

Universe

Jet Propulsion Laboratory

I n s i d e

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Water hints on both sides of Mars

By Guy Webster

Above: This microscopic image of "Flatrock," taken on Opportunity's 43rd sol on Mars, is representative of the science team's goal at the rock outcrop under investigation at Meridiani Planum. Below: Spirit used its panoramic camera to capture this view of the rocky terrain just to the left of straight ahead after finishing a drive to the northeast on March 5.



JPL's Spirit rover has found hints of a water history in a rock at Mars' Gusev Crater, but it is a very different type of rock than those in which Opportunity found clues to a wet past on the opposite side of the planet.

A dark volcanic rock dubbed "Humphrey," about 2 feet tall, shows bright material in interior crevices and cracks that looks like minerals crystallized out of water, Dr. Ray Arvidson of Washington University, St. Louis, reported at a March 5 news briefing at JPL. He is the deputy principal investigator for the rovers' science instruments.

"If we found this rock on Earth, we would say it is a volcanic rock that had a little fluid moving through it," Arvidson said. If this interpretation is correct, the fluid—water with minerals dissolved in it—may have been carried in the original magma that formed the rock or may have interacted with the rock later, he said.

The clues appear in an interior exposure of Humphrey where Spirit's rock abrasion tool scraped away the rock's surface to a depth of 0.08 inch. To gain more confidence that the bright material seen in cracks and pores is not dust that has intruded from the surface over the millennia, scientists intend to have Spirit grind more deeply into another dark rock, not yet selected. The bright material is not debris from the grinding process, said Stephen Gorevan of Honeybee Robotics, New York, lead scientist for the abrasion tool.

The amount of water suggested by the possible crystals in Humphrey is far less than what is indicated by the minerals and structures that Opportunity has revealed in rocks at Meridiani.

On March 2, NASA announced that scientists have concluded the part of Mars that Opportunity is exploring was soaking wet in the past.

Evidence the rover found in a rock outcrop led scientists to the conclusion. Clues from the rocks' composition, such as the presence of sul-

fates, and the rocks' physical appearance, such as niches where crystals grew, helped make the case for a watery history.

"Liquid water once flowed through these rocks. It changed their texture, and it changed their chemistry," said Dr. Steve Squyres of Cornell University, principal investigator for the science instruments on the rovers. "We've been able to read the tell-tale clues the water left behind, giving us confidence in that conclusion."

The rover found a very high concentration of sulfur in the outcrop with its alpha particle X-ray spectrometer, which identifies chemical elements in a sample.

"The chemical form of this sulfur appears to be in magnesium, iron or other sulfate salts," said Dr. Benton Clark of Lockheed Martin Space Systems, Denver. "Elements that can form chloride or even bromide salts have also been detected."

At the same location, the rover's Moessbauer spectrometer, which identifies iron-bearing minerals, detected a hydrated iron sulfate mineral called jarosite. Germany provided both the alpha particle X-ray spectrometer and the Moessbauer spectrometer. Opportunity's miniature thermal emission spectrometer has also provided evidence for sulfates.

On Earth, rocks with as much salt as this Mars rock either have formed in water or, after formation, have been highly altered by long exposures to water. Jarosite may point to the rock's wet history having been in an acidic lake or an acidic hot springs environment.

The water evidence from the rocks' physical appearance comes in at least three categories, said Dr. John Grotzinger, sedimentary geologist from the Massachusetts Institute of Technology: indentations called "vugs," spherules and crossbedding.

Pictures from the rover's panoramic camera and microscopic imager reveal the target rock, dubbed "El Capitan," is thoroughly pocked with indentations about 0.4 inches long and one-fourth or less that wide, with apparently random orientations. This distinctive texture is familiar to geologists as the sites where crystals of salt minerals form within rocks that sit in briny water. When the crystals later disappear, either by erosion or by dissolving in less-salty water, the voids left behind are called vugs, and in this case they conform to the geometry of possible former evaporite minerals.

On Opportunity's 44th sol, ending at 12:10 p.m. PST on March 9, the rock abrasion tool ground a hole of just over one-tenth of an inch in the "Mojo 2" target on "Flatrock." On March 8, diagnostic testing determined a voltage adjustment was necessary to overcome some mechanism "stickiness" in the routine during which the rock abrasion tool finds the highest point in the target area.

Spirit completed another 94 feet of its drive toward the rim of Bonneville crater on sol 64, bringing its total odometry to 1,030 feet—45.9 feet past the minimum mission success criterion.

The rover had some difficulty finding a way around an obstacle during the last portion of a direct drive that safely maneuvered it through a field of rocks. Spirit is climbing up a very steep part of Bonneville now, and ended this sol's drive tilted at a forward pitch of about 15 degrees.



Spitzer reveals stellar nursery

By Whitney Clavin

In a small galaxy close to our own lies a luminous cloud of gas and dust, called a nebula, which houses a family of newborn stars. If not for the death of a massive star millions of years ago, this stellar nursery never would have formed.

The nebula, Henize 206, and the remnants of the exploding star that created it, are pictured in superb detail in a new image from the JPL-managed Spitzer Space Telescope. Henize 206 sits just outside our own galaxy, the Milky Way, in a satellite galaxy 163,000 light-years away called the Large Magellanic Cloud. It is home to hundreds and possibly thousands of stars, ranging in age from 2 million to 10 million years old.

"The image is a wonderful example of the cycle of birth and death that gives rise to stars throughout the universe," said JPL's Dr. Varoujan Gorjian, principal investigator for the latest observation.

As in other stellar nurseries, the stars in Henize 206 were created when a dying star, or supernova, exploded, shooting shock waves through clouds of cosmic gas and dust. The gas and dust were subsequently compressed, gravity kicked in, and stars were born.

Eventually, some of the stars will die in a fiery blast,

triggering another cycle of birth and death. This recycling of stellar dust and gas occurs across the universe. Earth's own Sun descended from multiple generations of stars.

The new Spitzer picture provides a detailed snapshot of this universal phenomenon. By imaging Henize 206 in the infrared, Spitzer was able to see through blankets of dust that dominate visible light views. The resulting false-color image shows embedded young stars as bright white spots, and surrounding gas and dust in blue, green and red. Also revealed is a ring of green gas, which is the wake of the ancient supernova's explosion.

