EARTH AND PLANETARY SCIENCE TRAINING FOR NASA'S NEWEST ASTRONAUTS: 2018 TRAINING AND 2019 PLANNING. T. G. Graff [1], C. A. Evans[2], J. E. Bleacher[3], K. E. Young[3], M. A. Helper[4], B. J. Tewksbury[5], J. M. Hurtado Jr[6], L. A. Edgar[7], R. A. Thompson[8], W. L. Stefanov[2], G. R. Osinski[9], A. B. Regberg[2], R. A. Zeigler[2], P. W. Bauer[10], M. J. Wilkinson[1], M. J. Zimmerer[10], M. Timmons[10], and A. Read[10], [1]Jacobs, NASA/JSC, Houston, TX 77058 (*trevor.g.graff@nasa.gov*), [2]NASA/JSC, [3]NASA/GSFC, [4]University of Texas at Austin, [5]Hamilton College, [6]University of Texas at El Paso, [7]USGS/Flagstaff, [8]USGS/Denver, [9]University of Western Ontario, [10]New Mexico Bureau of Geology and Mineral Resources.

Introduction: The Johnson Space Center (JSC) is home to NASA's human spaceflight activity and the astronaut corps. With a legacy that reaches back to the early days of the space program, geoscientists have been training and preparing astronauts to observe the Earth from space and explore other planetary surfaces [1-8]. Continuing this legacy, the JSC Astromaterials Research and Exploration Science (ARES) Division has been closely coordinating with the Flight Operations Directorate (FOD) to conduct a comprehensive geoscience training program for the 2017 astronaut class [9-11].

The current Earth and Planetary Science (EPS) training program has been developed based on feedback from the 2009 and 2013 astronaut classes, input from the Lunar Exploration Analysis Group (LEAG), and findings from a NASA HQ commissioned Strategic Action Team on Geologic Astronaut Training. Approved by the NASA Astronaut Office and the Astronaut Candidate Training Working Group, the EPS program is a comprehensive 4-week training curriculum that includes classroom and field components. Classroom training modules include Geoscience Fundamentals (tectonics, structural geology, remote sensing, geomorphology, and volcanism), Earth Systems (land cover and land use, oceanography, and atmospheric and climate sciences), and Planetary Science and Missions (Moon, Mars, small bodies, and astrobiology). Field training activities include expeditions to Galveston Bay (2017), the Rio Grande Rift in New Mexico (2018), and Meteor Crater and volcanic destinations in Arizona (2019). Here we report on the completed EPS training conducted during 2018, as well as planned activities for 2019.

2018 Classroom Training: The 2018 classroom training took place from June 11th to 15th at JSC. The first day featured prominent Apollo program keynote speakers Harrison "Jack" Schmitt and Gerald "Gerry" Griffin, as well as LEAG Emeritus Chair Clive Neal. The first day also included a full tour of the ARES Lunar Curation Laboratory and lunar samples. This introductory day served to inspire the 2017 astronaut class by highlighting first-hand accounts and experiences from those involved in the Apollo program, NASA's scientific exploration goals, the importance of astronaut geoscience training, the significance of sample return and analysis of astromaterials samples, and more.

The mid-week classroom training (~18 hours) was comprised of a highly integrated set of geoscience fundamental content taught and facilitated by leading subject matter experts from universities, USGS, and NASA. Content themes included: 1) A Global View of Earth and Plate Tectonics, 2) Deformed Rocks – Faults, Folds, and Fractures, 3) Remote Sensing, 4) Igneous Process and Volcanism, and 5) Surface Processes and Landforms. Instruction integrated interactive learning activities and were sequenced to incrementally build and apply content knowledge. In addition, two remote live-video conference presentations were facilitated to reinforce content being taught. The first connected the 2017 astronaut class with USGS personnel on the ground at Hawaiian Volcano Observatory discussing the then-active eruptive episodes of Kilauea. The second live-video presentation was from the Turkana Basin in Kenya discussing the role of geology in recent discoveries in the ape and human lineage.

To reinforce and apply their new geoscience fundamental knowledge, the astronaut class completed a capstone exercise focusing on two case study regions. Using Google Earth, teams analyzed the volcanic features, bedrock structures, and surface processes in one of two regions (the central Andes or the East African Rift) and addressed the questions *what's there*, *what happened*, *when*, and *why*. Teams presented their regional analyses and rationale at the conclusion of the capstone exercise.

