EARTH AND PLANETARY SCIENCE TRAINING FOR THE 2017 ASTRONAUT CLASS. T. G. Graff[1], K. E. Young[2], C. A. Evans[3], J. E. Bleacher[4], R. Zeigler[3], B. Tewksbury[5], M. Helper[6], and J. M. Hurtado, Jr.[7]; [1]Jacobs, NASA JSC, Houston, TX 77058 (*trevor.g.graff@nasa.gov*); [2]UTEP-Jacobs/JETS at NASA JSC; [3]NASA JSC; [4]NASA GSFC; [5]Hamilton College; [6]UT-Austin; [7]UTEP.

Introduction: The Apollo astronauts underwent an extraordinary science training program geared toward preparing them for both lunar surface exploration and orbital observations. These early pioneers completed extensive classroom and field training in preparation for their unique missions. Building upon a strong foundation of geoscience fundamentals, Apollo science training progressed in intensity to include field excursions and instruction specifically tailored towards each mission's landing site and science objectives. Astronauts who flew on the final three Apollo J-class missions received over 1,000 hours per crewmember of hands-on geology training from professional geologists [1]. This robust training program yielded a unique set of lunar samples, in-situ observations, and scientific experiments that the science community is still reaping the benefits of today [1-5]. Following the Apollo era, Space Shuttle crews received 40-50 hours of training per crewmember geared primarily to Earth observations and imaging targets [6]. As the Constellation program focused once again on sending humans back to the lunar surface, there was momentum to expand the astronaut training to include more robust scientific classroom and field training. The 2009 and 2013 Astronaut classes therefore received detailed geoscience training geared toward future exploration targets [7].

Background: NASA's current exploration objectives highlight the need for current astronauts to continue receiving in-depth training in Earth and Planetary Science. Astronauts on the International Space Station (ISS) spend considerable time observing, photographing, and documenting the Earth. Gaining an understanding of the dominant Earth surface processes, human impacts, major geographic and physiographic provinces, and geologic and climatic events is vital for their ISS expeditionary training. Additionally, NASA is currently developing their long-term vision to once again send humans beyond low-Earth orbit. As lunar, martian, and small body targets are being discussed, it is clear that astronauts will once again be completing scientific exploration of bodies beyond our own. Additionally, as representatives of NASA who frequently promote the goals of the agency in a public forum, it is essential that astronauts understand Earth science, planetary science, and current NASA missions. The 2017 Earth and Planetary Science Training therefore focuses on developing a culture of exploration by both focusing on Earth science, as well as introducing planetary science concepts to help prepare for exploration of other worlds.

The 2017 Astronaut Class (consisting of 12 NASA astronauts and 2 astronauts from the Canadian Space Agency) reported for duty to NASA Johnson Space Center in August 2017. They will undergo two intensive years of initial training in a variety of subjects prior to becoming eligible for selection as a crew member on a designated space flight.

Training Overview: The 2017 Earth and Planetary Science (EPS) training program has been developed based on feedback from the 2009 and 2013 astronaut classes, LEAG (Lunar Exploration Analysis Group), and a NASA HQ commissioned Strategic Action Team on Geologic Astronaut Training. This comprehensive training program has been approved by the NASA Astronaut Office and the Astronaut Candidate Training Working Group and includes comprehensive classroom and field components. Throughout the EPS program, instructors will incorporate an expeditionary mindset to supplement the other operational and expeditionary training by providing team and leadership building experiences.

The 2017 Astronaut Class kicked off their EPS training with a one-day field trip to the Bolivar Peninsula, Galveston Bay, TX, in December 2017. In June 2018, they will complete one week of classroom training at NASA Johnson Space Center (JSC) in Geoscience Fundamentals followed immediately by one week of field training near Taos, NM. In the summer of 2019, they will complete the EPS training with one week of classroom activities at JSC in Earth Systems and Planetary Science before the final week of fieldwork near Flagstaff, AZ. Subject matter experts from across academia and government agencies (NASA, USGS) will serve as instructors for both the classroom and field components. In addition, keynote speakers will be incorporated to provide expertise, historical context, and personal accounts.

