SCIENCE ENGAGEMENT THROUGH HANDS-ON ACTIVITIES THAT PROMOTE SCIENTIFIC THINKING AND GENERATE EXCITEMENT AND AWARENESS OF NASA ASSETS, MISSIONS, AND SCIENCE. P.V.Graff[1], S.Foxworth[1], R.Miller[1], S.Runco[2], M.K.Luckey[2], and E.Maudlin[3] [1]Jacobs, NASA JSC, Houston, TX 77058, (paige.v.graff@nasa.gov),[2]NASA JSC, [3]NASA Intern.

Introduction: Engaging students, teachers, and the public with hands-on activities that infuse content related to NASA assets, missions, and science and reflect authentic scientific practices promotes understanding and generates excitement about NASA science, research, and exploration. These types of activities expose our next generation of explorers to science they may be inspired to pursue as a future STEM career and expose people of all ages to unique, exciting, and authentic aspects of NASA exploration. The activities discussed here (*Blue Marble Matches, Lunar Geologist Practice, Let's Discover New Frontiers, Target Asteroid, and Meteorite Bingo*) have been developed by Astromaterials Research and Exploration Science (ARES) Science Engagement Specialists in conjunction with ARES Scientists at the NASA Johnson Space Center. Activities are designed to be usable across a variety of educational environments (formal and informal) and reflect authentic scientific content and practices. The ARES Division [1], a division of the Exploration Integration and Science Directorate (EISD), is located at the NASA Johnson Space Center (JSC) in Houston, TX and houses JSC's physical science teams who perform planetary research and support current and future Earth and planetary missions. ARES is also responsible for the curation of NASA's astromaterial collections [2].

Blue Marble Matches: *Blue Marble Matches* [3] is a hands-on activity that enables individuals to gain experience modeling how scientists use Earth to better understand geologic features and processes that have sculpted the surface of Earth and potentially other terrestrial worlds. Best suited for formal learning environments (grades 3+), though adaptable for informal learning environments, this activity has been presented at numerous educator workshops and is used by many teachers in their classrooms. The 5E inquiry design of the activity enables individuals with little to no background in planetary science to be transformed into emerging scientists developing skills, building vocabulary, and engaging in comparative planetology practices. The activity steps individuals through a process in which they use imagery of Earth taken by astronauts on the Space Shuttle or International Space Station (ISS) to develop criteria to identify geologic features and therefore processes on Earth. Once defined, they apply that criteria to support the identification of geologic features and processes on other terrestrial worlds. The data used as part of *Blue Marble Matches* highlights numerous NASA missions such as the Apollo Missions (Moon); Mars Global Surveyor, Mars Odyssey (Mars); MESSENGER (Mercury); Magellan (Venus); Voyager and Galileo (Moons of Jupiter); Dawn (Ceres and Vesta), New Horizons (Pluto), as well as ISS expeditions. *Blue Marble Matches* helps individuals gain experience in authentic scientific practices while generating excitement about NASA science and exploration.

Lunar Geologist Practice (Classifying Lunar Samples): Classifying Lunar samples is an involved process that combines visual observations and data obtained through the use of scientific instrumentation. Preliminary classifications of samples, however, can be made through visual observations. Thus, this can be conducted by people of any age, provided that they apply a suitable set of criteria to justify their classifications. The *Lunar Geologist Practice* activity, part of the *Rocks, Soils, and Surfaces* curricular unit [4] involves classifying images of Apollo Lunar Samples, curated in NASA's Lunar Laboratory at JSC, into one of three general classification categories. Individuals apply identified criteria to support each classification. Audiences are first introduced to the general classifications and associated criteria before putting their Lunar geologist skills to work. To promote scientific thinking, whether using the activity in a formal or informal learning environment, participants (regardless of age) are asked to justify and support their classifications. This hands-on activity promotes scientific thinking and helps audiences make connections between collected Apollo Lunar samples and what they observe when they look up at our Moon or when they observe globes or maps of the Moon. This facilitates discussions about the Apollo Missions as well as missions such as the Lunar Reconnaissance Orbiter. This activity also highlights one of NASA's most unique and precious assets, the Apollo Lunar Samples. The Lunar and Meteorite Sample Disk Program [5], managed by ARES Curation, enables educators (formal and informal) to borrow authentic samples encapsulated in 6-inch Lucite disks with their audiences. The *Lunar Geologist Practice* activity, when paired with the Lunar Sample Disk, gives audiences an opportunity to gain experience classifying Lunar samples and then allows them to apply that experience and knowledge to the authentic samples within the Lunar Sample Disk. This enables

individuals to gain a stronger appreciation and understanding of the samples, NASA missions to the Moon, and science and research about our Moon.