"Before Spitzer, we were only seeing tantalizing hints of the newborn stars peeking through shrouds of dust," Gorjian said.

These observations provide astronomers with a laboratory for understanding the early universe, and stellar birth and death cycles. Unlike large galaxies, the Large Magellanic Cloud has a quirk. The gas permeating it contains roughly 20 to 50 percent of the heavier elements, such as iron, possessed by the Sun and gas clouds in the Milky Way. This low-metallicity state approximates the early universe, allowing astronomers to catch a glimpse of what stellar life was like billions of years ago, when heavy metals were scarce.

Henize 206 was first catalogued in the early 1950s by Dr. Karl Henize (pronounced Hen-eyes), an astronomer who became a NASA astronaut and flew aboard the Space Shuttle Challenger in 1985. He died in 1993 at age 66 while climbing Mount Everest.

The Spitzer image is available online at <http://www.spitzer.caltech.edu>.

Nebula Henize 206 as imaged by the Spitzer Space Telescope.



News Briefs



Dr. Michael Werner

Werner takes additional role

DR. MICHAEL WERNER has been named chief scientist of the Astronomy and Physics Directorate. Werner replaces DR. CHARLES BEICHMAN, who has been named executive director of Caltech's Michelson Science Center.

As chief scientist, Werner will have responsibility for the Astronomy and Physics Directorate's strategic science planning and science management. He will lead science-based initiatives both within JPL and with NASA and other potential sponsors. In addition, he will represent the directorate on the Science and Technology Management Council, and will play a continuing role as advocate for JPL science both within and external to JPL.

Werner will continue to serve as the Spitzer Space Telescope project scientist and leader of the Spitzer Science Working Group. He came to JPL from the Ames Research Center, where he served as SIRTf project scientist when the SIRTf Project was the responsibility of Ames. Previously, Werner was an assistant professor at Caltech from 1972-79. He earned a doctorate in astronomy from Cornell University in 1968.

Cassini releases Saturn image

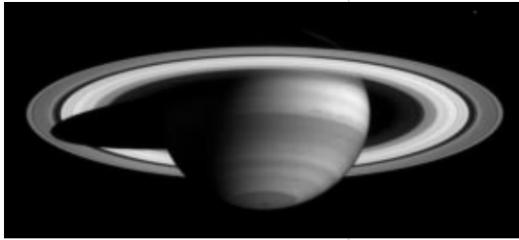
On its way to a summer rendezvous with Saturn, Cassini's narrow-angle camera took this image on Feb. 16 from a distance of 41.1 million miles through a special filter that reveals clouds and haze high in the atmosphere.

The image scale is 247 miles per pixel. The MT2 spectral filter samples a near-infrared region of the electromagnetic spectrum where methane gas absorbs light at a wavelength of 727 nanometers. In the image, methane gas is uniformly mixed with hydrogen, the main gas in Saturn's atmosphere. Dark locales are places of strong methane absorption, relatively free of high clouds; the bright areas are places with high, thick clouds that shield the methane below.

Image details reveal a high, thick equatorial cloud and a relatively deep or thin haze encircling the pole, as well as several distinct latitude bands with different cloud height attributes. It also shows a high atmospheric disturbance, just south of the equator, which has

persisted throughout the 1990s in images returned by the Hubble Space Telescope.

Cassini's narrow-angle camera took this image of Saturn on Feb. 16.



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Magazine honors Spitzer builders

Aviation Week & Space Technology magazine has honored the teams that built the Spitzer Space Telescope with a 2003 Aerospace Laurel award. The awards, now in their 47th year, recognize outstanding achievements in the global field of aerospace.

Team members at JPL and Ball Aerospace & Technologies Corp., Boulder, Colo., won in the "Space" category for redesigning Spitzer, which saved \$800 million and provided a powerful new instrument for studying the universe.

Formerly known as the Space Infrared Telescope Facility, Spitzer uses state-of-the-art infrared detectors to peer into the farthest, darkest and coolest reaches of space. To do this, it needs to stay cool; heat emitted by the spacecraft can interfere with its infrared detectors.

Engineers and scientists at JPL and Ball, building on an idea by Spitzer team member DR. FRANK LOW of the University of Arizona, solved this cooling problem with a clever redesign of past telescopes housed in large "thermos bottles." They shrank the thermos bottle to hold only the science instruments and the coolant, and planned for the first-ever Earth-trailing orbit, which takes Spitzer farther away from Earth's warmth. This innovative "warm launch" architecture allows the chilliness of space to do most of the cooling.

Launched in August 2003, Spitzer is the fourth of NASA's Great Observatories, a program that also includes the Hubble Space Telescope, Chandra X-ray Observatory and Compton Gamma Ray Observatory.

Section 353 honored at forum

Several members of Section 353 recently received honors at a national technology conference.

The Space Technology & Applications International Forum was held Feb. 8-11 in Albuquerque, N.M. The forum is organized by the Institute for Space and Nuclear Power Studies at the University of New Mexico. Attendance was up this year due to increased interest in nuclear power applications through Project Prometheus and the Jupiter Icy Moons Orbiter.

In the forum's "Conference on Thermophysics in Microgravity" category, Section 353 staff members KEITH NOVAK, CHARLES PHILLIPS, GAJANANA BIRUR, ERIC SUNADA and MICHAEL PAUKEN were awarded Outstanding Paper for 2003 for publication of "Development of a Thermal Control Architecture for the Mars Exploration Rovers."



On March 5, as Jupiter made its closest approach to Earth, the Voyager Flight Team reflected on this date 25 years ago when Voyager 1 flew closest to Jupiter. Last week, flight team members recalled the anxieties and the joys of the flyby—waiting for pictures to be returned and the many surprises revealed.

Scientists were surprised by many of Voyager's findings. Discovery of volcanoes on the satellite Io was the greatest surprise, according to Ed Massey, current manager of the Voyager and Ulysses projects. "It was the first time active volcanoes had been seen on another body in the solar system," he said. "Voyager also discovered a ring around the planet and observed auroral emissions in the polar regions."

