The Planetary Science Institute is a private, nonprofit 501(c)(3) corporation dedicated to Solar System exploration. It is headquartered in Tucson, Arizona, where it was founded in 1972.

PSI scientists are involved in NASA and international missions, the study of Mars and other planets, the Moon, asteroids, comets, interplanetary dust, impact physics, the origin of the Solar System, extra-solar planet formation, dynamic evolution of planetary systems, the rise of life, and other areas of research. They conduct fieldwork on all continents around the world. They also are actively involved in science education and public outreach through school programs, children’s books, popular science books and art.

PSI scientists and educators are based in 25 states and the District of Columbia, and work from various international locations.

**PSI Board of Trustees**

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**ON THE COVER:**

“Somewhere, Sometime on Mars”
Acrylic painting by William K. Hartmann, co-founder and Senior Scientist Emeritus at the Planetary Science Institute.

This painting was made at Arches National Park, transforming a view of South Window Arch into a future Martian scene by deleting vegetation, altering sky color, and adding a foreground impact crater typical of newly formed impacts being discovered on Mars.

Formation of arches at the National Park involved the dissolving of ancient soluble deposits in an ancient inland sea, and it seems plausible that similar processes could have happened in ancient, lake-filled craters on Mars.
PSI was honored this year by the generous donation of $40,000 to the Pierazzo Memorial Fund by Senior Scientist Michelle Thomsen. This fund supports the Pierazzo International Student Travel Awards, named in honor our late Senior Scientist Betty Pierazzo. They provide $2,000 to a graduate student at a U.S. institution to travel to a planetary-related meeting outside of the U.S., and another $2,000 to a graduate student at a non-U.S. institution to travel to a planetary-related meeting within the U.S. Dr. Thomsen’s gift now makes these awards self-sustainable and a permanent part of what PSI does as an institution.

The Dawn mission came to an end this year, going silent as it orbited the dwarf planet Ceres, gathering the highest resolution images yet of the cryovolcanic dome in Occator crater (dramatically white against the dark background of Ceres). High resolution gamma-ray and neutron detector data were obtained, further teasing out the elemental composition of Ceres. There are years of analysis ahead. More than 24 scientists now at PSI have worked on Dawn.

Basic research can be critical to the design of missions. Studying the scattering properties of water ice at very low phase angles, Senior Scientist Robert Nelson and his group determined that the surface of Jupiter’s icy Europa would have a very low density, comparable to freshly fallen snow. The planned Europa Lander may need to have large-area landing pads or a very long antenna!

Science means being open about changing our minds with new information. Senior Scientist Roger Clark came up with a new method for remotely measuring isotopic ratios of carbon dioxide and found that the water in Saturn’s rings and satellites is unexpectedly like water on the Earth, but that its moon Phoebe’s water is very unusual and may indicate an origin in the outermost reaches of the Solar System. This motivates some rethinking of models of Solar System formation which predict very different isotopic ratios of water at Earth and Saturn.

We embrace Solar Systems around other stars, where Senior Scientist Amy Barr Mlinar identified two planets orbiting TRAPPIST-1 as potentially habitable. The Earth is also a planet, and Senior Scientist Jeff Kargel studies glaciation on Mars and in the Himalayas. His research has reduced the hazards to villages in Nepal of high-altitude lakes and avalanches, for which he was awarded the Nepal Geographical Society Honorary Life Membership. Finally, the Sun is part of the Solar System. Associate Research Scientist Elizabeth Jensen made a major discovery of trailing components of a Coronal Mass Ejection. CMEs can cause problems with satellites orbiting the Earth and electrical grids. These new structures can have a significant impact on how we prepare for and mitigate these potentially very disruptive events.

Senior Scientist Faith Vilas was awarded the 2018 Harold Masursky Award for meritorious service to planetary science. One of the many things for which she was honored was her insuring the integrity of the Discovery mission selection process in the aftermath of the 9/11 attack, which occurred during rehearsal for the Dawn site visit at Orbital Sciences near Dulles Airport. I was there, and her taking charge of a situation in chaos to shut things down while figuring out in real time how to restart the process later in a way that was fair was a sight to behold.

Other PSI scientists being recognized this year include Senior Scientist Darby Dyar, who received the Shoemaker Distinguished Science Medal from NASA’s Solar System Exploration Research Virtual Institute for a career of significant contributions to laboratory studies. Senior Scientist David Grinspoon was awarded the Shoemaker Memorial Award for his lifework including the planetary-scale dilemmas we face as a species. Senior Scientist Amara Graps received the Europlanet Prize for Public Engagement with Planetary Science for her extensive activities in the Baltic states. Finally, Senior Scientist Candice Hansen was awarded NASA’s Outstanding Public Leadership Medal for JunoCam, which has given us images of Jupiter that have been startling in their beauty, revealing complex storms and atmospheric processes never before seen.

PSI lost a great friend, mentor and benefactor this year. Michael J.S. Belton was a world-renowned expert on comets, a broad thinker and pianist. He was generous with his ideas, and inspired many young scientists over the years, including myself. As a member of the PSI Board of Trustees, he played an important role in the generation of our strategic plan. Mike and his wife, Anna Don, established a fund to support a series of Belton Symposia, which will span at least the next 20 years and shape the future of comet nucleus studies. He will be deeply missed.

— Mark V. Sykes
Darby Dyar Honored for Lunar/Asteroid Science Contributions

Senior Scientist Darby Dyar received the Eugene Shoemaker Distinguished Science Medal from NASA’s Solar System Exploration Research Virtual Institute (SSERVI) for her significant contributions to the field of lunar and/or asteroid science throughout the course of her scientific career.

SSERVI said: “Dyar has had a distinguished career spanning more than 30 years in which she authored 242 peer reviewed publications. Her areas of expertise are numerous, including optical mineralogy, crystal chemistry, and numerous spectroscopic techniques. In recent years she has also revolutionized the use of machine learning techniques in the analysis and interpretation of X-ray absorption spectra. The careful laboratory work and model development that she has led throughout her career have enabled thousands of other papers that have utilized the data she has generated; her work will prove to be substantially more important than any single mission. Without Dyar in our field for the last 30 years, our understanding of planetary processes and the interpretation of various mission data would be much poorer.”

Amara Graps Recognized for Work in Planetary Science Communication to General Public

Senior Scientist Amara Graps was awarded the 2018 Europlanet Prize for Public Engagement with Planetary Science for her far-reaching work to inspire and promote space activities in the Baltic region within the scientific and industrial communities, in education and in wider society.

