PISCES
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Economic Development

Why is Hawaii a Great Analog for Mars?

Mauna Loa's barren and rugged volcanic slopes (above left) bear a striking resemblance to the rocky, rust-colored surface of Mars (above right). But wait, there's more…

If you keep up with our newsletters, you've heard us talk a lot about Hawaii as a valuable testing ground for space exploration technologies—in part due to its expansive, isolated basaltic lava fields. But besides offering a similar looking environment (which supports valuable studies like those conducted at HI-SEAS), Hawaii's landscapes offer more than meets the eye.

Hawaii Island, commonly known as the Big Island, is known for its diverse climates and landscapes—many of them characterized by rugged, basaltic lava fields. PISCES' Materials Science team has been collecting and analyzing samples of volcanic basalt from various locations on the island to determine which work best for sintering. Recently, PISCES Geologist Kyla Defore began analyzing these samples and comparing them with data on Martian rock gathered by NASA—specifically, Martian meteorites. The results were amazingly similar.

"At first I was skeptical, but the data proved sound and I was amazed. There are tiny variances between Hawaii and Mars, but they are extremely similar."

For good measure, Kyla also compared the Hawaii basalt samples with MGS-1 Mars regolith simulant and data gathered by NASA's Pathfinder rover on Martian regolith. In all cases, Hawaii's lava rock appeared nearly identical in composition to Martian rock.

Gathering the data was more than a stone's throw. Over the last 18 months, Kyla and student interns have been gathering samples and breaking them down into fine pellets for analysis.

(Cont. on page 3…)

Message from the Program Director

Aloha Kakou and Happy Holidays,

Last month, we were pleased to welcome two new members to our Board of Directors: Dennis Gibson, Senior Vice President of the consulting firm Booz Allen Hamilton; and Dr. Jeff Taylor of UH Manoa's Hawaii Institute of Geophysics and Planetology. Dr. Taylor specializes in planetary volcanology, igneous processes and extraterrestrial materials. His expertise will bring invaluable support to the sintering research we are doing with Hawaiian basalt. In fact, our geology technician Kyla Defore has already been working closely with Dr. Taylor to create a catalog identifying the properties of basalt sourced from various locations on Hawaii Island.

Kyla's research has yielded valuable data to help us better understand how chemical variations in various basalts produce different effects in sintering.

(Cont. on page 5…)

Connect with Us!

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Workforce Development

2018 flew by faster than you can say "liftoff." Many of our students were riding the year's thrust at equal speed to reach their goals. Here's a brief look back at our outstanding college interns and STARS Program students who were mentored at PISCES and continue their trajectories toward the stars…

12 Girls Graduate STEM Career Program

Above: High School students get a peek inside the instrument test room at Subaru Telescope Headquarters in Hilo during the 2018 STARS Program.

PISCES held its largest STARS (STEM Aerospace Research Scholars) Program to date this summer, graduating 12 local high school girls from all over the state. The week-long summer program is designed to encourage young women to pursue careers in aerospace, astronomy and related STEM fields. This year's workshop included a mock lunar rover mission, an overnight stay at the HI-SEAS Mars simulation habitat, inside tours at several Maunakea observatories and a stellar supporting cast of passionate female scientists, engineers and educators. In feedback surveys, 100% of participating students reported they are more likely to pursue a career in STEM after attending STARS.

Intern Upgrades PISCES Rover with New Gadgets

PISCES intern Jack Anderson completed a series of exciting upgrades to PISCES' Helelani rover during 2018 including a dynamic LIDAR system for 3D mapping. Helelani is now hardware-ready for autonomous navigation and will soon be driving herself with the push of a button. Jack was a student of Hawaii Community College and transferred to UH Hilo to study computer science. Not only does he apply his know-how to the rover, but he also attends many outreach events with PISCES to demonstrate Helelani and answer student questions.

PISCES Intern Hired at NASA-JPL

Above: Waiakea High School graduate Aaron Roth configures a stereoscopic imaging camera during his summer internship at PISCES.

Former PISCES Intern Aaron Roth of Hilo began his hands-on learning with the agency's analog planetary rover Helelani in 2017. Now the Waiakea High School graduate will be working on the real thing—NASA's Mars rover. Aaron is currently a fourth-year student in Computer Science at Arizona State University and landed a position at NASA's Jet Propulsion Laboratory in Pasadena, Calif. He will begin his position after he graduates next spring.

STARS Alumnus Awarded First Hokuala Scholarship

Above: Honoka'a High School graduate Keilani Steele after receiving news of her scholarship award.

