Shoemaker E. M.* Nozette S.
Clementine: An Inexpensive Mission to the Moon and Geographos

Lucey P. G.*
The Clementine Instrument Complement

McEwen A. S.*
Clementine: Anticipated Scientific Datasets from the Moon and Geographos

Spudis P. D.* Lucey P. G.
Contributions of the Clementine Mission to Our Understanding of the Processes and
History of the Moon

Meyer C.*
Opportunity for Early Science Return by the Artemis Program

Lofgren G. E.*
The First Lunar Outpost: The Design Reference Mission and a New Era in
Lunar Science

Chicarro A. F.*
Mission to the Moon: An ESA Study on Future Exploration

Thursday, March 18, 1993
NASA PROGRAM MANAGERS' MEETING
5:30 p.m. Room A

Tammy Dickinson, NASA Headquarters
Planetary Materials and Geochemistry

Stephan Baloga, NASA Headquarters
Planetary Geology and Geophysics

Henry Brinton, NASA Headquarters
Joseph Boyce, NASA Headquarters
Friday, March 19, 1993
CAIs
8:30 a.m. Room A

Chair: G. MacPherson

Meeker G. P.* Quick J. E. Paque J. M.
Limited Subsolidus Diffusion in Type BI CAI: Evidence from Ti Distribution in Spinel

Deloule E.* Kennedy A. K. Hutcheon I. D. El Gorey A.
Isotopic and Trace Element Characteristics of an Unusual Refractory Inclusion from Essebi

Greenwood R. C.* Morse A. Long J. V. P.
Petrography, Mineralogy, and Mg Isotope Composition of Vicx: A Vigarano CoAl2O3-bearing Type B Inclusion

Casanova I.* Grossman L.
Distribution of Vanadium and Melting of Opaque Assemblages in Efremovka CAIs

Lindstrom D. J.* Keller L. P. Martinez R. R.
INAA of CAIs from the Maralinga CK4 Chondrite: Effects of Parent Body Thermal Metamorphism

Simon S. B.* Grossman L. Hsu A.
Petrography and Origin of Refractory Inclusions from the Murray and Murchison C2 Chondrites

Beckett J. R.* Stolper E.
The Stability of Hibonite and Other Aluminous Phases in Silicate Melts: Implications for the Origin of Hibonite-bearing Inclusions

Wang J.* Davis A. M. Hashimoto A. Clayton R. N.
Diffusion-controlled Magnesium Isotopic Fractionation of a Single Crystal Forsterite Evaporated from the Solid State

Nagahara H.*
Evaporation in Equilibrium, in Vacuum, and in Hydrogen Gas

Paillat O.* Wassburg G. J.
Self Diffusion of Alkaline-Earth in Ca-Mg-Aluminosilicate Melts. Experimental Improvements on the Determination of the Self Diffusion Coefficients
Friday, March 19, 1993
COMETS AND ASTEROIDS
8:30 a.m. Room B

Chairs: D. T. Britt and S. Murchie

Schulz R.* A'Hearn M. F. Birch P. V. Bowers C. Kempin M. Martin R.
\(C_p, \text{ CN and Dust in Comet Wilson (1987VII)}\)

Fomenkova M.* Chang S.
Mass and Spatial Distribution of Carbonaceous Component in Comet Halley

Hartmann W. K.*
The Physical Mechanism of Comet Outbursts: An Experiment

Heliocentric Zoning of the Asteroid Belt by Aluminum-26 Heating

Britt D. T.* Howell E. S. Bell J. F. Lebofsky L. A.
1.2- to 3.5-\(\mu\)m Observations of Asteroid 4179 Toutatis

Kelley M. S.* Gaffey M. J.
An Initial Perspective of S-Asteroid Subtypes Within Asteroid Families

Clark B. E.* Lucey P. G. Bell J. F. Fanale F. P.
Spectral Mixing Models of S-type Asteroids

Sunshine J. M.* Pieters C. M.
Determining the Composition of Olivine on Asteroidal Surfaces