The prize recognizes and honors outstanding communication to the general public in planetary science by an individual or an institution. It is awarded to individuals or groups who have developed innovative practices in planetary science communication, and whose efforts are contributing significantly to a wider public engagement with, and enthusiasm for, planetary science.

Graps, based in Riga, Latvia, was recognized for her efforts to bridge gaps that exist that prevent the general public from understanding, and embracing, developments in planetary science. She is the founder of the not-for-profit organization, Baltics in Space. Graps’ work with Baltics in Space supported the successful European Planetary Science Congress (EPSC) 2017, sponsored by PSI, which took place in Riga Sept. 17-22, 2017. The event made a significant contribution to raising the profile of space in Latvia and the Baltics with audiences ranging from members of Parliament and Ministries, business, the media, educators and schools.

David Grinspoon Honored for Life and Work

Senior Scientist David Grinspoon received the 2018 Eugene Shoemaker Memorial Award Oct. 2 at Arizona State University.

The award, presented by ASU’s Beyond Center for Fundamental Concepts in Science, is given annually to a leading scientist in honor of his or her life and work. It is named for Shoemaker, who is known for pioneering research with his wife, Carolyn, in the field of asteroid and comet impacts.

Candace Hansen Receives Medal for JunoCam Work

Senior Scientist Candice Hansen received NASA’s Outstanding Public Leadership Medal for her work on the JunoCam camera that is taking amazing images of Jupiter.

Hansen is a Co-Investigator on the Juno mission now orbiting Jupiter, responsible for the development and operation of the JunoCam outreach camera that engages the public in planning images of Jupiter. Amateur astronomers supply images from their backyard telescopes for planning. Citizen scientists and artists download raw images and then contribute their own processed versions to the JunoCam online gallery (https://www.missionjuno.swri.edu/junocam/processing).

The NASA Outstanding Public Leadership medal is awarded to non-government employees for notable leadership accomplishments that have significantly influenced the NASA mission. This includes sustained leadership and exceptionally high-impact leadership achievements that demonstrate the individual’s effectiveness in advancing the agency’s goals and image in present and future terms.

Jeff Kargel Recognized for Himalayan Work

Senior Scientist Jeff Kargel was awarded the Nepal Geographical Society Honorary Life Membership on the basis of his work on Himalayan natural hazards and geomorphology.

That work included applied science and science in support of humanitarian activity, including his response to the 2015 earthquake in Nepal, his research that led to the lowering of Imja Lake to reduce its hazard, and work regarding several other natural disaster events and hazards. The work for which he was recognized also included the basic science examination of glacial lake accelerated melting

PSI SCIENTISTS GARNERED MANY PRESTIGIOUS AWARDS DURING 2018
of glaciers, the mass balance of Himalayan glaciers, and the role of lithology and bedrock geology in controlling landslides.

Faith Vilas Receives Masursky Award for Meritorious Service

The Division for Planetary Sciences (DPS) of the American Astronomical Society gave the 2018 Harold Masursky Award for Meritorious Service to Planetary Science to Faith Vilas. Vilas is the Deputy PI for SSERVI's Toolbox for Research and Exploration (TREX) team led by PSI’s Amanda Hendrix.

"DPS awards the 2018 Harold Masursky Award for meritorious service to planetary science to Faith Vilas. During a time of national duress following the chaos of the 9/11 attack, she insured the integrity of the Discovery program selection process. As the first Chair of the NASA Small Bodies Assessment Group, she established its operational practices and made it the viable entity that continues today," the DPS citation said.

AWARD-WINNING SCIENTISTS

From left to right: Darby Dyar (photo credit: Molly McCanta); Amara Graps; Candice Hansen; and Jeff Kargel

"As Chair of the DPS, Vilas played a key role in establishing the Carl Sagan Medal, which was the first major statement in support of the importance of communicating our science with the public. She has mentored and inspired young people who have become well-known figures in our profession, and others who have taken an appreciation of our science into other careers. She has served on numerous Academy and NASA panels. Her service to the field and to society has been exemplary."

The Harold Masursky Award for Meritorious Service to Planetary Science was established by the DPS to recognize and honor individuals who have rendered outstanding service to planetary science and exploration through engineering, managerial, programmatic, or public service activities.

2018 NASA GROUP ACHIEVEMENT HONOR AWARDS

A number of PSI scientists received 2018 NASA Honor Awards, Group Achievement Awards, including:

- **Bruce Barraclough**, Cassini Plasma Spectrometer Team
  For significant science contributions by the Cassini Plasma Spectrometer team to the Cassini mission.

- **Roger Clark** and **Emily Joseph**, Visual and Infrared Mapping Spectrometer Team
  For exceptional contributions to the Visual and Infrared Mapping Spectrometer Investigation during Cassini’s Solstice and Grand Finale Mission.

- **Candice Hansen**, Juno Mission Re-Design Team
  For excellence in defining, assessing and implementing a major mission re-design resulting from remaining in a 53-day orbit.

- **Candice Hansen**, JunoCam Imaging and Public Engagement Team
  For outstanding engagement of the public to participate in the acquisition and processing of raw images from JunoCam at Jupiter.

- **Candice Hansen** and **Amanda Hendrix**, Ultraviolet Imaging Spectrograph Science Team
  For outstanding contributions to understanding the Saturn system using ultraviolet imaging and spectroscopy during Cassini’s Solstice and Grand Finale missions.

- **Amanda Hendrix**, Cassini Project Science Team
  For exceptional achievement in maximizing the overall scientific success of the Cassini Solstice mission within project constraints, thus enabling unprecedented science return.

- **Charles Wood**, Cassini Radar Science and Operations Team
  For exceptional Cassini Radar Team performance in the operations and analysis during Cassini’s Solstice Mission and Grand Finale resulting in unprecedented science return.
PSI scientists working on NASA’s Juno mission continue to learn more about Jupiter and its moons.

Large cyclones have been discovered clustered around Jupiter’s poles by NASA’s Juno spacecraft. The circumpolar cyclones were discovered on Juno’s first pass over Jupiter’s poles, and subsequent data has revealed how remarkably stable they are. The circumpolar cyclones ring a single cyclone at each pole.

Using visible images from NASA’s JunoCam camera headed by PSI Senior Scientist Candice Hansen, and infrared images obtained by the spacecraft’s Jovian Infrared Auroral Mapper (JIRAM), researchers found eight circumpolar cyclones arranged around a single northern polar cyclone and five circumpolar cyclones encircling a southern polar cyclone.