The remainder of the 2018 classroom training consisted of a planetary science overview and a series of pre-fieldwork mapping exercises. The interactive pre-fieldwork mapping exercises (~7 total hours) was spread throughout the classroom week in order to take advantage of the content knowledge built each day. The mapping exercises involved analysis of satellite images and other remotely sensed data, enabling students to progressively build an initial geologic map, cross-section, a "bucket list" of locations of interest, and a provisional geologic history of their mapping

region in preparation for the following week's field activities.

2018 Field Training: The 2018 field training took place from June 17th to 22nd, immediately following the classroom training. The field location and mapping areas were located in the Rio Grande del Norte National Monument upper gorge area, near Questa, New Mexico (on the Sunshine 7.5' Quadrangle). This region was selected based on a number of training objectives and logistical purposes and has a long history of Apollo and Shuttle astronaut training [12-13]. Basecamp was established at the El Aguaje Campground with logistics support and local area expertise provided by the New Mexico Bureau of Geology and Mineral Resources.

The class was divided into four mapping teams (two teams of four astronauts and two teams of three), each assigned a primary and assistant instructor. Each student had an orthophotograph, topographic map, digital elevation map, Landsat remote sensing data, International Space Station (ISS) image, and numerous GigaPan images of the designated mapping region. In addition, each student had a field book with pertinent field reference cue cards, hand lens, field clipboard, drafting film, and an optional iPad-mini with digital mapping data and software. The team gear consisted of a first aid kit, two-way radio, GPS, rock hammer, binoculars, and compass. Two teams also had access and capability to fly small UAVs to acquire reconnaissance imagery. Teams had three full mapping days after an initial orientation and safety briefing.

The overarching field objectives were to 1) observe and apply classroom geoscience fundamental concepts, 2) construct a geologic map and cross section, and 3) practice expeditionary skills and behavior. Each field team successfully developed detailed geologic maps and cross sections through diligent observations, sample collection, dynamic and iterative planning efforts, and use of multiple working hypotheses. Teams collectively presented their finished products and interpretations of geologic history at the conclusion of the field week. In addition to the practical aspects of applying basic geoscience concepts and learning fieldwork fundamentals, this training environment provided a unique platform for practicing expeditionary skills and behavior, a component that is highly valued by the Astronaut Office.

2019 Training Plan: The 2019 training will again consist of a classroom week at JSC followed by a field week. The 2019 classroom portion will cover both the Earth Systems and Planetary Science and Missions modules [11]. Building on the successful 2018 classroom format, the 2019 classroom training will integrate hands-on activities, unique and timely live-video presentations, a planetary-focused capstone exercise, and include expert instructors from across NASA, USGS, and universities. The classroom portion will again prepare students for the field by covering sampling tools and protocols, field instrumentation, traverse planning, and preliminary mapping.

The 2019 field location will be north of Flagstaff, Arizona in the San Francisco volcanic field, and will include an excursion to Meteor Crater and possibly other local geologic and historic sites. Three days will be devoted to a designated mapping region with the goal of producing final products and team presentations. Unique to this field exercise, mapping teams will collect additional data using field-portable spectrometers and other instruments to help inform field and sampling decisions. In addition, the overall field scenario will incorporate planetary analog sampling tools and protocols.

Conclusions: A successful Earth and Planetary Science training program was conducted in 2018 for NASA's newest astronaut class. Detailed lessons learned were captured from the students and instructors for both classroom and field components. Planning is currently underway for the remaining 2019 training activities. This intensive geoscience training program ultimately establishes foundational knowledge for the 2017 astronaut class to continue their learning through analog mission involvement and other science opportunities, as well as preparing them as knowledgeable science representatives of the agency.

2018 EPS Field Training

References: [1] Lofgren G. et al. (2011) GSA SP483, 33-48. [2] Schmitt H. H. et al. (2011) GSA SP483, 1-16. [3] Hodges K. V. and Schmitt H. H. (2011) GSA SP483, 17-32. [4] El Baz F. (2011) GSA SP483, 49-66. [5] Phinney W. C. (2015) NASA/SP-2015-626. [6] Evans C. A. et al. (2011) GSA SP483, 67-74. [7] Eppler D. et al. (2016) GSA Today v.26 no.8, 34-35. [8] Bleacher J. E. et al. (2017) Planetary Science Vision 2050 Workshop, 8088, [9] Young K. E. et al. (2017) HRP IWS, [10] Evans C. A. et al. (2018) AGU, P31H-3798, [11] Graff T. G. et al. (2018) 49th LPSC, 2547, [12] Muehlberger W. R. (2004) NMGS Field Conference Guidebook, 272-277, [13] Dickerson P. W. (2004) Field Conference Guidebook, 278-281.