Hiroi T.* Pieters C. M. Zolensky M. E.
Comparison of Reflectance Spectra of C Asteroids and Unique C Chondrites Y86720, Y82162, and B7904

Vilas F.* Hiroi T. Zolensky M. E.
Comparison of Visible and Near-Infrared Reflectance Spectra of CM2 Carbonaceous Chondrites and Primitive Asteroids

Murchie S.* Erard S.
The Spectrum of Phobos from Phobos 2 Observations at 0.3–2.6 \(\mu\)m: Comparison to Previous Data and Meteorite Analogs

Chapman C. R.* Neukum G. Veverka J. Belton M.
Cratering on Gaspra

Botke W. F. Jr.* Nolan M. C. Greenberg R.
Collision Lifetimes and Impact Statistics of Near-Earth Asteroids

Friday, March 19, 1993
EDUCATING YOUNG PEOPLE IN EARTH AND PLANETARY SCIENCES
8:30 a.m. Room C

Chairs: J. O. Annexstad and J. M. Boyce

Taylor G. J.* Lindstrom M. M.
Sparking Young Minds with Moon Rocks and Meteorites

Lindstrom M. M.* NASA Partners-in-Space Team
Spaceship Earth: A Partnership in Curriculum Writing

Lebofsky L. A.* Lebofsky N. R.
Teaching Planetary Sciences to Elementary School Teachers: Programs that Work

Allton J. H.* Allton C. S.
Encouraging Interest in Space Exploration and Planetary Science Among Navajo Primary Students

Barlow N. G.*
Encouraging Female Interest in Science and Mathematics

Postawko S. E.* Morrissey M. L. Taylor G. J. Mouginis-Mark P.
Schools of the Pacific Rainfall Climate Experiment

Metzger S. M.*
Do It Yourself: Remote Sensing: Generating an Inexpensive High-Tech, Real Science Lake Mapping Project for the Classroom

Tatsumura M. J.* Taylor G. J. Mouginis-Mark P. J.
Tumuli and Tubes: Teaching Scientific Techniques

Annexstad J. O.* Melchior R. C.
A Space Studies Curriculum for Small Colleges and Universities

Guinness E. A.* Arvidson R. E. Marin M. Dueck S.
The Planetary Data System Educational CD-ROM

French L. M.
Planetary Science and Astronomy in the Middle School Classroom
Tuesday, March 16, 1993
POSTER SESSION I
7:00--9:00 p.m. LPI

CHICXULUB, KT BOUNDARY, AND OTHER IMPACT EJECTA

Oriz Alemán C., Pilkington M., Hildebrand A. R., Roest W. R., Grieve R. A. F., Keating P.
Modelling the Gravity and Magnetic Field Anomalies of the Chicxulub Crater

Bohor B. F., Betteston W. J.
Arryopa El Mimbral, Mexico, K/T Unit: Origin as Debris Flow/Turbidite, Not a Tsunami Deposit

Clayes P., Alvarez W., Smit J., Hildebrand A. R., Montanari A.
KT Boundary Impact Glasses from the Gulf of Mexico Region

Pope K. O., Ocampo A. C., Baines K. H., Ivanov B. A.
Global Blackout Following the K/T Chicxulub Impact: Results of Impact and Atmospheric Modeling

Tyburczy J. A., Ahrens T. J.
Impact-induced Devolatilization of CaSO₄ Anhydrite and Implications for K-T Extinctions: Preliminary Results

Chen G., Ahrens T. J.
Shock Induced Reaction in Chicxulub Target Materials (CaSO₄ and SiO₂) and Their Relation to Extinctions

Bondy-Sanders S. Q., Hervig R. L.
Minor and Trace Element Composition and Age of Yukon Probable-Microtektites

IMPACT CRATERING AND SHOCK METAMORPHISM

Colwell J. E.
Power-Law Confusion: You Say Incremental, I Say Differential

Benz W., Ashbaugh E.
Explicit 3D Continuum Fracture Modeling with Smooth Particle Hydrodynamics