“Jupiter’s circumpolar cyclones are unique; the polar regions are unlike any of the other gas giants,” said Hansen, JunoCam instrument lead and Juno Co-Investigator. “The circumpolar cyclones in the north are as big as the continental United States. The cyclones in the south are even larger.

“And they are surprisingly stable. They are identifiable from one close pass to the next, with a 53-day separation, and they are in a very stable configuration – no new ones have spun up, no old ones have dissipated,” she said.

Wind speeds measured 580 miles from the center of these giant storms range from 100 mph to 220 mph, she said.

The study of two potential plume sites on Jupiter’s moon Europa has shown a lack of expected hotspot signatures, unlike Enceladus where plumes have a very clear and obvious temperature signature, research by PSI Senior Scientist Julie Rathbun shows.

“We searched through the available Galileo thermal data at the locations proposed as the sites of potential plumes. Reanalysis of temperature data from the Galileo mission does not show anything special in the locations where plumes have possibly been observed. There are no hotspot signatures at either of the sites,” Rathbun said. “This is surprising because the Enceladus plumes have a clear thermal signature at their site of origin, so this suggests that either the Europa plumes are very different, or the plumes are only occasional, or that they don’t exist, or that their thermal signature is too small to have been detected by current data.”

Plumes are jets of gas that are sent upward from a planet’s surface, similar to Old Faithful in Yellowstone National Park. For the gas to be shot upward, an energy
source is needed. Generally, that energy source will also heat the surface around the plume source, like we see in Yellowstone with hotspots at the geysers and hot springs nearby. This is also what is seen on Enceladus, a hot region where the plumes erupt from Enceladus’ surface. The hot spots at Yellowstone and Enceladus are unmistakable and readily observed. The lack of a hotspot at Europa suggests the plumes there are very different, if they exist at all.

Rathbun’s findings, titled “A closer look at Galileo thermal data from possible plume sources near Pwyll, Europa,” were presented at a press conference at the Division for Planetary Sciences of the American Astronomical Society 50th annual meeting in Knoxville, Tenn.

Rathbun’s work follows up on earlier observations that suggested a plume originating from an area north of Pwyll on Europa, and reanalysis of Galileo magnetometer and plasma data also suggests a plume source about 1,000 kilometers northeast of the first site.

Hansen’s efforts to engage citizen scientists in furthering the study of Jupiter saw continued success.

Hansen oversees the JunoCam outreach camera program that engages the public in planning images of Jupiter resulted in many amazing images of Jupiter. Amateur astronomers supply images from their backyard telescopes for planning. Citizen scientists and artists download raw images and then contribute their own processed versions to the JunoCam online gallery (https://www.missionjuno.swri.edu/junocam/processing).

Research by PSI Senior Scientist Robert Nelson shows that spacecraft landing on Jupiter’s moon Europa could see the craft sink due to high surface porosity.

Nelson was the lead author of a laboratory study of the photopolarimetric properties of bright particles that explain unusual negative polarization behavior at low phase angles observed for decades in association with atmosphereless bodies including asteroids 44 Nysa, 64 Angelina and the Galilean satellites Io, Europa and Ganymede.

These observations are explained by extremely fine-grained particles with void space greater than about 95 percent. Grain sizes would be on the order of the wavelength of light of the observations (a fraction of a micron). This corresponds to material that would be less dense than freshly fallen snow, raising questions about the risk of a Europa lander sinking into the surface of the Jupiter satellite.

Observations were made using a goniometric photopolarimeter of novel design located at Mt. San Antonio College in Walnut, California. The powders used were aluminum oxide (Al₂O₃), which is an excellent regolith analog for high albedo airless bodies in the Solar System, including water ice bodies such as Europa.

“Of course, before the landing of the Luna 2 robotic spacecraft in 1959, there was concern that the Moon might be covered in low density dust into which any future astronauts might sink,” Nelson said. “However, we must keep in mind that remote visible-wavelength observations of objects like Europa are only probing the outermost microns of the surface.”
Mysterious straight bright stripes have been discovered on Saturn’s moon Dione, PSI Associate Research Scientist Alex Patthoff found. The origins of these linear “virgae” (virgae meaning a stripe or streak of color) are most likely caused by the draping of surface materials like material from Saturn’s rings, passing comets, or co-orbital moons Helene and Polydeuces.

“The evidence preserved in the linear virgae has implications for the orbital evolution and impact processes within the Saturnian system,” Patthoff said. “The interaction of Dione’s surface and exogenic material has implications for its habitability and provides evidence for the delivery of ingredients that may contribute to the habitability of ocean worlds in general.

“Their orientation, parallel to the equator, and linearity are unlike anything else we’ve seen in the Solar System,” Patthoff said. “If they are caused by an exogenic source, that could be another means to bring new material to Dione. That material could have implications for the biological potential of Dione’s subsurface ocean.”

By developing a new method for measuring isotopic ratios of water and carbon dioxide remotely, scientists led by PSI Senior Scientist Roger N. Clark have found that the water in Saturn’s rings and satellites is unexpectedly like water on the Earth, except on Saturn’s moon Phoebe, where the water is more unusual than on any other object so far studied in the Solar System. This means we need to change models of the formation of the Solar System because the new results are in conflict with existing models.

Isotopes are different forms of elements but with differing numbers of neutrons. Adding a neutron adds mass to the element, and that can change processes of how a planet, comet, or moon is formed. Water is composed of two hydrogen (H) atoms and one oxygen atom, H₂O. Adding a neutron to one hydrogen atom, then called deuterium (D), increases the mass of a water molecule (HDO) by about 5 percent, and that small change results in isotopic differences in the formation of a planet, moon, or comet, and changes the evaporation of water after formation. The deuterium to hydrogen ratio (D/H) is a fingerprint of the formation conditions, including temperature and evolution over time.

The discovery of an unusual deuterium to hydrogen isotopic ratio for Saturn’s moon Phoebe means it was formed in and comes from a far part of the cold outer Solar System far beyond Saturn, Clark said.

The measurements were made from the NASA Cassini spacecraft using the Visual and Infrared Mapping Spectrometer (VIMS) over the course of the mission. An improved calibration of the instrument, completed early in 2018, enabled the precision needed for these measurements of reflected light from the rings and satellites. The new method of measuring isotopic ratios on solids like water ice and carbon dioxide ice using reflectance spectroscopy remotely will enable measurements of isotopic ratios for other objects throughout the Solar System, putting further constraints on models of Solar System formation.

