A PATHWAY TO PLANETARY SCIENCE IN THE PACIFIC. L. D. Teodoro[1] , H. A. Ishii[1], J. P. Bradley[1], H. M. Kaluna[2] , G. J. Taylor[1,3] and M. S. Nii[3], [1]Hawai'i Institute of Geophysics and Planetology, University of Hawai'i at Mānoa, 1680 East West Road, POST 602, Honolulu, HI 96822, USA (hope.ishii@hawaii.edu), [2]Department of Physics and Astronomy, University of Hawai'i at Hilo, 200 W. Kawili St., Hilo, HI 96720, USA, [3]Hawai'i Space Grant Consortium, University of Hawai'i at Mānoa, 1680 East West Road, POST 501, Honolulu, HI 96822, USA.

Introduction: Opportunities to actively engage in scientific research are limited for students in the Pacific Islands due to their remote location and limited resources. Few scientists visit classrooms or give public talks, take-your-child-to-work days rarely involve science, and there are few opportunities to observe science research. Even so, many of these students are eager for opportunities and successful careers in science fields, especially those that benefit and inform life on their home islands. Here, we describe the pathway taken by one student, co-author Lean, from the Northern Mariana Islands, a US commonwealth, that exposed her to the myriad opportunities in science and lured her into geology and planetary science. To engage her in planetary required exposure, opportunities, a mentoring community and financial support.

Exposure to scientific research: Lean grew up on Saipan in the Northern Mariana Islands and performed well in high school. She participated in Pacific STEP-UP [1], a summer science program that introduced her to the thrill of research. Her first research exposure was on prevention of box jellyfish stings with synthetic materials, a problem relevant to her home island. She was hooked on research. Her teachers encouraged her to go to college, and she started at the Northern Marianas College, a community college, and then transferred to the University of Hawaii at Mānoa (UH Mānoa), a research university, a daring 3700 miles from home.

Opportunities and support for planetary science research: At UH Mānoa, Lean joined SOEST Maile Mentoring Bridge [2], a program focused on supporting Native Hawaiians, Hawaiian locals and other underrepresented ethnic minorities in ocean, earth and environmental sciences by developing strong mentoring relationships with graduate students or science professionals. The program is funded by grants from NSF Directorate for Geosciences and Kamehameha Schools. Monthly lunch meetings build relationships, expose students to ongoing science and possible careers, and provide support and advice. Free tutoring and assistance with internship, scholarship and graduate school applications are also offered. STEM mentoring programs at other UH campuses provide similar support for Pacific Island students to engage in science, for example, the Keaholoa STEM Scholar Program at UH, Hilo. Underrepresented minorities are often first generation college students and have low

Fig. 1. Filter exchange in the high-volume air sampler at Mauna Loa Observatory.

retention rates at the undergraduate level. Such programs provide a much-needed sense of community support (family/'ohana) as students overcome challenges of pursuing a degree and imposter syndrome. They also provide exposure to research opportunities: Lean's mentor is an underrepresented minority postdoc studying asteroids and space weathering processes that alter them. She made Lean aware of opportunities for research in planetary science through the Hawaii Space Grant Consortium (HSGC, [3]).

The Hawai'i Space Grant Consortium is an educational program funded by NASA. It offers paid traineeships and fellowships for full-time undergraduate students. Because money is a major limitor for many Pacific Islanders, providing funding support is necessary to make research possible. HSGC includes UH Mānoa, UH Hilo, UH Maui College, University of Guam, six community colleges across the Hawaiian islands and two industry partners. Goals include strengthening STEM education, developing links to local high tech businesses, and increasing opportunities for women and minorities. Lean was especially interested in a Hawai'i Space Grant Consortium research project and got started with two more mentors.

Collecting cosmic dust: An estimated 20,000-40,000 tons of extraterrestrial (ET) dust, produced by small bodies like comets and asteroids, is captured by Earth's gravity and arrives at Earth's surface each year [4]. ET dust has historically been collected by stratospheric aircraft in silicone oil or by melting and filtering polar ice and snow, but these suffer from contamination and leaching effects [5]. Mauna Loa, a shield volcano on the island of Hawai'i, is an ideal location for collecting asteroid and comet dust. In collaboration with the National Oceanographic and Atmospheric

Administration (NOAA), a new collection is underway capturing particles directly from the air onto clean, dry filters using a high-volume air sampler at the Mauna Loa Observatory (MLO) at 11,141 ft elevation [6]. Downslope airflow at night results in reduced levels of natural and manmade particles in clean, dry, well-mixed Central Pacific air. (This site has been used to measure the Keeling Curve of CO_2 levels in the atmosphere.) ET particles have been previously collected in water baths at MLO for helium isotope studies, and levels of $^3He/^4He$, frequently >100× atmospheric levels, confirm high fractions of ET dust [6].