Modelling Hypervelocity Impacts into Aluminum Structures Based on LDEF Data

Housen K.
Simulation of Collisional Fragmentation with Explosives

Schultz P. H., Gault D. E.
Impactor Control of Central Peak and Peak-Ring Formation

Evans N. J., Ahrens T. J., Shahinpoor M., Anderson W. W.
 Projectile-Target Mixing in Melted Ejecta Formed During a Hypervelocity Impact Cratering Event

Cintala M. J., Grieve R. A. F.
Differential Scaling: Implications for Central Structures in Large Lunar Craters

A Fresh Look at crater Scaling Laws for Normal and Oblique Hypervelocity Impacts

Yanagisawa M., Ito T.
Antipodal Fragment Velocities for Porous and Weak Targets at Catastrophic Impacts

Reimold W. U., Le Roux F. G., Koeberl C., Shirey S. B.
Kalkskop Crater, Eastern Cape—A New Impact Crater in South Africa

Storzer D., Koeberl C., Reimold W. U.
The Age of the Pretoria Saltpan Impact Crater, South Africa

Wong A., Reid A. M., Hall S. A., Sharpn V. L.
Characterization of the Marquez Dome Buried Impact Crater Using Gravity and Magnetic Data

Xue S., Herzog G. F., Hall G. S., Klein J., Middleton R., Juenemann D.
Stable Ni Isotopes and ⁹¹Be and ⁶⁰Al in Metallic Spheroids from Meteor Crater, Arizona

Tonks W. B., Melosh H. J.
Core Formation by Giant Impacts: Conditions for Intact Melt Region Formation

Hartmann W. K., Gaskell R. W.
Confirmation of Saturation Equilibrium Conditions in Crater Populations

Chyba C. F.
Collisions of Small Spacewatch Asteroids with the Earth

Melosh H. J., Artemjeva N. A., Golub A. P., Nemchinov I. V., Shuvalov V. V., Trubetskaya I. A.
Remote Visual Detection of Impacts on the Lunar Surface

Wieczorek M. A., Mendell W. W.
Degradation Sequence of Young Lunar Craters from Orbital Infrared Survey

DIFFERENTIATED METEORITES

Drake M. J., Owen T., Swindle T., Musselwhite D.
Noble Gas Evidence of an Aqueous Reservoir Near the Surface of Mars More Recently than 1.3 Ga

Wentworth S. J., Gooding J. L.
Weathering Features and Secondary Minerals in Antarctic Shergottites ALHA77005 and LEE88516

Agerkvist D. P., Vistißen L.
Mössbauer Spectroscopy of the SNC Meteorite Zagami

Fisher D. S., Burns R. G.
Crosstie and Iron Sulfide Mineralogy of CM-type Carbonaceous Chondrites from Cryogenic Mössbauer Spectra
Brearley A. J.
*Carbonaceous Chondrite Cloths in the Kapoeta Howardite*

Nazarov M., Brandtstätter F., Kurat G.
*Carbonaceous Xenoliths from the Erevon Howardite*

Buchanan P. C., Zolensky M. E., Reid A. M., Barrett R. A.
*EET78713 Clast N: A CM2 Fragment in an HED Polymict Breccia*

Petaev M. I.
*Lamellor Olivine in the Divnne Achondrite: Evidence for High-Pressure Exsolution?*

Grady M. M., Pillinger C. T.
*EUROMET Ureilite Consortium: A Preliminary Report on Carbon and Nitrogen Geochemistry*

Petaev M. I., Clarke R. S. Jr., Olsen E. J., Jarosewich E., Davis A. M., Steele J. M.