Classroom Training: The classroom training is divided into three integrated modules 1) Geoscience Fundamentals, 2) Earth Systems, and 3) Planetary Science and Missions.

Geoscience Fundamentals: This module includes topics relevant to both Earth science and planetary systems including plate tectonics, structural geology, remote sensing, igneous processes and volcanism, surface processes, and an introduction to how these processes manifest on planetary surfaces. In addition to these core fundamentals, the class will complete a series of integrated mapping exercises in preparation for their field training.

Earth Systems: This training will include topics such as land cover/land use, oceanography, and atmospheric/climate science. These training modules are geared specifically for observations and data collection from the ISS.

Planetary Science and Missions: The final training module will include introductions to the Moon, Mars, small bodies (comets and asteroids), astromaterials, and astrobiology. This module will incorporate the current status and objectives of the on-going missions within the Science Mission Directorate. Providing practical observations to compliment classroom instruction, the class will also visit the astromaterial curation laboratories at NASA JSC (the Lunar Lab, Meteorite Lab, etc.) and associated research laboratories.

Field Training: The field training component has been expanded to allow for maximum hands-on time spent solidifying core concepts in a field environment. Three integrated field experiences will be part of the EPS training.

Bolivar Peninsula on Galveston Bay, TX: The first field excursion with the 2017 class was completed on December 1, 2017. This field experience consisted of a one day trip to the Bolivar Peninsula on Galveston Bay, TX. The astronaut candidates studied photos taken from the ISS of Galveston Bay before and after major storm systems swept the area to highlight the effects that major weather systems can have on coastal regions. They followed these analyses with trenching activities (Fig 1) designed to look at these storm deposits in-situ and examined field-portable instrument data from these same deposits in an effort to tie remote sensing datasets to ground observations, as well as to introduce the concept of in-situ analysis prior to their additional field training.

Figure 1: The 2017 Astronaut Class trenching during Bolivar Peninsula field trip to observe storm deposits.

Northern Rio Grande, NM: The Rio Grande del Norte site near Taos, NM, has long been used for astronaut training. Following a series of mapping exercises that will be completed during the prior classroom training week, the class will be split into smaller field teams and mentored by experienced field geologists. Each astronaut team will make observations and construct geologic maps, before presenting their findings to the other small teams at the end of the week. An expeditionary component will be incorporated throughout this week, as they will be living and working in the field, working in small teams, and rotating through leadership opportunities.

Northern AZ: The area surrounding Flagstaff, AZ has also long been used as a training ground for astronauts and other NASA programs. At both the Meteor Crater area as well as the San Francisco Volcanic Field (SFVF), the class will have first-hand experience with features produced by volcanic and impact cratering processes, which are visible both from ISS and ubiquitous in exploration targets on other planetary surfaces. They will explore Meteor Crater before moving to the SFVF for a field campaign emphasizing sample identification, collection, and mapping. There will also be a team-based focus on operation of field-portable instrumentation and real-time integration of science results, with regular small team presentations based on this data integration. The Arizona field campaign will tie directly back to the JSC classroom training and the visits to curation facilities and laboratories, as well as exploration concepts that are currently under development for future human planetary surface activities.

Moving Forward: It is clear from the wealth of science gleaned from the six Apollo lunar surface missions that the geology training each astronaut received was vital to the scientific success of the Apollo program [1-7]. Moving forward to the next generation of planetary surface exploration, it is equally vital to provide equivalent training to future planetary explorers. Astronauts are not only incredibly effective ambassadors in garnering public support for NASA and its scientific objectives, but they will also be the people who one day will collect the samples, in-situ instrument data, and field observations that the scientific community will take advantage of for future decades.

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