The two Voyagers continued on to reveal new science at Saturn, Uranus and Neptune. And they still are providing new information about the outer reaches of the solar wind and the transition to interstellar space.

Correction: Office Professionals Mentoring Group

An article in the Feb. 27 issue of Universe on the Office Professionals Mentoring Group contained an incorrect application deadline. The actual deadline is Monday, March 22. For more information on the program, call Joy Hodges at ext. 4-7041.

Special Events Calendar

Ongoing Support Groups

Alcoholics Anonymous—Meetings are available. Call the Employee Assistance Program at ext. 4-3680 for time and location.

Caregivers Support Group—Meets the first Thursday of the month at noon in Building 167-111 (the Wellness Place). For more information, call the Employee Assistance Program at ext. 4-3680.

Codependents Anonymous—Meeting at noon every Wednesday. Call Occupational Health Services at ext. 4-3319.

Gay, Lesbian and Bisexual Group—Meets the first Friday and third Thursday of the month at noon in Building 111-117. Call the Employee Assistance Program at ext. 4-3680 or Randy Herrera at ext. 3-0664.

Parents Group for Children With Special Needs—Meets the second Thursday of the month at noon in Building 167-111 (the Wellness Place).

Working Parents Support Group—Meets the third Thursday of the month at noon in Building 167-111. For more information, call the Employee Assistance Program at ext. 4-3680.

Saturday, March 13

The Gizmo Guys—Allan Jacobs and Barrett Felker use juggling to demonstrate the science of patterns in this children's performance, set for 2 p.m. in Caltech's Beckman Auditorium. Tickets are \$12 for adults, \$7 for children. For more information, call (626) 395-4652.

Sunday, March 14

Chamber Music—The Juilliard String Quartet will perform at 3:30 p.m. in Caltech's Beckman Auditorium. Tickets are \$29, \$25, \$21 and \$17. For more information, call (626) 395-4652.

Monday, March 15

Beowulf Users Group Meeting—JPL partner Northrop Grumman Information Technology Pasadena will host from 11:30 a.m. to 2:30 p.m. at the Westin Pasadena, 191 N. Los Robles Ave. Dr. Thomas Sterling and Donald Becker, chief technical officer of Scyld Computing Corp., will speak. Free admission. For further information, contact Daniel Zormeier, program manager for Northrop Grumman IT, at (626) 351-1515 or Daniel.Zormeier@jpl.nasa.gov.

Tues.-Wed., March 16-17

"Purchasing at JPL"—This two half-day interactive course will be held in the 167 conference room from 8:30 a.m. to 12:30 p.m. and will explore the acquisition process from end-to-end. Those who purchase commodities or services using the services of the Acquisition Division should plan on attending. Register online at <http://jplregistrar.jpl.nasa.gov/stc/persreg>. Questions? Call Dana Edler (4-5825) or Aileen Batin (4-4281).

Thursday, March 18

"Remote Imagery and Supercomputing: A Match Made OnEarth"—At noon in the 167 conference room, Lucian Plesea of the Parallel Applications Technologies Group will describe OnEarth, a complete mosaic image of the Earth that is a combination of Linux storage clusters, parallel computers and high-performance networks, comprising 8,000 individual Landsat scenes.

Thu.-Fri., March 18-19

Von Kármán Lecture Series—"Return to Sender: The Stardust Sample Return Mission" will be presented by Project Manager Tom Duxbury at 7 p.m. Thursday in von Kármán Auditorium and Friday in Pasadena City College's Vosloh Forum, 1570 E. Colorado Blvd. Thursday's lecture will be webcast at <http://www.jpl.nasa.gov/events/lectures/mar04.cfm>. For more information, call Public Services at ext. 4-0112.

Friday, March 19

Investment Advice—Fidelity will offer one-on-one counseling in Building 249-114. For an appointment, call (800) 642-7131.

Mon.-Tues., March 22-23

Investment Advice—TIAA/CREF will offer one-on-one counseling in Building 249-114. For an appointment, visit www.tiaa-cref.org or call (877) 209-3140, ext. 2614.

Wednesday, March 24

JPL Toastmasters Club—Meeting at 5 p.m. in the 167 conference room. Call Debbi Llata at ext. 3-3690 for information.

Software Test Engineers, Unite!—Judy Cohen, technical group supervisor of the Mission Software Test and Integration Group, and John Veredge, software test engineer in the Mission Software Integration and Test Group, will discuss the formation of a JPL Software Test Guild, with the goal of improving the level of knowledge of the entire software test process within the JPL software community. To be held at 1:30 p.m. in the 238-543 conference room.

Thursday, March 25

Caltech Architectural Tour—The Caltech Women's Club offers this free tour, which is open to the public. Meet at the Athenaeum front hall, 551 S. Hill Ave., Pasadena. Tour begins at 11 a.m. and lasts 1 1/2 hours. For reservations, call Susan Lee at (626) 395-6327.

Clogging Class—This new class for beginners will be offered every other Thursday at noon in Building 300-217. For more information, call Shary DeVore at ext. 4-1024.

JPL Golf Club—Meeting at noon in Building 306-302.

Voyager 1 Jupiter flyby anniversary observed

Voyager team members celebrate the 1979 Jupiter flyby.

Main Gate upgrade underway

JPL's Main Gate remains closed due to construction for security upgrades and enhancements. The area north of the bus circle is closed to vehicle traffic in both directions.

The project will last until approximately mid-April. To alleviate some of the evening traffic volume, the South Gate will remain open 24 hours Monday through Friday to allow JPLers to exit the Lab.

JPLers are reminded to use the East Gate for on-Lab drive-on access, especially during the morning commute. By avoiding Oak Grove Drive, employees will reduce long queues and traffic bottlenecks. Access to the East Gate and East lot can be reached from Windsor and Ventura.

Access to the Blue lot is possible via Ranger Road from the north. Access to the West lot—Ranger Road to Mesa Road—is not affected. The visitor and annex lots also will not be affected. Arrangements will be made to accom-

modate on-Lab vehicle access after hours and weekends with the Security Officers at the Oak Grove checkpoint.