The MLO air sampler is equipped with an anemometer and wind sector controller to limit sampling to down-mountain airflows > 1 m/s. Particles are collected on polycarbonate membrane filters with 5 µm diameter perforations. Flow rate and active sampling exposure time are monitored. Improvements to the collection parameters include a timer to eliminate intermittent collection during the transition from up- to downslope airflow. We estimate that ~40-125 ET particles >5 µm in diameter will be captured per month. Since particle loading is modest, we are now exploring reducing filter area and, thus, the required search area.

Particles are examined by scanning electron microscopy (SEM) and energy dispersive x-ray spectroscopy (EDX) to search for those with chondritic (solar-like) compositions. Figure 3 shows one such particle identified on a filter after concentrating particles near the filter center. Near-chondritic compositions indicate the lack of differentiation expected for small primitive solar system bodies. In this manner, we have identified several candidates for confirmation by transmission electron microscopy (TEM) for assessment of mineralogy, petrography and hydrous/anhydrous nature necessary to classify the particles further.

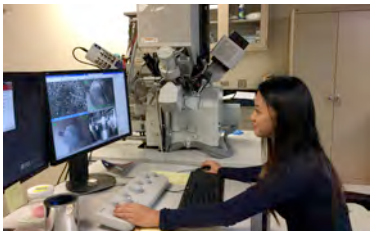

Fig. 2. SEM-EDX mapping to search for extraterrestrial particle candidates on an FEI Helios 660 Focused Ion Beam instrument.

Conclusions: To engage Pacific Island students in science requires exposure, opportunities, a supportive mentoring community, and financial support. Here, we have described the powerful combination of the SOEST Maile Mentoring Bridge at University of Hawai‘i at Mānoa, which provides a mentoring support, community, exposure to interesting science and opportunities to engage with active scientists, together with the Hawai‘i Space Grant Consortium Fellowship program, which provides funding and development support for future space scientists and engineers. A major benefit of these programs is the growth of a cohort of students supporting each other in scientific inquiry.

Finally, a local connection to the islands is important for engaging students in research of significance and relevance to them. In particular, planetary science research projects that take advantage of unique conditions in the Pacific, like the Mauna Loa Cosmic Dust Collection described here, remote observing in the Pacific skies, and studying Pacific environments as analogs to those on other planets/moons are ideal for engaging Pacific Island students in planetary science.

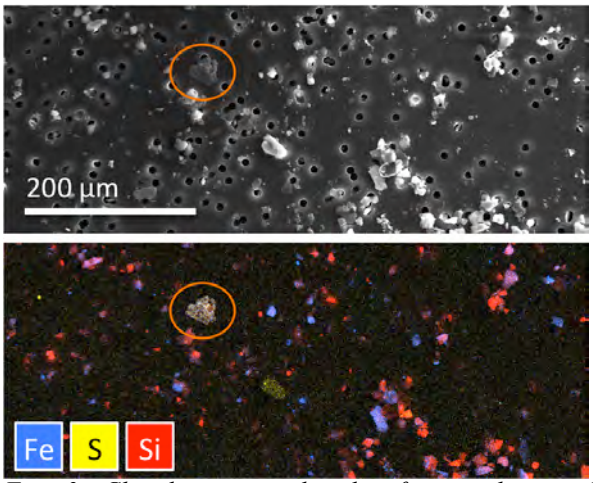

Fig. 3. Chondritic particle identification by rapid SEM-EDX mapping on a post-collection-concentrated filter. ET candidate particle is circled.

The future: Lean is working on her BS degree in geology and will continue her planetary science career as a summer intern at NASA’s Jet Propulsion Lab investigating the formation and evolution of asteroid families via physical properties of asteroids derived from NEOWISE thermal infrared measurements. She hopes one day to be a NASA astronaut, break her family’s cycle of poverty, and engage more students in STEM on her home island.

References: [1] www.pacificstepup.org [2] www.soest.hawaii.edu/maile [3] www.spacegrant.hawaii.edu [4] Love & Brownlee (1993) *Science,* 262:550-553. [5] Wozniakiewicz et al. (2014) *LPS XXXXV,* Abstract #1823. [6] Ishii et al. (2017) *LPS XLVIII,* Abstract #1141.

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