The Saturn system D/H values close to the Earth’s values imply a similar water source for the inner and outer Solar System, and new models need to be developed where the change from inner to outer Solar System is less.
A new investigative technique shows the latitudinal distribution of ice-rich landforms on Mars. This large-scale study enables future, more detailed investigations to study several young deposits of ice and sediment in the north polar basin.

"The young ice deposits are extremely important for several reasons. First, they represent a different epoch in Mars’ climate history when ice was stable at the mid-latitudes. We can probe them for more information and gather details about Mars’ climate,” said Isaac B. Smith, PSI Research Scientist and co-author of three new papers on the topic. “Second, if humans are to explore Mars, they will want to go to mid-latitude locations where the Sun is up all year. Identifying where the ice is supports that. Finally, astrobiologists are very interested in locations where ice and rock interact because it may offer clues about habitability.”

The northern plains of Mars are comprised of several basins filled by sediments. The region has been proposed to have hosted an ancient ocean and currently contains ice in the ground even at latitudes where the ice is not stable.

“We used this type of investigation to speed up the process of seeking ground ice. The team broke up very long sections into 20 kilometer by 20 kilometer squares,” Smith said. “This sped up the process of interpreting huge areas by orders of magnitude. The benefit is that we can now trace the latitudinal placement of various features in a spatial context, useful for making conclusions about ground ice on Mars.”

Smith supported the research by providing information on what is found beneath the Martian surface using his analysis of data from NASA’s Mars SHAllow RADar sounder (SHARAD) instrument on the Mars Reconnaissance Orbiter spacecraft.

The announcement of the presence of liquid water beneath the surface of Martian poles validates research published by PSI Senior Scientist Stephen Clifford back in 1987. Data collected by the Mars Advanced Radar for Subsurface and Ionospheric Sounding (MARSIS) orbital radar sounder on the European Space Agency’s Mars Express spacecraft points to a lake of liquid water buried about one mile beneath the layers of ice and dust that comprise the south polar cap of Mars.


On Earth, microorganisms have been found in the subglacial lakes of Antarctica that have existed in isolation from the external Antarctic environment for 35 million years or more and, since many of the 400 subglacial lakes that have been identified so far appear to be hydraulically connected, it is reasonable to conclude that microbial life may exist nearly everywhere beneath the Antarctic ice, Clifford said.

The discovery of life in a subglacial lake on Mars would have enormous significance for our understanding of the prevalence of life in our Solar System. Ice-covered oceans are believed to exist on Europa, Ganymede, Enceladus, Titan, Triton, and several other bodies in the Solar System.

PSI Senior Scientist R. Aileen Yingst was in the driver’s seat Feb. 15, directing the science activities for NASA’s Opportunity Rover as it spent its 5,000th day exploring the Martian surface. Yingst served as Science Operations Working Group chairperson, running the group that decided what the rover did that sol, or Martian day.

“I headed up the science planning for what Opportunity did during sol 5,000,” said Yingst, who is an Associate Principal Investigator for the rover. “The rover got a nice selfie shot to mark the day. We also imaged a channel in which the rover has been driving. It’s another day at the office, but the office is millions of miles away. Science on Mars is always special, amazing, incredible and different.”
NASA’s Dawn spacecraft has gone silent, ending an 11-year odyssey that explored the two largest objects in the main asteroid belt, giant asteroid Vesta and dwarf planet Ceres.

Dawn has run out of fuel, ending a mission on which dozens of Planetary Science Institute researchers have worked. While the Dawn spacecraft’s mission officially came to an end, results keep flowing from analysis of data collected during the mission to Ceres and Vesta. The spacecraft can no longer keep its antennae trained on Earth to speak or listen to mission control, and can no longer turn its solar panels to the sun for recharging.


Senior Scientist Pasquale Tricarico found that Ceres experienced a polar reorientation of approximately 36 degrees. Using data from the Dawn mission, Tricarico determined the magnitude of the reorientation with three independent and corroborating lines of evidence. Global Gravity Inversion, from a paper Tricarico published in 2013, helped determine the density variations of Ceres, especially in the crust. This is what was used to find the equatorial density anomaly. Statistical analysis of topography was used for ridge analysis and the paleo-pole. And for matching the crustal fractures, a well-proven method by Isamu Matsuyama and Francis Nimmo was used.

"The most surprising aspect of this paper is to me the observation that the pole of Ceres must have followed an indirect path to its current pole. A multi-step reorientation could mean that the equatorial density anomaly was still evolving during the reorientation, and this could be because the crust and mantle were weakly rotationally coupled, allowing the crust to start reorienting while the mantle would lag behind," Tricarico said.

"If crust and mantle are allowed to shift with respect to one another, that could point to a layer of reduced friction between crust and mantle, and one of the possible mechanisms to reduce friction could be an ancient water ocean beneath the crust.”

The Dawn mission has orbited Ceres for more than three years, gathering very detailed observations and allowing the construction of precise geophysical models. These models can then be adapted for comparison to other icy bodies, Tricarico said. One such example is the parallel between the well-known equatorial ridge of Iapetus, the moon of Saturn, and the remnants of the paleo-equatorial ridge of Ceres.

Finite Element Method models used to analyze images from Dawn show Ceres has experienced cryovolcanism throughout its geologic history, with an average surface extrusion rate of about 10,000 cubic meters per year, orders of magnitude lower than that of basaltic volcanism on the terrestrial planets.

Icy volcanoes have erupted throughout the history of Ceres, but such continuous activity has not had the same extensive impact on the dwarf planet’s surface as standard volcanism on Earth, says a Nature Astronomy paper “Cryovolcanic rates on Ceres revealed by topography.” Michael M. Sori of the University of Arizona Lunar and Planetary Laboratory is lead author, and PSI Senior Scientist Hanna G. Sizemore is second author.

Cryovolcanoes erupt liquid or gaseous volatiles such as water, ammonia or methane instead of spewing molten rock as seen on Earth. Salty water is likely the major component of cryolavas on Ceres. Ceres offers the best opportunity to test the significance of cryovolcanism on outer Solar System bodies, compared to regular volcanism on terrestrial planets like Earth.