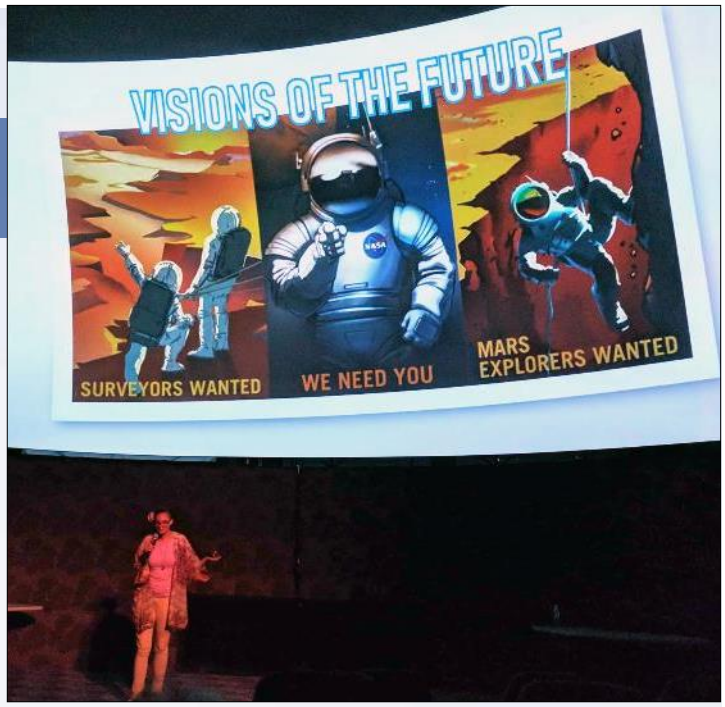
STARS Program alumnus Keilani Steele landed the first Hokuala Scholarship award earlier this year to study astronomy at a university of her choosing. Keilani is already experienced with world-class telescopes—she was selected for viewing time on Maunakea at CFH Telescope and W.M. Keck Observatory through the Maunakea Scholars Program. Keilani attended the STARS Program in 2017 and plans to study at UH Hilo.

Outreach & Education

PISCES Explores "Solutions for Colonizing Mars" at 'Imiloa

How do you inhabit an extremely hazardous environment without breathable air or drinking water? And how do you do it without bringing an entire house with you? These questions were the focus of a talk given by PISCES Geologist Kyla Defore on Nov. 16 for 'Imiloa Astronomy Center's Maunakea Skies talk series.

In "Living Off the Martian Land: Solutions for Colonizing Mars," Kyla explored how costly space travel can be, and how PISCES is researching viable solutions to help establish a permanent human presence on places like Mars. In particular, she highlighted the resources people can extract from Mars' seemingly barren surface: oxygen, water, rocket propellant and construction materials for shelter. Included in her talk were these fun facts: NASA's estimate of a manned mission to Mars: $100 billion + (includes a spacecraft, water, food, habitation, filters, and life support systems). Kyla also demonstrated the striking similarities between Hawaii's basalt and Mars regolith, and how Hawaii's volcanic terrain serve as valuable testing grounds for space exploration missions.



In the darkness of 'Imiloa's planetarium, PISCES Geologist Kyla Defore sheds light on possible solutions for making Mars an affordable destination for future explorers. Photo: Matthew Edison.

Hawaii's Similarity to Mars Cont...