Pedestrian access from the West parking lots will continue to be available through the turnstiles, and crosswalks from the Blue lot will also be open. The Visitor Center will be used as an alternate pedestrian route when the normal sidewalks are impacted by construction.

JPL's Day Bus, Campus Shuttle and Woodbury Shuttle bus stops have temporarily relocated to the bus turnaround circle adjacent to the Visitor Center. The bus schedules will remain the same. MTA and local bus service will continue to make normal pickups and drop-offs at the bus circle.

JPLers are reminded to exercise caution in and around the construction area. For more information, call construction coordinator Frank Shanklin at ext. 3-0505.

SOUTHERN HEMISPHERE ADVENTURES



Lab missions go from frozen tundra to great heights



Tumbleweed Rover Goes on a Roll

By Natalie Godwin

A balloon-shaped robot explorer that one day could search for evidence that water existed on other planets has survived some of the most trying conditions on planet Earth during a 40-mile, wind-driven trek across Antarctica.

The tumbleweed rover, which is being developed at JPL, left the National Science Foundation's Amundsen-Scott South Pole Station on Jan. 24, and spent the next eight days rolling across Antarctica's polar plateau.

Along the way, the beach ball-shaped device, roughly 6 feet in diameter, used the global Iridium satellite network to send information on its position, the surrounding air temperature, pressure, humidity and light intensity to a ground station at JPL.

The test was designed to confirm the rover's long-term durability in an extremely cold environment, with an eye toward eventually using the devices to explore the Martian polar caps and other planets in the solar system.

The final tumbleweed rover is envisioned as a lightweight, roughly 88-pound device that can serve multiple roles as an independent robotic explorer. The rover's design can allow it to act in turn as a parachute while descending through an atmosphere; an airbag on landing; and, ultimately, as an unmanned vehicle equipped with a package of scientific instruments.

The tumbleweed rover is based on concepts going back to the 1970s and has been pursued by several investigators at JPL. Dr. Alberto Behar, a robotics researcher in the Robotic Vehicles Group, recently deployed this prototype at the South Pole. "We are testing a new mode of rover transportation that uses the available environmental resources to give us an added edge to cover more ground using fewer on-board resources," he said. "This gives us the ability to use the precious cargo (on Earth) or payload (in space) mass for more applicable science instrumentation."

Even though the average external temperature during the rover's deployment was recorded to be on average -22 degrees Fahrenheit, the rover kept its internal instrument payload at an average temperature of roughly 86 degrees Fahrenheit. The rover was able to stay warm by self-heating due to running electronics and an internal air pump.

The ultra-durable ball reached speeds of about 10 mph over the Antarctic ice cap, and traveled at an average speed of about 3.7 mph. The winds at the South Pole were unusually low during the test. As a result, there were several periods during its deployment when the rover did not move at all. Even taking those lulls into account, the rover managed an average speed of 0.8 mph over the course of the deployment.

Behar said the rover's design is especially well suited for polar missions to use instrument packages to look for water beneath a surface desert or an ice sheet, a task that cannot be done accurately from orbit.

Plans to construct the next-generation tumbleweed rover are already underway at JPL.

Future refinements of the design are likely to focus on reducing the rover's weight and rolling resistance to reduce the minimum winds needed to enable it to travel farther and the adaptation of the payload to include a ground-penetrating radar to conduct terrain and ice surveys.

Behar says he hopes an updated version of the rover will be deployed again later this year, and the design may one day find itself rolling on the polar icecaps of Mars.

Behar, who oversaw the design, construction, testing and deployment of the project, credited a number of JPLers who made significant contributions: Frank Carsey, science and design; Jack Jones, design consultant; Jaret Matthews, design, construct and test; Fabien Nicaise, ground station operator; Aaron Simo, ground station operator; Jiunn-Jenq (Jay) Wu, design consultant; and Evelyn Reed, administrative.

He also recognized the contributions of Waleed Abdalati of NASA Headquarters for program sponsorship, as well as science officer Vladimir Papitashvili and logistics officer Brian Stone, both from the National Science Foundation.

The tumbleweed rover project is managed by JPL and was supported jointly by NASA's Office of Space Science and the National Science Foundation.

For more information on the tumbleweed rover, visit <http://robotics.jpl.nasa.gov/~behar/southpoletw.htm>.

A Sweeping Airborne Expedition

By Alan Buis

An international team of scientists from NASA and other research institutions has embarked on a three-week expedition of discovery that will take them from the lush, dense rain forests of Central America to the frigid isolation of Antarctica.

Armed with a unique radar instrument, the team will survey selected sites in Central America to help unearth archaeological secrets, and to preserve resources and biological and cultural diversity. Then the scientists are off to South America's Patagonia ice fields and Antarctica to conduct topographic surveys of ice to better gauge the effect of climate change.

Despite these harsh, exotic locales, this expedition won't encounter a single snake or spider, and parkas are definitely not required. That's because the team's savvy tour guide is an all-weather imaging tool, the Airborne Synthetic Aperture Radar, or Airsar, developed and managed by JPL. Carried aboard a NASA DC-8 laboratory, Airsar can penetrate clouds and also collect data at night. Its high-resolution sensors operate at multiple wavelengths, polarizations and in interferometric modes. This means they "see" beneath treetops, and through thin sand and dry snow pack. The sensors can produce topographic models.



Drs. Ron Blom, Eric Rignot and Sassan Saatchi of JPL are leaders of the campaign's terrestrial science, cryospheric, and ecology and conservation science teams, respectively. They left NASA's Dryden Flight Research Center in California on the DC-8 bound for southern Mexico and Central America.

Rignot will continue on to Chile to survey Patagonian ice fields, and the Antarctic Peninsula.

Much of the archaeological evidence needed to understand Pre-Columbian societies in Central America comes from identifying and documenting features remaining on the landscape. Difficult terrain and logistics have limited ground-data collection. Previous remote-sensing techniques were unable to penetrate the forest canopy. Airsar is expected to detect features such as fortifications, causeways, walls and other evidence of advanced civilizations hidden beneath the forest. Images will shed insights into how modern humans interact with their landscape, how ancient peoples lived and what became of them.