“There was a great deal of interest in searching for cryovolcanoes on Ceres as soon as Dawn arrived there, because thermal models had predicted they might exist. Ahuna Mons was a great candidate right away. I carried out a global search that identified 31 other large domes, based on analysis of Dawn’s Framing Camera images and topography data,” Sizemore said. “Making the case that they were volcanic was difficult because they were more ancient than Ahuna and the surfaces were heavily cratered. In this study, we were able to compare the shapes of the mountains to numerical models of how they should relax over time if they were made out of icy lava. That
strengthened the case that they were volcanic features, and let us make comparisons to volcanism on other planets.”

“Given how small Ceres is, and how quickly it cooled off after its formation, it would be exciting to identify only one or two possible cryovolcanoes on the surface. To identify a large population of features that may be cryovolcanoes would suggest a long history of volcanism extending up to nearly the present day, which is tremendously exciting,” said Sizemore. “Ceres is a little world that ought to be ‘dead,’ but these new results suggest it might not be. Seeing so much potential evidence for cryovolcanism on Ceres also lends more weight to discussions of cryovolcanic processes on larger icy moons in the outer Solar System, where it’s likely more vigorous.”

—Hanna G. Sizemore, PSI Senior Scientist

Feng and Griffin Named 2019 Pierazzo Award Winners

Ying (Katherina) Feng and Sammy Griffin were named winners of the 2019 Pierazzo International Student Travel Award. The Pierazzo Award was established by PSI in memory of Senior Scientist Betty Pierazzo to support and encourage graduate students to build international collaborations and relationships in planetary science.

Feng, of the University of California, Santa Cruz will receive the award for a U.S.-based graduate student traveling to a planetary meeting outside the U.S. Her research title is “Probing the Phase Dependence of Atmospheric Inference for Hot Jupiters” and she will be attending the Exoclimes V conference at Oxford, the United Kingdom, Aug. 12-15, 2019.

Griffin, of the University of Glasgow, will receive the award for a non-U.S.-based graduate traveling to a planetary meeting within the U.S. Her research title is “New Insights into the Magmatic and Shock History of the Naklite Meteorites from Electron Backscatter Diffraction” and she will be attending the 50th Lunar and Planetary Science Conference in Houston, Texas, March 18-22, 2019.

A PSI representative will present each awardee with a certificate and check for $2,000 at their respective conferences.
As it has been for more than 45 years, PSI’s strength and advantage continue to be in its people. Our culture of openness and high level of mutual support distinguishes us as an organization.

In 2018 PSI continued to grow, adding 21 new research and administrative staff members.

**NEW PSI STAFF MEMBERS FOR 2018:**

- Zachary M. Bain  
  Student Research Assistant
- Stephen Clifford 
  Senior Scientist
- Jianqing Feng  
  Postdoctoral Research Scientist
- Pamela L. Gay  
  Senior Scientist & Senior Education and Communication Specialist
- Amber Gray  
  Technical Document Writer
- Mackenzie White  
  Graduate Student Research Assistant

- Triana Hernandez-Henz  
  Student Research Assistant
- David Hornisher  
  Technical Support Specialist
- Alan Howard  
  Senior Scientist
- Georgiana Kramer  
  Senior Scientist
- Margaret E. Landis  
  Postdoctoral Research Scientist

- Chien-Hsiu Lee  
  Associate Research Scientist
- Cynthia K. Little  
  Senior Research Associate
- Stephen P. Scheidt  
  Associate Research Scientist
- Lorenzo Tavazzani  
  Graduate Student Research Assistant
- Kevin D. Webster  
  Associate Research Scientist

- Bailey Williamson  
  Student Research Assistant
- Jason W. Witry  
  Research Assistant
- Stephen E. Wood  
  Senior Scientist
- Chun N. Wu  
  Student Junior Software Programmer

**NOT PICTURED:**

- Sophia Borowsky  
  Student Research Assistant
- Mackenzie White  
  Graduate Student Research Assistant
PSI supports many science education and “Citizen Science” projects that have a national and international reach. Currently, our scientists, education specialists, staff, and docents are based in 23 states, the District of Columbia, and several international locations. In 2018 we announced that all funding from the “Friends of PSI” program (see www.psi/support/friends for more info) will support the wide variety of Education and Public Outreach (EPO) initiatives that our scientists and educators undertake in their own communities through events, workshops, and science fairs. We are always seeking new ways to demonstrate our commitment to reaching and inspiring the next generation of scientists.

The diversity of programs led by our scientists ranges from participation in events with an epic global reach such as the International Observe the Moon Night to chatting about planetary science and ongoing space missions with the local shoppers at a farmer’s market in Colorado.

Some of the past year’s EPO highlights included:

**PSI Active at International Observe the Moon Night Events**

Andrea Jones led NASA's Lunar Reconnaissance Orbiter (LRO) outreach team in the most popular International Observe the Moon Night (InOMN) to date with more than 1,000 registered events and an estimated 160,000 participants in 75 countries around the globe.

Georgiana Kramer gave an International Observe the Moon Skype presentation with Q&A with a group at The Space Station Museum in Novato, California. She also accompanied members of the Boys and Girls Club of Greater Houston on a trip to Space Center Houston, the official visitor center of NASA Johnson Space Center, where she discussed the Moon for their “Living on the Moon” art project.

Locally, PSI collaborated with the University of Arizona’s Flandrau Science Center and Planetarium to provide activities for InOMN. People flocked to take part in the hands-on educational activities and to make use of an array of telescopes on the UA Mall to observe the Moon. The Tucson Amateur Astronomy Association provided the telescopes.

**Tucson Festival of Books Features PSI Researchers, Educators**

PSI’s display at the Tucson Festival of Books attracted hundreds of visitors during the two-day event held on the University of Arizona Mall. PSI’s exhibit, held in the event’s Science City area, included hands-on activities featuring samples of three different types of meteorites – stony, iron, and stony-iron, as well as many different types of impact rocks which were created when meteorites impacted with Earth.

Larry Lebofsky scheduled volunteers for the event, and participants included Thea Canizo, Stephen Ferris, Vivian Morrison, Don Davis, Maya Bakerman, Connor McNally, Joe Spitale, Bea Mueller and Mike Drum.

**Thousands of Family SciFest 2018 Attendees Enjoy STEM-Based Activities**

PSI offered kids of all ages a chance to learn about meteorites and use an infrared (IR) camera at the Seventh Annual Family SciFest event held at Children’s Museum Tucson. The event attracted 2,264 people and featured hands-on activities presented by 39 exhibitors.