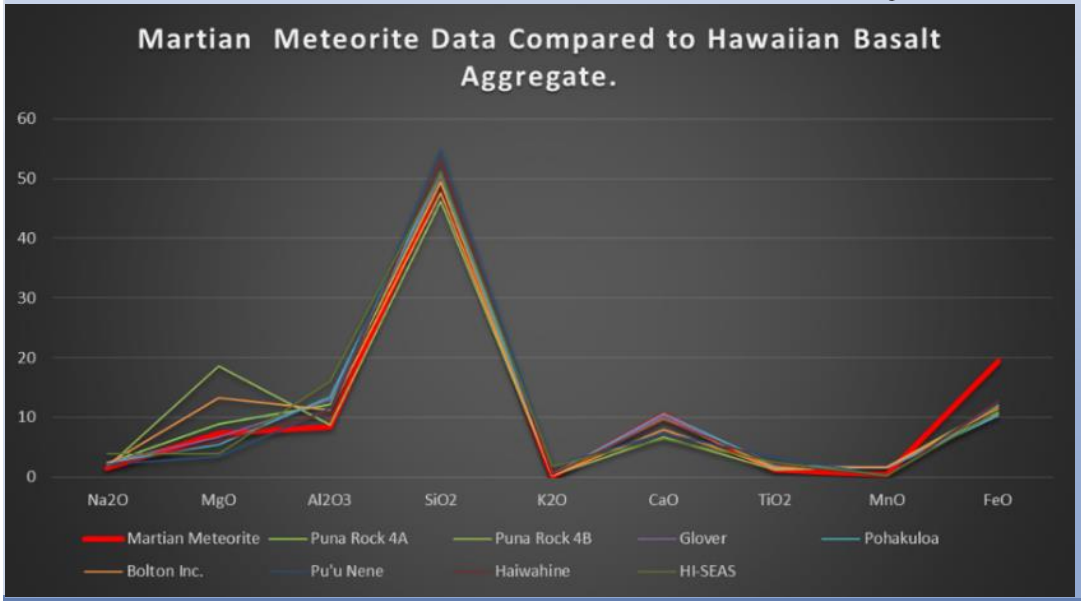
Using an Energy Dispersive X-Ray Fluorescence (EDXRF) spectrometer, Kyla parsed the elemental compositions of these samples and creating the graph shown below.

PISCES' larger goal in this research is to determine the ideal basalt rock for sintering that will consistently create a stable product. "We want to find the perfect temperature and the perfect rock material," Kyla said.

The next step in the project will run the Hawaii samples through an X-ray Diffraction machine to determine their exact crystal and mineral content. The resulting data set will be combined with the original data set, providing a comprehensive overview of Hawaii basalts. The overview will ultimately reveal which properties yield the best sintering product.

"Basically, it's like finding the ideal recipe for baking a cake. And we're in the process of writing the book," Kyla said.

PISCES intends to present the results of these studies in formal scientific papers at several aerospace conferences next year. The presentations could forge new partnerships to further basalt sintering research and In-Situ Resource Utilization (ISRU) technology.



Graph: The composition of a Martian meteorite (red) is shown in comparison to Hawaiian basalt samples sourced from eight locations on Hawaii Island. The overlapping lines represent the similarity of their compositions. Note: The value of FeO for the Martian meteorite was not available.

Guest Spotlight


Photo courtesy of NASA

Large Scale 3D Printing with Basalt Regolith

Robert P. Mueller - Senior Technologist, NASA

Rob Mueller is a senior technologist in the Exploration Research and Technology Programs Directorate at NASA's Kennedy Space Center in Florida. He is the co-founder of the NASA Swamp Works innovation labs and the Kennedy Granular Mechanics & Regolith Operations Lab. He also leads KSC's Autonomous-Robotic Systems involved with In-Situ Resource Utilization (ISRU).

Shelter is a fundamental need for human and equipment operating in extreme environments. The environments of solar system bodies like the Moon, Mars and asteroids are harsh and unforgiving, requiring special measures beyond those typically required for extreme environments on Earth (i.e. the polar regions, barren deserts and high altitudes). In space, factors like radiation, extreme temperature variations, micrometeorites, rocket plume blast effects during launch/landing, dust storms, Mars weather and topography are just a handful of the challenges that must be mitigated to ensure successful human and robotic operations.

Construction of structures to address these challenges (such as landing pads, blast protection berms, roads, dust free lots, shade walls/structures, hangars and habitats) will be necessary for a long term and sustainable presence in space—an effort that will ultimately lead to the expansion of human civilization into the solar system. Due to the extraordinary logistics and high cost of launching rockets and resources out of Earth's gravity well, it will not be practical to bring the materials from home. However, if we take advantage of the vast amounts of indigenous resources already present on other planets and it will be possible to build the infrastructure needed for extreme environments while substantially reducing costs. Since solutions based on robotics and advanced materials are now in development, these indigenous construction materials can be collected and built with automation—and eventually even autonomy. One example of the radically improved technologies now emerging is three-dimensional automated additive construction (3DAAC), also known as 3D printing with concrete, mortar and other basalt-based composite materials.

3D printed ogive. Courtesy photo.

Our team at NASA's Swamp Works lab at Kennedy Space Center (KSC) has designed, fabricated and tested a specialized robotic print head using a polymer concrete composite material. The initial results of this research show it's possible to 3D print infrastructure and shelters using a Polyethylene Terephthalate Glycol (PETG)/basalt glass fiber material in the form of pelletized feedstock. PETG is a material commonly used in plastic water bottles; basalt regolith is widely available on the Moon and Mars. Using at least 70% of materials available in space (and without any additional materials), the Swamp Works team printed a one-meter diameter ogive (see image on bottom left). The construction involved mounting the print head on a large industrial robot arm outfitted with a pneumatic feed system. The maximum overhang angle of the ogive was 35 degrees from horizontal. We've found that overhang angles, including printing horizontally (90 degrees), are possible with cooling fans and without any supporting materials.