Let's Discover New Frontiers: NASA Discovery and New Frontiers Missions are exciting endeavors that in some cases, have enabled the collection of extraterrestrial samples to be brought back to Earth, all of which are curated at the NASA Astromaterials Curation facilities at NASA JSC. Not only are the missions exciting, the manner in which samples are collected is fascinating and the collected samples themselves provide significant insight into the understanding of the history and evolution of our Solar System. The *Let's Discover New Frontiers* activity highlights aspects of three sample return missions: Stardust, Genesis, and OSIRIS-REx. In addition to highlighting each mission, aspects associated with sample collection, and the importance of sample return, the activity also encourages individuals to apply mission principles as they design their own sample return mission. This activity, easily adaptable for formal or informal learning environments, highlights NASA missions along with a variety of NASA's unique assets, the collected extraterrestrial samples. When this activity is facilitated by staff from ARES, sharing a curation display sample (i.e. wafer pieces with embedded solar wind samples collected by the Genesis Mission to the Sun; or an aerogel sample, the sample collection material used as part of the Stardust Mission) brings excitement, awareness, and authenticity of the stories of these missions to an even higher level. This activity also facilitates discussion and excitement about past, present, and future Discovery/New Frontiers missions.

Target Asteroid: The OSIRIS-REx mission is a current example of a NASA mission targeting a specific asteroid, Bennu, to investigate. What criteria did Bennu meet to be selected for investigation? Have other asteroids been explored and if so, how and why were they selected? These questions led to the development of the *Target Asteroid* activity. This activity aims to have audiences gain insight into the process of selecting an asteroid to investigate as part of a Solar System Exploration Mission. As this process is quite extensive and complex, the *Target Asteroid* activity takes on a simplified approach: a focus on four asteroid characteristics (location, size, rotation period and a very generic set of asteroid classes) and an introduction to aspects related to mission rationale and type of exploration mission (fly-by, orbiter, lander, sample return) to find a suitable asteroid target for exploration. Best suited for middle school-aged students and higher in a formal or structured informal learning environment, this activity highlights past, present, and future missions that involve asteroids. Once individuals gain an understanding of the process involved in selecting a target asteroid for investigation, they are encouraged to design their own mission. This requires applying design principles they experienced as part of the activity. This activity enables individuals to gain an understanding of part of the process involved in selecting an asteroid to investigate and generates excitement about NASA missions and the seemingly endless possibilities of worlds within our Solar System that have yet to be explored!

Meteorite Bingo: People of all ages enjoy a game of bingo from time to time. Add in scientific content on meteorites, and now you are able to highlight the Antarctic Search for Meteorites (ANSMET) Meteorite Collection, curated by our NASA Astromaterials Meteorite staff. *Meteorite Bingo* is a game, initially developed by a summer intern with input from ARES Science Engagement Specialists and Scientists. A draft version of the activity was tested at four library events with audiences ranging from age 5 through high school. The activity proved itself to be a fun and engaging way to share one of NASA's other unique assets, the ANSMET Meteorite Collection. Although the bingo game does not model an authentic scientific process, it does facilitate a means in which to provide awareness of ANSMET expeditions and NASA's curation of these precious meteorite samples. *Meteorite Bingo*, together with the NASA Meteorite Sample Disks (similar to the Lunar Sample Disks but with ANSMET meteorite samples encapsulated within the 6-inch Lucite Sample Disk), enables audiences to not only learn about meteorites, but provides them with the opportunity to hold authentic meteorite samples in their hands. This opens up the opportunity to literally bring rocks from space directly to a formal or informal learning environment and is an additional means in which to bring awareness and excitement about NASA assets and expeditions.

Conclusions: Engaging students, teachers, and the public with hands-on activities that infuse content related to NASA assets, missions, and science promotes scientific thinking and generates excitement and awareness of the rich and cutting-edge science, research, and exploration being facilitated through NASA's Science Mission Directorate.

References: [1] Astromaterials Research and Exploration Science, https://ares.jsc.nasa.gov/ [2] Astromaterials Acquisition & Curation Office, https://curator.jsc.nasa.gov/ [3] Blue Marble Matches https://ares.jsc.nasa.gov/interaction/eeab/blue-marble-matches.html [4] Rocks, Soils, & Surfaces, https://ares.jsc.nasa.gov/interaction/lmdp/rss.html [5] NASA Lunar and Meteorite Sample Disk Program, https://ares.jsc.nasa.gov/interaction/lmdp/.