Sanlyn Buxner and Maya Bakerman were kept busy throughout the event by a constant stream of kids and parents visiting PSI’s display table.

**PSI Holds Teacher Lunar Workshop**

Three PSI educators participated in the Arizona Science Teacher Association’s “Terra Luna” event held at the Franklin Phonetic School in Prescott, Ariz.

Maya Bakerman, Sanlyn Buxner and Larry Lebofsky held a Moon-focused workshop for teachers that included meteorite kits, moon mapping, Earth-Moon comparisons, Moon phase activities, cratering activities and studying historic images from NASA’s Lunar Reconnaissance Orbiter.

**And More**

Georgiana Kramer donned a superhero costume to offer girls an opportunity to see the power of science and be inspired by what is possible when they embrace their personal power. She made appearances as The Lunatic Phenomenon, as part of the Female Superheroes of Science group that made planetary science-based presentations to schools and girls’ organizations.

Not only do PSI scientists engage with students, parents, teachers, and the general public at museums, schools, and festivals, but they also encourage their peers at other organizations to conduct EPO activities. For example, Jennifer Grier presented “Understanding the Needs of Space Scientists in Education, Public Engagement, and Communications: Implications for Practice” at the Lunar and Planetary Science Conference held in March.

PSI scientists serve as judges in science fairs such as the Southern Arizona Research, Science, and Engineering Foundation (SARSEF) and PSI contributes prizes to the winners.
PSI is a nonprofit research organization and it relies on NASA contracts for the majority of its funding. Because the NASA budget is vulnerable to budget cuts (and, unfortunately, government shutdowns as was witnessed this year), it is necessary for PSI to seek private sector donations to augment the funding that it receives from NASA.

To sustain the Institute’s nationwide Education and Public Outreach (EPO) efforts we reach out to businesses and individuals (both local and national) to support our activities through their tax-deductible contributions. Throughout the year, PSI conducts a few different fundraising events and campaigns that include:

**Annual Dinner**

The PSI Annual Fundraising Dinner is the organization’s flagship event. The 2018 Dinner featured former Astronaut and Space Shuttle Commander, Pamela Melroy (Colonel, USAF, Ret.) as the keynote speaker. Pam’s riveting presentation provided highlights of her spaceflight experience including a step-by-step narration of a spacewalk to repair damage to the International Space Station’s Solar Array. During her remarkable career Pam has logged more than 38 days in space. She is the recipient of numerous awards and special honors including the NASA Distinguished Service Medal, the NASA Outstanding Leadership Medal, and the Air Force Meritorious Service Medal, among others.

The event’s table sponsors included PSI Board members, PSI staff members, and local businesses that generously support the Institute’s work.

One of the evening’s fun highlights was the raffle price drawing that included dozens of rare and unique items such as a scale model of Vesta (modeled in chocolate!), NASA collectibles, books, spa treatments, jewelry, artwork, and a vacation weekend.

**Challenge Match Campaign**

PSI’s year-end “Challenge Match Campaign” is now in its fourth year and continues to provide much-needed unrestricted revenue for the Institute. To launch the 2018 Challenge Campaign a group of generous PSI supporters cumulatively pledged $12,000 to form the campaign’s revenue goal. To receive the pledged sum PSI was required to raise matching funds. Thanks to the generosity of our donors, the campaign was a great success. The total raised exceeded the goal amount by 35 percent.

**Friends of PSI Program**

The “Friends of PSI” program is the Institute’s core group of supporters. This group is comprised of individuals and businesses who further PSI’s global work through an annual, tax-deductible membership donation. “Friends” receive the PSI Quarterly Newsletter, a discount on tickets to the Annual Dinner, breaking news press release announcements, and alerts about scientists’ podcasts.

This year we made a significant change in the “Friends of PSI” program, allocating all “Friends” revenue to support the Institute’s EPO activities.

PSI scientists and educators log many hours in their respective communities, volunteering their time at events such as Science Fairs, Astronomy Nights, and other STEM-related activities. These important outreach activities can include the use of one of the Institute’s custom Rock/Meteor Kits for “hands on” demonstrations. The funding from the “Friends” program enables PSI to ship these kits and to develop appropriate collateral materials to enhance the presentations.

**Betty Pierazzo Fund**

Created to honor the late Elizabeth Pierazzo, a PSI Senior Scientist, this fund assists early-career scientists. Two students are selected each year (one U.S.-based, one international-based) who receive a check of $2,000 to defray the cost of their travel to attend a scientific conference.

**Belton Fund**

Created by Michael and Anna Don Belton, this fund supports a biennial Symposium on Comets. The inaugural event is planned for 2020.

**Grants and Business Sponsorships**

Additional funding efforts include submitting grant applications and making presentations to Tucson-area businesses identified as possible donors and/or sponsors for a specific research area and/or for EPO efforts.

**Other**

PSI continues to partner with Amazon through the AmazonSmile program and a PSI Gift Shop is available on the PSI website.
THANK YOU TO OUR 2018 BENEFACTORS

With deep appreciation the Planetary Science Institute acknowledges the following individual and organizational benefactors who made contributions between Jan. 1, 2018 and Dec. 31, 2018.

