

KISSING MARS ROCKS WITH THE ROVER'S RATS: AN EDUCATIONAL EXERCISE TO UNDERSTAND DRILLING ROCKS ON MARS. David A. Williams¹, Patrick L. Whelley¹, Jacob E. Bleacher², Shelby R. Cave¹, Veronica A. Zabala-Aliberto¹, Angelina A. Zabala³, and Ronald Greeley¹; ¹School of Earth and Space Exploration, Arizona State University, Box 871404, Tempe, Arizona, 85287 (David.Williams@asu.edu); ²Planetary Geodynamics Laboratory, NASA Goddard Spaceflight Center, Greenbelt, Maryland; ³Wigwam Creek Middle School, Litchfield Park, Arizona.

Introduction: The ongoing successful explorations of NASA's *Mars Exploration Rovers* (MER), *Spirit* and *Opportunity*, has enhanced interest from the general public in space exploration. We have created the following Education-Public Outreach (EPO) activity to inform elementary school children about the scientific rationale behind drilling rocks on Mars to determine their compositions. Using various types of Hershey™ Kisses to represent different types of rocks, and straws to represent the MER Rock Abrasion Tool (RAT), students can participate in a inexpensive, easy to do, and tasty exercise to understand the how and why of the RAT operations on Mars.

Background: The MER science goals are to investigate the geology at two different sites on Mars where water once might have been present, and to assess the past environmental conditions to determine if the water once could have supported life [1]. The rocks encountered by *Spirit* and *Opportunity* are coated with material that obscures the underlying chemistry [2] and potential evidence for water. In anticipation of coatings, both MER were equipped with a Rock Abrasion Tool [RAT, 1]. The RAT enables a 4.5 cm diameter cylindrical hole to be ground into the face of rocks a few cm deep (depending on rock physical properties). Brushes on the RAT enables dust and loose material to be swept off the face of rocks. Both grinding and brushing have been successful in exposing the interior of rocks not observable pre-brush or grind [2, 3]. In the rock dubbed "Humphrey" a grind exposed an alteration rind, olivine crystals, and light toned veins (suggesting aqueous alteration) [2]. Both brushes are still operational (more than 3 years after landing), but the diamond cutting teeth on the *Spirit* RAT have worn completely down, and thus *Opportunity* is the only rover with grind capabilities.

Materials: This exercise was conceived by one of us (AAZ, a 7th grader) for the Sally K. Ride Festival at ASU in 2005. The pedagogy of this exercise is a hands-on experience, or kinesthetic approach to the learning process. Kinesthetic learning styles ensure that the participant thinks out issues, ideas and problems while the exercise is being conducted. This exercise can be performed with a minimum of items obtainable at your local grocery store: a variety of bags of Hershey™ Kisses (at least two different kinds are required, but it is better to use multiple kinds), simple bendable soda straws, paper towels, and garbage bags (the latter two items for cleanup). The activity will be enhanced if there are additional audio-visual materials

available so the children can visualize a MER rover, the RAT, and how it is used.

Methodology: The activity begins with a short talk discussing Mars and the MER mission, using PanCam images [1], Lego™ models of the rovers, and/or DVDs of the MER mission that show the computer animation of the RAT in action [4]. Then the students are asked to pick a Kiss at random from a container, and each is given a bendable straw. The student is asked to describe what they see in their hand. The common answer is "A Hershey™'s Kiss". Although correct, the student is asked to describe exactly what they see and they often can be led to indicate that they see an item wrapped in foil. At this point the student is asked if they believe the entire item to be composed of the foil that they see on the surface, to which they often reply, "No". The student is then asked to pretend that they have never eaten a Hershey™ Kiss, and then they are asked how they can be sure that the item is not entirely composed of foil. They are often led to the idea that they should remove the foil and check for themselves what is underneath the foil. At this time we discuss the concept of desert varnish, and describe how the interior of a rock can often differ from its external coating. We describe how this issue also occurs on Mars and further explain the RAT. At this time we explain how they can imagine that their straw is like the RAT, and that the Hershey™'s Kiss is like a rock on Mars, possibly different on the inside than what we can see on the outside, and possibly different from nearby rocks that appear the same as one another due to their coating. After the student tears away the foil with the straw it becomes clear that the outer coating does not represent the composition of their rock's interior. The students then drill into the flat base of the Kiss with the straw, and eventually will access the interior (e.g., almond, peanut butter, caramel, cherry cordial, dark chocolate (on the Hugs™ striped Kisses), or same as the outside (for plain Kisses). Through this exercise the students see the differences between the foil covering, outer rock layer (chocolate), and inner rock materials (filling), which we can relate to the variation in rock composition as observed in MER PanCam and Microscopic Imager (MI) images [1]. After drilling the Kisses the students typically eat them, and throw the straws and wrappers in the garbage. Paper towels are need to clean up the work area.

A variation of the exercise can be done using a container with various foil-removed Kisses. In this case most of the "rocks" look the same, except for the striped Hugs™ (which can be related to layered sedi-

mentary rocks) and the Dark Chocolate Kisses (which can be related to another variation in rock composition). After drilling, the analogies can be further extended to relate the Kisses with almonds to rocks with crystals, or to relate the Kisses with peanut butter or caramel to rocks with fluid or molten interiors.

Evaluation of Exercise: We performed this exercise for elementary and middle school children at the See ASU event in Tempe in February 2006, the CopperCon Science Fiction-Fantasy convention in Phoenix in September 2006, and the Pappas School for Homeless Children in Tempe in October 2006. Several items to note: 1) The exercise works best on a small class of students or other focused group in a separate room or area, away from other distractions; 2) It is best not to refrigerate the Kisses prior to use, as this makes them too hard to drill with the straws (in some cases they were cooled to prevent excessive softening in the Arizona heat, but this did not occur); 3) It is important to

screen participating students for peanut allergies, if using the Kisses containing peanut butter or almonds.

Summary: We developed an EPO exercise using straws and Hershey™ Kisses to simulate the operation of the RAT on the MER to teach students why rocks are drilled on Mars. In the three applications of the exercise, we received nothing but positive comments from teachers and adult supervisors of children, and as expected the students loved it. The exercise stimulated more specific questions from students about RAT and rover operations, and older children inquired about the three different rock types (igneous, sedimentary, metamorphic). This inexpensive, easy to do exercise can enhance children's understanding of the surface exploration of Mars, particularly if supported by appropriate MER-related audio-visual materials.

References: [1] Squyres, S.W., et al., 2003, *JGR* 108 (E12), 8062, doi:10.1029/2003JE002121; [2] McSween, H.Y. et al., 2004, *Science* 305, 842- 845; [3] Morris, R.V., et al., 2006, *JGR* 111, E02S13, doi:10.1029/2005JE002584; [4] *Eyes on Mars*, 2003, DVD, available at www.starrynight.com; .



Figure 1. Photo of Hershey™ Kiss exercise from See ASU, Tempe, Arizona, February 2006.