In South America and Antarctica, Airsar will collect imagery and high-precision topography data to help determine the contribution of Southern Hemisphere glaciers to sea level rise due to climate change. In Patagonia, a recent study by NASA and others found the contribution more than doubled from 1995 to 2000 compared to the previous 25 years. Airsar will make it possible to determine whether that trend is continuing or accelerating.

Not much is known about the poorly mapped glaciers in the Antarctic Peninsula, an area 10 times larger than Patagonia. The area recently experienced rapid atmospheric warming, triggering a widespread retreat of floating ice shelves, reducing permanent snow cover and lengthening the melt season. Airsar will provide reliable information on ice shelf thickness to measure the contribution of the glaciers to sea level rise. It will also provide a precise topographic reference for comparison with satellite laser altimetry data from NASA's Icesat satellite and previous airborne data.

AirSar's 2004 campaign is a collaboration of many U.S. and Central American institutions and scientists, including NASA; the National Science Foundation; the Smithsonian Institution; National Geographic; Conservation International; the Organization of Tropical Studies; the Central American Commission for Environment and Development; and the Inter-American Development Bank.

For more information about Airsar and NASA's DC-8, visit <http://airsar.jpl.nasa.gov> and <http://www.dfr.nasa.gov/Research>, respectively.

Above: Dr. Alberto Behar led the tumbleweed rover mission to the South Pole.

Far left: Behar said the rover's design is especially well suited for polar missions to use instrument packages to look for water beneath a surface desert or an ice sheet.

Airsar will survey the topography of South America's Patagonia ice fields, shown at left.

Passings

E. LEE BRUBAKER, retired from Section 511, died Sept. 23. Brubaker worked at JPL for 27 years. He is survived by his wife, Dorothy.

ROY ARMOUR, who retired from Section 521 after 24 years of service, died Nov. 20. He is survived by his wife, Patricia.

JACK LASWELL, retired from Section 372 after 14 years of service, died Nov. 22.

KENNETH KAKTIN, retired from Section 661, died Dec. 8. Kaktin worked at JPL for 26 years. He is survived by his wife, Shirley.

JAMES EDWARDS, retired from Section 333, died Dec. 8. Edwards worked at JPL for 20 years. He is survived by his wife, Marilyn.

JOHN MCCONKEY, retired from Section 622 after 11 years of service, died Dec. 21.

SOLOMON ZVERDLING, who retired from Section 382 after eight years of service, died Dec. 27. He is survived by his wife, Evelyn.

JOHN KIEVIT, retired from Section 352, died Jan. 6. He is survived by his wife, Susan.

NATHAN BUROW, who retired from Section 330 after 39 years of service, died Jan. 28. He is survived by his wife, Edna.

Letters

My sincere appreciation to my JPL and Caltech colleagues for your flowers, cards and condolences on the passing of my father. Thanks also to JPL for the beautiful peace lilly.

Mary Wong

To my friends and colleagues: The kindness and generosity that you showed at the time of my grandfather's death are much appreciated. The flowers, phone calls and notes really meant a lot to me during this difficult time. The plant and sympathy card sent by the Laboratory lifted my spirits. Thank you for all your support.

Jean Iannitti-Sehic

I would like to thank the JPL ERC and the Cassini Project for the cards and the beautiful plant following my brother's passing. Losing my twin at such a young age was something that I had really never thought of until he got sick. Also, a very special thanks to Greg Chin, Herlen Reed and Dave Doody for all of their creative scheduling in order that I could be with my brother whenever he needed assistance.

John Tullius

Retirees

The following JPL employees retired in March:

Ronald Howe, 42 years, Section 324; Frederick Stuhr, 41 years, Section 334; Nancy Curran, 31 years, Section 430; Robert Klotz, 26 years, Section 360; Susan Henry, 18 years, Section 200.

Classifieds

For Sale

AQUARIUM, 75 gal., 48" W x 22" H x 13" D, 25" H wooden base and accessories, \$100. 661/291-1912, Rich.

BABY ITEMS: crib, wood, made in Italy, incl. matr., height adjustable, exc. cond., photo avail., \$150/obo; Century car seat, front-facing, up to 40 lbs., gd. cond., \$25/obo. 626/791-6101.

BED, Cometa queen, cherry wood, Italian design; see at <http://www.modfurniture.com/italian.html>; paid \$1,300 new, sell for \$850. 244-8822.

BIKE, mt'n., 1991 men's Schwinn High Plains model, 7 spd., integrated lock and chain, tire repair kit, pump, headlight, water bottle, bike rack for car, gd. cond., \$100/obo. 248-7331.

BOOKS, "John Carter of Mars," 11, paperback series, nr. mint cond., sold as set, \$22; paperbacks, "Conan," several, \$2/ea. 626/332-2682, Steve.

CANOE, Old Towne, Katahdyn, 16',

burgundy, used twice, approx. 6 yrs. old, retails for \$849, sell for \$600. 957-7742.

COMPUTER, Compaq Presario 4550, AMD K6, 233 MHz, 4MB HD, 48MB RAM, 56K modem, CD/Zip drive, 3.5" floppy, Windows 95; PRINTER, HP DeskJet, 722C, \$100. 626/644-1296.

DESK for computer, mobile, cherry veneer, made by O'Sullivan, model 61925, exc. cond., like new, sell for best offer. 626/449-0997.

DINING ROOM SET, mahogany, table (68" x 18") x 42," 6 chairs, buffet, exc. cond., \$1,000. 626/355-1293.

DRYER, Kenmore, 90-series, electric, 2 yrs. old, gd. cond., Santa Clarita area, \$200/obo. 661/816-4188.

DRYER, Kenmore basic model, gas, white, 10 yrs. old, exc. cond., \$50. 953-2841, Max.

DUFFEL BAG, Samsonite Outline 5, brand new, dark green, top-quality 1680D ballistic nylon, carry-on size (19" x 12" x 12"), padded handles/shoulder strap, large main packing area, exterior pockets, MSRP \$170, sacrifice at \$70/obo. 626/794-9579.

ENTERTAINMENT CENTER, all oak wood, gd. cond., fits 32" TV/stereo/books, etc., glass windows, \$200/obo. 686-0095.