$15,000 and up
Dr. Mark V. Sykes and Ms. Marilyn Guengerich

$10,000-$14,999
Dr. David P. Brown
Dr. Jay Melosh

$100-$249
Anonymous
Mr. and Mrs. Alfred and Maria Anzaldua
Mr. Alex Berman
Mr. and Mrs. Robert and Judith Breault
Mr. Joshua Cahill
Dr. Thea L. Catizono
Ms. Alexa Carle-Hickman
Mrs. Bessie T. Chan
Mr. and Mrs. Paul and Etta Chan
Mr. Stewart C. Chan
Mr. and Ms. Robert and Elisabeth Chrien
Ms. Florence Don
Mr. and Mrs. Bruce and Lynne Dusenberry
Mr. and Mrs. Larry and Judith East
Mr. Stephen Fleming
Ms. Janet E. Fong
Lt. Col. Robert Gent and Judge Terrie Gent
Dr. Amanda Hendrix and Mr. David Richardson
Dr. Vicki Hansen
Mr. and Mrs. David and Shirley Hartmann
Mr. Douglas Huie
Dr. David Johnson
Dr. Dave Kretsinger
Dr. C. Darrell Lane
Mr. Taft Lee
Mr. Stephen J. Lew
Ms. Rosina Y. Lim
Dr. Cynthia Little
Mr. and Mrs. Richard and Christine Logan
Dr. Franklin L. Louie
Mr. Arthur Mabbett
Ms. Melissa A. McGrath
Drs. Robert and Gloria McMillan
Dr. and Mrs. Andrew and Anna Nelson
Ms. Sherryl Nelson
Mr. and Mrs. John and Kathleen O'Brien
Ms. Beatrice N. Parker
Mr. Neil C. Parker
Dr. Thomas H. Prettyman
Drs. Vishnu Reddy and Lucille Le Corre
Dr. Nalin Samarasinha
Ms. Desiree Schaub
Mrs. Susanna Schippers
Mr. Claud Smith
Mr. and Mrs. Dennis and Lynette Smith
Mr. Randy Sooter
Dr. Anna Spitz
Dr. Sugata Tan
Dr. Michelle Thomsen
Dr. and Mrs. Bryan J. and Gayle L. Travis
Mr. Ivo Van Der Ryt
Dr. David Vaniman and Ms. Donna Gary
Mr. Tom M. Vovers
Dr. Kevin Webster
Dr. and Mrs. Stuart J. and Suzy Weidenschilling
Dr. Paul Weissman
Mr. Kenneth Wilcox
Ms. Patricia Wong

$5,000-$14,999
Dr. David P. Brown

$1,000-$1,999
Anonymous
Mr. and Mrs. Maurizio and Tina Balistreri
Mr. Bruce Barnett and Ms. Tammi Palmer
Drs. Donald R. Davis and Diana E. Wheeler
Echo Construction
Mr. and Dr. John and Dorothy Oehler

$500-$999
Anonymous
Anonymous

$250-$499
Mr. and Mrs. Joe and Diana Alexander
Dr. and Mrs. William and Barbara Bickel
CODAC Behavioral Health Services
Dr. Uwe Fink
Ms. Kimberly Foote
Dr. and Mrs. James and Molly Head
Mr. Ed Jackson
Dr. and Mrs. Lee and Donna Rogers
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Mr. Benjamin Smith and Ms. Liisa Phillips
Dr. Alan Stern

$2,000-$4,999
Conoco Phillips
Dr. and Mrs. William and Gayle Hartmann
Dr. and Mrs. Tim and Carol Hunter
Col. Pamela Melroy, Retired
Vector

$1,000-$1,999
Anonymous
Mr. and Mrs. Maurizio and Tina Balistreri
Mr. Bruce Barnett and Ms. Tammi Palmer
Drs. Donald R. Davis and Diana E. Wheeler
Echo Construction
Mr. and Dr. John and Dorothy Oehler

$500-$999
Anonymous
Anonymous

$1-$99
Mr. and Mrs. Alfred and Maria Anzaldua
Mr. Alex Berman
Mr. and Mrs. Robert and Judith Breault
Mr. Joshua Cahill
Dr. Thea L. Catizono
Ms. Alexa Carle-Hickman
Mrs. Bessie T. Chan
Mr. and Mrs. Paul and Etta Chan
Mr. Stewart C. Chan
Mr. and Ms. Robert and Elisabeth Chrien
Ms. Florence Don
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Mr. and Mrs. Larry and Judith East
Mr. Stephen Fleming
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Dr. Amanda Hendrix and Mr. David Richardson
Dr. Vicki Hansen
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Dr. C. Darrell Lane
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Dr. Thomas H. Prettyman
Drs. Vishnu Reddy and Lucille Le Corre
Dr. Nalin Samarasinha
Ms. Desiree Schaub
Mrs. Susanna Schippers
Mr. Claud Smith
Mr. and Mrs. Dennis and Lynette Smith
Mr. Randy Sooter
Dr. Anna Spitz
Dr. Sugata Tan
Dr. Michelle Thomsen
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Mr. Ivo Van Der Ryt
Dr. David Vaniman and Ms. Donna Gary
Mr. Tom M. Vovers
Dr. Kevin Webster
Dr. and Mrs. Stuart J. and Suzy Weidenschilling
Dr. Paul Weissman
Mr. Kenneth Wilcox
Ms. Patricia Wong

Mr. and Mrs. Brent and Joanne Archinal
Dr. and Mrs. Victor and Pauline Baker
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Mr. and Dr. William and Kathleen Bethel
Mr. Gary Bingham
Mr. and Mrs. Bill and Ann Buckmaster
Mr. John Cerney
Ms. Kathleen Chan
Mr. Christopher Chyba
Ms. Ann Cleaves
Ms. Linda K. Conroy
Mr. Avery Davis and Mrs. Debbie Golden-Davis
Ms. Norma J. Don
Mr. Paul Emmert
Mrs. Veronika Flournoy
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Mr. Donald Gin
Mr. Terrence Greenwood
Dr. David Fales and Ms. Sara Hammond
Mr. Sidney M. Hirsh
Ms. Chris Holmberg
Mr. Stephen D. Hopkins
Mr. William F. Houghton
Dr. Tim Jull
Mr. Charles Katzenmeyer
Dr. D. Jerece Langendoen and Ms. Nancy Kelly
Mrs. Louise W. Lee
Dr. and Mrs. Kurt and Elisabeth Marti
Ms. Audrey Mondet
Ms. Joy A. Newman
Mr. Kenneth Scoville
Dr. Sarah Sutton
Mr. Eric D. Tarallo
Dr. Henry Throop
Tucson Chinese Golf Club
Mr. Anthony Villari
Mr. Peeranut Visetsuth
Dr. Andrew Wheeler
Ms. Tiny M. Wong

Mr. and Mrs. William and Carol Hunter
Col. Pamela Melroy, Retired
Vector

With deep appreciation the Planetary Science Institute acknowledges the following individual and organizational benefactors who made contributions between Jan. 1, 2018 and Dec. 31, 2018.
PSI continues to experience annual growth with revenues totaling $13.1 million for the fiscal year ended Sept. 30, 2018. During the fiscal year, PSI was actively involved in 118 prime awards issued by federal agencies and 137 subawards/contracts issued by other institutions. Ninety-seven percent of all funding originated from NASA.

### REVENUES

<table>
<thead>
<tr>
<th>Source</th>
<th>Amount</th>
</tr>
</thead>
<tbody>
<tr>
<td>Grants and Contracts</td>
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<td>Contributions</td>
<td>188,765</td>
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<td>Other</td>
<td>16,619</td>
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<tr>
<td><strong>Total Revenues</strong></td>
<td><strong>$13,131,881</strong></td>
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PSI’s financial records are audited annually by independent auditors. A condensed Statement of Financial Position from PSI’s audit report as of Sept. 30, 2018 is reflected below.