Our continuing development work at the Swamp Works lab will enable printing of virtually any large structure with extreme overhangs and no supports. The KSC team is collaborating with PISCES to develop new basalt materials for applications in space exploration and construction to extend human civilization beyond Earth.

RCUH Executive Director Sylvia Yuen stands with PISCES Public Information Officer Chris Yoakum outside the Waialae Country Club during RCUH's annual awards luncheon on Nov. 5, 2018.

PISCES PIO Nominated as RCUH Employee of the Year

PISCES' Public Information Officer Chris Yoakum was honored during RCUH's annual awards luncheon in early November among a handful of individuals nominated for the 2018 Outstanding Employee of the Year award.

Chris was recognized for playing a key role in securing grant funding for PISCES' Workforce Development programs, as well as his efforts to expand the agency's outreach and communications activities. In 2017, he secured more than $35,000 to provide STEM work and education opportunities to local high school and college students. He also expanded PISCES' participation in community outreach and education events to engage youth and the public in the agency's aerospace development work.

"It was an honor to be nominated and recognized for the work I've been doing here," Chris said. "PISCES has given me a lot of support and opportunities to grow as a professional, and I feel grateful to be a part of the team."

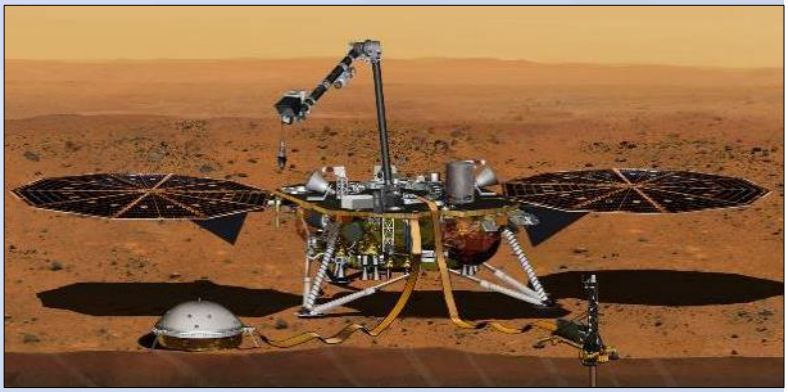
Director's Message *continued...*

She is now using this data to identify possibilities for commercial products made of sintered basalt. We hope this research will deliver economic benefits for the State of Hawaii, and one day support astronauts on the Moon and Mars by providing sustainable resources.

Speaking of Mars, NASA's InSight probe just completed a successful landing on the surface of the Red Planet. This is a great accomplishment for space exploration and adds to a growing list of successful landings on Mars. The instruments aboard InSight will beam back new data on Martian seismic activity, providing clues about the geological make up beneath the surface. Also, two cubesats, MarCO-A and MarCO-B, supported the mission by relaying high-speed data from InSight to Earth.

While interest in human travel to Mars remains strong, sending astronauts back to the Moon to establish a permanent base is gaining increasing traction. As you probably know, the White House's new space policy is focused on returning astronauts to the Moon to pave the way for eventual missions to Mars.

Under this renewed interest in lunar activity, the Hawaii Space Exploration Analog and Simulation (HI-SEAS) habitat is shifting its current focus of long duration, Mars-based missions to short-term assignments that simulate lunar conditions. PISCES staff will be directly involved in this new series of Moon simulation missions at HI-SEAS.



NASA's InSight probe . PC: Artist rendering, NASA-JPL/Caltech.

Lastly, the market expectation for small satellites and small satellite launch vehicles continues to grow. Private space companies like Rocket Lab are developing new domestic launch facilities. (Construction for the company's second launchpad began in October on Virginia's Eastern Shore.) As more small launch vehicles enter the market, there will be a growing demand for small vehicle launch facilities around the world. This will create strong economic growth opportunities for places (like Hawaii) that support desirable launch trajectories.

It is exciting to be at the nexus of a new era in Space Exploration! On behalf of the PISCES 'ohana, I wish you Happy Holidays and a prosperous New Year.

Mele Kalikimaka a Hau 'oli Makahiki Hou, R. Romo

Rodrigo Romo, PISCES Program Director