EXERCISE MACHINE, Strider, elliptical path, full-stride w/heart rate monitor, Sharper Image #SR409, new; see at www.sharperimage.com, \$150. 661/297-0219.

EXERCISE MACHINE, pilates, exc. cond., \$80/obo. 248-7839.

FOOD PROCESSOR, Cuisinart, new, never used, Pro line II, stainless steel, value close to \$200, sell \$100. 352-4406.

FURNITURE: Bassett sectional, 2-piece, one is a sleeper, floral print; coffee table, 40" end tables (2), 26," mission style, photos avail., all in gd. cond., parts can be sold separately, \$500/obo. 626/791-6101.

GLASSES for drinking, "Apollo 13," set of 24, 10 oz., colorful red/white/blue w/stars im-prints; inscription: "Safe Return, A Triumph of Courage, Ingenuity, Teamwork." April 17, '70, USA, James Lovell Jr., Fred Haise Jr., John Swigert Jr., make offers. 626/482-7836.

GUITAR, Manuel Rodriguez Cutaway B, nylon-string, perfect cond., beautiful tone w/piezo and condenser pickup; see pics: www.fender.com, \$600. 626/432-1990, Kevin.

HEADBOARD, solid pecan wood, King sz., old, dk. finish, open ornate design. 626/798-3235.

INCOME TAX GUIDE BOOK for 2004, J.K. Las-ser's, w/forms, brand new, \$10; DIET TAPES, Jenny Craig, set of 14, \$25; COMPUTER POWER CONTROL CENTER, 5 power switches + 1 master switch, 5 surge-protected outlets + 2 modem/fax/phone jacks, new, \$20. 790-3899.

JACKET, dinner, men's, formal, burgundy, elegant, like new, sz. 40 long, for weddings, cruises, any formal occasion, \$100 value, sell \$25/offer; PILLOWS for bed, 2, standard sz., new in original wrap, fiber-filled, non-allergenic, \$5/ea. 626/793-1895.

JOGGER for baby, Instep, \$30; SECTIONAL, corner, 3-piece, leather, \$500; SLEEPER, loveseat, \$120; DINING TABLE, glass top, rattan, 4 matching chairs, \$100; LIGHT BULBS, 25, new, 40-watt, 4', fluorescent, \$20. 626/355-7086.

LOVESEAT, 5.5' long, floral design, soft shades, exc. cond., \$100. 626/644-1296.

MATRESS/BOX SPRINGS, + heavy frame, Simmons Beautyrest, "Dresden-Firm," CA King, new 4/02, used 1.5 yrs., perfect cond., paid over \$1,100 on sale, sell for \$500. 805/955-0331.

MIXER, Kitchen Aid, 5 qt., prof. bowl lift stand, approx. 6 yrs. old, white; incl. bowl, mixing paddle, dough hook, and wire whip, exc. working cond., \$150/obo. 661/298-4550.

ORGAN, Yamaha 415, electronic console w/13 pedals, 3 keyboards, 144 rhythm patterns, pd. \$7,500, sacrifice for \$2,000; PORT REPLICATOR, for IBM ThinkPad, works with T20, T21, A20, A21, or X, R series, like new, \$85; CONTROLLER CARD, Ultra ATA, w/cable, fits into 32-bit PCI 2.1 or 2.2 expansion slot on motherboard, brand new, \$20. 790-3899.

OVEN, GE, under-counter convection, blk., 220v, approx. 10 yrs. old, in storage for last 7 yrs., \$1,000 new, sell for \$450/obo. 661/298-4550.

PANTS for snowboarding/skiing, Kemper, men's, medium; women's, large, like new, \$20/ea. 626/254-1507, Emily.

PIANO, Kimball console, 41" tall, med. brown pecan finish, exc. cond., 20 yrs. old, incl. bench, \$900. 790-4028.

PURSES, Coach Station Bag, mahogany leather, \$60; Coach City Bag, tan leather, \$40; Coach City Bag, blk. leather, \$50; MATTRESS/ BOX SPRING/FRAME (2), Serta Perfect Sleeper, twin, \$300/ea; GRAND-FATHER CLOCK, Howard Miller, \$400. 626/793-3232.

ROASTER for oven turkey, self-basting cover, exc. cond., 15 x 11 x 7.5, \$30 value, \$8; DINNER BUN WARMER, electric, for the buffet, \$7; PLATES (6), 10," porcelain, nice pastoral patterns, \$9/all; DISH for baking, covered, 6," Pyrex glass, \$5; DISH for vegetables, 8," glazed porcelain, w/handles, \$5. 626/793-1895, Albert.

ROBOT, Evolution Robotics ER-1, never used, in box, requires laptop computer, \$160. 653-7099.

STOVE, gas, vintage, 1950s, O'Keefe & Merritt, 4-burner, center griddle, clean, works well, storage on left side, oven on right, even the clock works, \$195/obo. 310/392-9073 or Shuby753@comcast.net.

TENTS, Sears Hillary, 9 x 9 ft., fiberglass poles, vg. cond., 2/880. 626/797-6982.

WALL UNIT, 3-piece, 32" x 80" x 18"/ea., rosewood laminate finish, gd. cond., \$300. 626/355-1293.

Vehicles/Accessories

'01 CHEVY Cavalier, white, 4 dr., automatic, exc. cond., just smogged, \$4,700. 626/379-3503, Erik.

'00 CHEVY Corvette coupe, blk/blk., 14K

mi., 6 spd., hud, CD changer, ext. warranty, loaded, \$30K/obo. 248-5253.

'93 CHEVY Suburban 2500, 2 x 4, 350, V8, exc. cond., red, street scene front grill, well-maint., low mi., a/c, power doors/windows, wood trim dash, custom front seat/sheepskin covers, running boards, new tires w/Weld wheels and Flow Master exhaust, \$10,500/obo. 626/359-7666.

'83 CHEVY El Camino standard 2D, pickup shell, 98K mi., runs well, V8 305 engine, will carry 4 x 8 plywood flat in bed, automatic, brown w/yellow top, \$3,000/obo. 626/444-6691, Forrest Janes.