TECHNIQUES AND EXPERIMENTAL STUDIES

Kubicki J. D., Stolper E. M.
*Evaporation Kinetics of Mg3SiO4 Crystals and Melts from Molecular Dynamics Simulations*

Borisov A., Palme H., Spettel B.
*The Solubility of Gold in Silicate Melts: First Results*

Boesenberg J. S., Detaney J. S.
*Preliminary Results of Mn Partitioning Experiments on Murchison Analogues*

Jurewicz S. R., Jones J. H.
*Experimental Partitioning of Zr, Ti, and Nb Between Silicate Liquid and a Complex Noble Metal Alloy and the Partitioning of Ti Between Perovskite and Platinum Metal*

*Microanalysis of Iron Oxidation State in Iron Oxides Using X-ray Absorption Near Edge Structure (XANES)*

TERRESTRIAL STUDIES

Liu Y.-G., Schmitt R. A.
*Earth’s Partial Pressure of CO2 Over the Past 120 Ma: Evidence from Ce Anomalies in the Deep (>600 m) Pacific Ocean, I*

Niedermann S., Bugster O., Hofmann B., Thalmann Ch., Reimold W. U.
*Dating Native Gold by Noble Gas Analyses*

Kurosawa M., Yurimoto H., Sueno S.
*Water in Earth’s Mantle: Hydrogen Analysis of Mantle Olivine, Pyroxenes and Garnet Using the SIMS*

*Primary Differentiation in the Early Earth: Nd and Sr Isotopic Evidence from Diamondiferous Eclogites for Both Old Depleted and Old Enriched Mantle, Yakutia, Siberia*

COSMIC RAY EFFECTS, ION IMPLANTATION, AND ORBITS

Masarik J., Reedy R. C.
*Effects of Bulk Composition on Production Rates of Cosmogenic Nuclides in Meteorites*

Wacker J. F.
*Aluminum-26 Activities in Meteorites*

Michlovich E., Elmore D., Vogt S., Lipschutz M., Masarik J., Reedy R. C.
*Production Profile and Model Comparisons in Canyon Diablo*

Shima M., Okada A., Nagao K.
*The Chondrite Milioneseki—New Observed Fall*

Pedroni A.
*Abundance and Composition of Solar Kr in the H3-H6 Chondrite Acfer111*

Sugiuira N., Futagami T., Nagai S.
*Implantation of Nitrogen: Effects of Hydrogen and Implantation Energy*

Punganis K. V., Graf Th., Marti K.
*Low-Energy Ion Implantation: Large Mass Fractionation of Argon*

Benoit P. H., Sears D. W. G.
*Meteorites from Recent Amor-type Orbits*

Jackson A. A., Zook H. A.
*Orbital Evolution of Dust from Comet Schwassmann-Wachmann 1: A Case of One-to-One Resonance Trapping*

REMOTE SENSING/SPACE WEATHERING

Clark B. E., Fanale F. P., Robinson M. S.
*Simulation of Possible Regolith Optical Alteration Effects on Carbonaceous Chondrite Meteorites*

*From Minerals to Rocks: Toward Modeling Lithologies with Remote Sensing*

Pieters C. M., Mustard J. F., Pratt S. F., Sunshine J. M., Hoppin A.
*Visible-Infrared Properties of Controlled Laboratory Soils*

Wilson L., Parfit E. A.
*Formation of Perched Lava Ponds on Basaltic Volcanoes: Interaction Between Cooling Rate and Flow Geometry Allows Estimation of Lava Effusion Rates*
SOLAR SYSTEM ORIGINS

Ruzmaikina T. V., Khatuncev I. V., Konkina T. V.
Formation of the Low-Mass Solar Nebula

Sears W. D.
Diffusive Redistribution of Water Vapor in the Solar Nebula Revisited

Boss A. P., Myhill E. A.
Initiating Solar System Formation Through Stellar Shock Waves

Malcev R. J., Winters R. R.
Tidal Regime of Infrag Deep Planetoid Capture Model for the Earth-Moon System: Does It Relate to the Archean Sedimentary Rock Record?

VENUS CRATERS

Ivanov M. A., Basilevsky A. T.
Density of Impact Craters on Tessera, Venus

Wood C. A., Tam W.
Morphologic Classes of Impact Basins on Venus

Wichman R. W.
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**TESTING THE DANTE ROBOT**

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Universities Space Research Association

Center for Advanced Space Studies

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