### EXPENSES

<table>
<thead>
<tr>
<th>Category</th>
<th>Amount</th>
</tr>
</thead>
<tbody>
<tr>
<td>Salaries and Benefits</td>
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<td>Operating</td>
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<td>Depreciation</td>
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<td>Interest</td>
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<tr>
<td><strong>Total Expenses</strong></td>
<td><strong>$12,953,213</strong></td>
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</table>

### ACTIVE PROJECTS BY PRIME AWARDING AGENCY

<table>
<thead>
<tr>
<th>Agency</th>
<th>Projects</th>
</tr>
</thead>
<tbody>
<tr>
<td>NASA</td>
<td>246</td>
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<tr>
<td>NSF</td>
<td>4</td>
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<tr>
<td>USGS</td>
<td>1</td>
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<tr>
<td>Non-Federal</td>
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<tr>
<td><strong>Total</strong></td>
<td>255</td>
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</table>

<table>
<thead>
<tr>
<th>Category</th>
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<tr>
<td>Program Services</td>
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<td>Management &amp; General</td>
<td>1,465,579</td>
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<tr>
<td>Fundraising</td>
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<tr>
<td><strong>Total Expenses</strong></td>
<td><strong>$12,953,213</strong></td>
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</tbody>
</table>

Salaries and related fringe benefits represent 76 percent of PSI’s total expenses of $13 million. Operating expenses include $1.1 million paid on subawards to other institutions whose scientists are included on PSI prime awards. Program services expenses were 88 percent of total expenses.

### EXPENSES BY FUNCTION

<table>
<thead>
<tr>
<th>Category</th>
<th>Amount</th>
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<tbody>
<tr>
<td>Current Assets</td>
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<tr>
<td>Property &amp; Equipment, Net</td>
<td>1,123,937</td>
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<tr>
<td><strong>Total Assets</strong></td>
<td><strong>$3,358,331</strong></td>
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<tr>
<td>Current Liabilities</td>
<td>$1,727,990</td>
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<tr>
<td>Long-term Liabilities</td>
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<tr>
<td>Net Assets with Donor Restrictions</td>
<td>105,850</td>
</tr>
<tr>
<td>Net Assets without Donor Restrictions</td>
<td>573,367</td>
</tr>
<tr>
<td><strong>Total Liabilities &amp; Net Assets</strong></td>
<td><strong>$3,358,331</strong></td>
</tr>
</tbody>
</table>
Oleg Abramov. Constraining lunar bombardment history by modeling impact age distributions. NASA Solar System Workings program.


Steve Clifford. An integrated atmospheric and subsurface investigation of the evolution of the early Martian hydrosphere: Implications for the occurrence and duration of potentially habitable liquid water environments on a cold early Mars. NASA Habitable Worlds program.


Paul Hardersen. Citizen science and students: Engaging populations to accomplish fundamental astronomical research. NASA Topical Workshops, Symposia, and Conferences program.


Alan Howard. Assessing a cold-icy vs. warm-wet climate for early Mars with valley network morphometry and landscape evolution models. NASA Mars Data Analysis program, University of Colorado Boulder subaward.

Alan Howard. Interface development and documentation for a planetary landform evolution simulation platform. NASA Planetary Data Archiving, Restoration, and Tools program, SETI Institute subaward.

Catherine Johnson. Fluxgate magnetometer for InSight, Mars lander, Discovery mission. NASA InSight mission, University of California Los Angeles subaward.

Catherine Johnson. Europa Clipper ICEMAG instrument preliminary design review. NASA Europa mission, Jet Propulsion Laboratory subcontract.

Jeff Kargel. Astrobiology at the water-rock interface and beyond. NASA Astrobiology program, Jet Propulsion Laboratory transfer.


Jian-Yang Li. Determining the mineralogical evolution to asteroid (145) Adeona through degree of aqueous alteration to support Dawn extended mission. NASA Stratospheric Observatory for Infrared Astronomy (SOFIA) program, Universities Space Research Association – Cycle Six General Observer Grant.


Scott Mest. Updating the geologic maps of the Apollo 15-16-17 landing sites. NASA Planetary Data Archiving, Restoration, and Tools program.


Gareth Morgan. Local subsurface ice mapping through the integration of SHARAD derived data products with other datasets. Jet Propulsion Laboratory subcontract.


Eric Palmer. Stereophotoclinometry (SPC) short course. PSI consulting services.


Asmin Pathare. Lunar and Martian crater production in the last billion years. NASA Solar System Workings program, University of California Los Angeles subaward.

Alex Patthoff. Characterizing the mysterious linear virgae across the mid-sized satellites in the Saturnian system. Cassini Data Analysis program, Smithsonian Institution subaward.

Neil Pearson. Laboratory support services for building, operation and training of a vacuum spectroscopy facility. PSI consulting services.

Thomas Prettyman. 2001 Odyssey gamma ray spectrometer extended mission. NASA Odyssey program, University of Arizona subcontract.

Nathaniel Putzig. Subsurface water ice mapping (SWIM) in the northern hemisphere of Mars. NASA Mapping of Water Deposits to Support Mars Exploration Program Studies, Jet Propulsion Laboratory subcontract.


Jim Rice. MER geomorphic and sedimentological investigations. NASA Mars Exploration Rover mission, Jet Propulsion Laboratory subcontract.

Nalin Samarasinha. Non-gravitational forces and torque in Comet 67P/Churyumov-Gerasimenko and determining their relationship to cometary activity. NASA Rosetta Data Analysis program.


Matthew Siegler. Thermal conductivity measurement of regolith down to T = 15 K. NASA Solar System Workings program, Jet Propulsion Laboratory subcontract.

Elizabeth Sklute. Collaborative research: Formation, stability, and detection of amorphous ferric sulfate salts on Mars. National Science Foundation, Planetary Astronomy program.

Elizabeth Sklute. Ultraviolet through mid-infrared optical constants of minerals and glasses relevant to planetary spectroscopic analyses. NASA Primary Data Archiving, Restoration and Tools program, The Research Foundation for the State University of New York subaward.

Jordan Stecklof. Investigating clouds on Titan. NASA Cassini Data Analysis program, Southwest Research Institute subaward.


PSI 2018 ANNUAL RETREAT

PLANETARY SCIENCE INSTITUTE
EST. 1972