'72 CHEVY El Camino 396 SS Malibu, 375 HP, runs strong, cowl hood, Holley Street Avenger dbl. pump carb, Edelbrock performer manifold, headers, cam Turbo 350 w/B&M shifter, rally pk., Mallory ignition & dist., new ft. shocks, rally wheels, dress-up kit, bucket seats, much more, smog exempt; \$13,900/obo. 661/993-9239.

'95 DODGE Ram, 1500 SLT pickup, blk., exc. cond., Fabtech lift kit, Flow master exhaust, Kenwood CD stereo system w/amp and subs, tinted windows, newly carpeted, recently serviced and smogged, euro tail lights, bed liner, 119K mi., \$7,400/obo. 247-3637.

'98 FORD Explorer Sport, automatic, 49K mi., light blue, 2WD, power windows, keyless entry, alarm, 2 dr., very clean, ext. warranty, all records, exc. maint., \$7,995/obo. 626/943-9779.

'91 FORD Aerostar van, Eddie Bauer, 4.0 V6, dual a/c, 117K mi., CD player, loaded, needs little work, runs well, \$2,800/obo. 626/797-4173.

'00 HONDA Accord EX coupe, V6, blk., factory spoiler/fog lights, sunroof, leather, new tires, 50,500 mi., exc. cond., \$13,500. 323/842-2042.

'00 HYUNDAI Tiburon SC, vg. cond., automatic, sunroof, \$7,999/obo. 626/487-6208.

'94 ISUZU Trooper LS, 4 dr., 4WD, V6, 3.2L DOHC, automatic locking hubs, antilock brakes, cruise control, alarm, am/fm stereo, 12-CD player, white, exc. shape, tinted windows, new a/c & transmission, pwr. steering/windows/locks, tilt wheel, rear window defroster/wiper, exterior spare tire carrier, \$6,800/obo. 957-3296.

'98 JEEP Grand Cherokee Special Edition, 5.2L, V8, 4WD, 75K mi., pwr everything, cruise control, cassette, CD, premium sound, dual airbags/pwr. seats, moonroof, roof-rack, tinted windows, tow pkg., tilt wheel, oversized tires w/new spare, premium wheels, 4 wheel ABS, lots of aftermarket additions, must sell, great cond., pics. avail., \$10,900/obo. 352-6646, Ben or verdugo_verde@comcast.net.

'93 JEEP Grand Cherokee Laredo, white, 4.0L, 6 cyl., 4WD, gd. cond., \$3,900. 957-8463.

'92 PLYMOUTH Grand Voyager, charcoal gray, 3.3L, V6, gd. cond., runs well, \$1,850. 957-8463.

'98 SATURN SL2, 4 dr., automatic, loaded, exc. cond., \$3,900. 626/379-3503, Erik.

'02 TOYOTA Highlander, V6, alloy wheels, a/c, power everything, moonroof, roof rack, tow package, privacy glass, am/fm/CD, huskyliner rubber mats and cargo liner (OEM mats incl.), white w/gray cloth interior, absolutely pristine, 16K mi., sell for \$24,000/obo. 653-8565, Ken.

'01 TOYOTA Prius, hybrid, great commuter car, 44-50 mpg, 4 dr., automatic, air, CD, keyless entry, 60K mi., white, 100K mi. warranty on battery, owner just bought a new Prius, \$11,800. 626/319-9585, Frank.

'00 TOYOTA Tundra Limited, all power, ABS, 6-CD, tow package, snug tog w/carpet kit, 56K mi., \$17,900. 909/596-9007.

TRAILER HITCH for 5th wheeler, 15,000 lb. slider, no rails, very gd. cond., \$375. 909/596-8039.

'76 TRIUMPH motorcycle, 750 cc, twin cylinder, model T-120, all orig., professionally maint., exc. cond., \$3,000. 714/231-8591.

'96 VOLKSWAGEN Jetta GLS, 4 dr. sedan, 2L, 5 spd., 96K mi., a/c, power windows/doors/locks, cc, tilt wheel, am/fm/cass., moonroof, new registration, great MPG, \$3,400. 626/355-7086.

Free

CATS (2), 14 yrs. old, due to new baby and issues with allergies; friendly; one is a lap cat; both are indoor only; to good home, can be adopted separately. 661/263-2993.

COMPUTER, Sun SPARCStation 2 w/16" color monitor, 64 MB RAM, no disks/keyboard, can run Sparc Linux or Sun/Solaris OS (neither included), 368-8649 or tefs@aprelix.com.

FILL DIRT, clean, 12 cu. yds. avail., as much as you like, nr. Los Robles/Jackson, Pas. 626/791-3103, or dtrask6@its.caltech.edu.

KITTENS, to good home, 323/854-0914 or 323/221-7249.

MATTRESS, twin, standard length w/box spring, approx. 75 x 39," pick up from S. Pasadena. 626/403-9374.

Wanted

HIKING TRIP LEADERS for JPL Hiking trips: car camps, day hikes, slide shows, anything outdoors; this year trip leaders get free admission to hiking; trip leaders organization meeting Monday, March 15, 6-7 p.m., 301-169; see <http://www.jplrecreclubs.caltech.edu> hiking for details. RAQUETBALL PLAYERS: all levels invited to join Caltech Racquetball Club, Caltech Gym membership is prerequisite; JPL badge is sufficient for eligibility; for lessons, drop in Wednesdays, challenge ladder, tournaments and other events, \$10/year; info at <http://www.athletics.caltech.edu/Recreation/#Braun> or <http://www.its.caltech.edu/~rball>. SPACE INFORMATION/memorabilia from U.S. & other countries, past & present, for personal use. 790-8523, Marc Rayman.

For Rent

ALTADENA room, quiet neighborhood, nr. Woodbury and New York, 3.3 mi. to JPL,

beautiful hardwd. floors, fireplace, washer/dryer, kitchen privileges, util. incl., high-speed internet and cable avail. at add'l cost, \$500. 626/345-0625.

ALTADENA house, 5 bd., 2 ba., 5 min. to JPL, fenced yard, pets ok, new carpets, plumbing, hardwd. floors, \$2,300 w/lease. 626/798-5796.

ALTADENA house to share, 2 bd., 1 ba., living and dining area, sits just above the East Lot, walk to work, lots of storage space, DSL, somewhat furnished, quiet cul-de-sac, \$600 + \$500 dep. 626/222-6943.

ALTADENA rear house, W. Mariposa, nr. JPL, 1 bd., 1 ba., new windows/blinds/ kitchen tile/carpet/flooring/paint, water/trash/gardener pd., \$875. 626/797-4273.

ARCADIA condo, 2 bd., 2 ba., partially furnished, a/c, secured complex, pool and washing facility; 1200 E. Huntington Drive at Michillinda, \$1,400 + util. + \$1,500 sec. dep. 626/794-6606, Sandy Harlan.

GLENDALE house, 2 bd., 1 ba., lg. kitchen, 1-car garage, easy care yard, located on Adams Hill, 15 min. from JPL, avail. mid-March, \$1,475. 661/254-4464, Fred or Marian Tomey.

LA CRESCENTA house, Upper Briggs Terrace, spectacular views, quiet, isolated, 2 bd., 1.5 ba. + lg. artist view loft over lg. garage, all on rim of 300-acre canyon, new kitchen installed, 1/3 acre, hot tub, 15 min. to JPL, will consider small pet, deer/critters often seen; 2325 Maurice Ave., avail. 4/1/04, maybe sooner; \$2,500 + 2 mo. sec., 1 yr. lease. 310/322-8513, Jim.

MONROVIA, attractive condo share, garaged parking, lg. room, priv. ba. (bath & shower), dressing rm., priv. enclosed patio, pool/spa, sauna, shared kitchen & living rm., DSL Internet, cable TV, laundry facilities, no pets/smoking, must not be allergic to cats, \$700 incl. util. 626/422-9892.

PASADENA home for lease, 2 bd., 2 ba., hardwd. floors in living and dining rms., beautiful fireplace w/hardwd. mantle, remodeled kitchen, laundry rm., convenient location on tree-lined street, nr. Rose Parade route, new paint/carpet, \$1,800 incl. gardener; 76 N. San Marino Ave. 626/796-7222.

PASADENA house on private street in Madison Heights, 2 bd., 2 ba., office, hardwd. floors, cent. air/heat, lg. living room and updated kitchen, stove, dishwasher, fireplace, ample natural light, brick patio, 1-car garage, gardener, washer/dryer, non-smoker, avail. after 3/15, \$2,400. 626/793-3983.

PASADENA apt., nice, 1 bd., 1 ba., hardwd. floors, incl. water, close to 210 fwy., \$600. 626/798-9169, Dino.

PASADENA condo to share; quiet, excellent location; lg., freshly painted, very private wing (room+bath w/generous closets), shared kitchen, living room, lg. balcony w/peaceful view, laundry facility, secure parking; Calif/Los Robles; female preferred; \$470. 626/796-9221.

PASADENA, Caltech's Health Educator seeking non-smoking, cal-friendly roommate to share 2 bd., 2 ba. condo, 3 blocks from campus, unfurnished bd. + priv. ba., cent. air/heat, fireplace, lg. balcony, lots of closet space, laundry, parking, terrific location, avail. April 1, 1 yr. lease, 1 mo. sec. dep., \$800 plus 1/2 gas and electric. 626/833-2961.

PASADENA apt., furnished and unfurn., 2 bd., 1.5 ba., 2-story townhome-style, dishwasher, cent. a/c, refrig. & stove, laundry room, patio, parking, close to Caltech & JPL, \$1,095-\$1,125/+ util. 626/577-3060, ext. 14, Dennis.

PASADENA bungalow home for lease, nr. JPL/Caltech, fireplace, wood floors, 3 bd., one is a master bd., 2 ba., nice kitchen, lots of storage, laundry room, 2-car garage w/working shop area, enclosed back yard w/fruit trees and flowers, gardener, no pets, \$1,500 + \$1,500 sec. dep. 626/794-0455.

VALENCIA house, 1st time rent, 4 bd., 2 ba., remodeled kitchen & ba., immaculate tile + berber carpet, fireplace, big backyard, covered patio, 2-car garage, California distinguished school, vanpool to JPL; avail. May, \$2,100. 661/430-0800.

Vacation Rentals

BALBOA ISLAND, cute upstairs apartment, fully furnished, 2 bd., 1 ba., deck, parking, laundry, steps to bay, slps. 5; avail. weekly, June-September, \$1,000-\$1,500/week. 626/429-3677 or bettyrs@earthlink.net.

BIG BEAR LAKEFRONT luxury townhome, 2 decks, tennis, pool/spa, nr. skiing, beautiful master bd. suite, slps. 6. 949/786-6548.

CABO SAN LUCAS, 1 bd., 5-star resort, slps. 4, on the beach, a/c, 2 pools, tennis court, spa, salon, restaurant and bar on site, short walk to town, nearby activities include fishing, golf, and horseback riding, \$600/week before July. 368-8649 or tefs@aprelix.com.

HAWAII, Maui condo, NW coast, ocean front view, 25 ft. fr. surf, 1 bd. w/loft, compl. furn., phone, color TV, VCR, microwave, d/w, pool, priv. lanai, slps. 4, laundry fac., low season rate \$115/nite/2, high season rate \$130/nite/2, \$15/nite/add'l person. 949/348-8047 or jackandrandy@cox.net.

MAMMOTH, Snowcreek, 2 bd., 2 ba., + loft, slps. 6-8, fully equip'd kitchen incl. microwave, D/W, cable TV, VCR, phone, balcony w/view to mtns., Jacz., sauna, streams, fishpond, close to Mammoth Creek, JPL disc'nt. 626/798-9222 or 626/794-0455 or valeriee@caltech.edu.

OCEANSIDE condo, on the sand, charming, 1 bd., panoramic view, walk to pier & harbor, pool/spa, game room, slps. 4. 949/786-6548.

RESORTS, 5-star; incl. Carmel, Tahoe, Sedona, Colorado Rockies and Florida; luxurious residential-style studios w/furnished kitchenette, starting at \$511 for 7 nts; larger units w/1-3 bd., living rm., full kitch. 626/794-9579 or fivestarresorts@earthlink.net.

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