

DEVELOPMENT OF INSTRUCTIONAL ROCK KITS FOR USE IN PROFESSIONAL DEVELOPMENT WORKSHOPS AND CLASSROOMS. L. A. Lebofsky^{1,2}, A. M. Baldrige¹, S. R. Buxner^{1,2}, T. L. Cañizo¹, F. C. Chuang¹, S. K. Croft^{1,3}, D. A. Crown¹, S. J. Kortenkamp¹, and E. Pierazzo¹, ¹Planetary Science Institute, 1700 E. Fort Lowell Rd., Suite 106, Tucson, AZ 85719 (lebofsky@psi.edu), ²University of Arizona, Tucson, AZ 85721, ³Science, Pima Community College, Tucson, AZ 85719.

Introduction: Hands-on learning allows students to understand science concepts by directly observing and experiencing the things they are studying. With the advent of classroom technology, students can enhance their hands-on education through the use of computers. The Planetary Science Institute (PSI) is creating a series of instructional rock kits and related informational materials that is being introduced to elementary and middle school science teachers in Tucson, Arizona, through our professional development workshops [1, 2]. PSI will then provide teachers with supporting material and training so that they can use these kits as tools for students' hands-on learning in the classroom. Use of these instructional kits provides an important experience with natural materials that is essential to instruction in the Earth and Space Science standards. With a stronger knowledge of science content and of how science is actually conducted, the workshops and instructional rock kits instill greater confidence in teachers' ability to teach Earth and Space Science content.

Instructional Rock Kits: We have developed two instructional rock kits and related informational materials that are used for a variety of hands-on activities in our professional development workshops and in classrooms. The kits are available for check-out by teachers desiring to involve their students more deeply in the study of impact craters and meteorites. Hands-on experiences with actual samples provide students with an understanding of the formation and properties of impact rocks and meteorites as well as practice in the same skills scientists follow in their study of the rocks.

Impact Rock Kit: The Impact Rock Kit consists of hand samples of impact rocks gathered at the Haughton (Nunavut, Canada) and Ries (Germany) impact craters during field geologists' exploration of the craters. This rock kit is fully integrated with "The Explorer's Guide to Impact Craters" website [3, 4] hosted by PSI (www.psi.edu/explorecraters/) which includes virtual tours of Meteor Crater, Haughton Crater and Ries Crater, and indicates sample collection sites. Possible applications in the classroom of the Impact Rock Kits combined with the website are provided to teachers through the *Impact Cratering* professional development workshop. Each kit contains 10 samples of impact-altered or impact-generated rocks. The accompanying

explanation sheet describes where within (or outside) an impact crater these samples are found, the impact process(es) that led to their formation, where on the Earth the samples were collected, and their approximate ages. Teachers will give us feedback on both the training session and their experience in using the kits in their classrooms; this feedback will help us refine the materials and the check-out process. The rock kits are also available for loan to museums and other informal educational settings. To date, in addition to the teacher training programs at PSI and other sites, use in middle school classes in Tucson, and use in undergraduate courses, the kits recently have been sent to Morgan State University (Baltimore, MD) for a Geo-Space Science camp for high school students.

Meteorite Rock Kits: The Meteorite Rock Kit was initially developed to provide hands-on experience for students as a component of The Explorer's Guide to Impact Craters project. However, the kits have now become the focal point for the new *Asteroid-Meteorite Connection* professional development workshop as an integral part of the hands-on experience for the participating teachers. These kits contain a representative selection of differentiated and undifferentiated meteorites, including samples from Vesta and Hebe. These kits also include a small selection of "meteorwongs." As a part of the *Asteroid-Meteorite Connection* workshop, we have designed three activities involving the use of the Meteorite Rock Kit:

1. *Classifying meteorites into basic types* (carbonaceous chondrites, ordinary chondrites, achondrites, stony-irons, and irons) using basic features such as color (black for carbon), presence of chondrules, and presence of metal flecks or massive metal. The objective is to let the teachers become familiar with the main meteorite types, their important characteristics, and minerals.
2. *Measuring the reflectance spectra of selected meteorites* using an ALTA II spectrometer. The objective is to have teachers gain experience with the concept of reflectance spectra and show how spectra can be used to connect meteorites to asteroids.

3. *Identifying geologic processes in meteorites* starting with the rock cycle and samples of terrestrial rocks. We emphasize processes relevant to meteorites such as sedimentation, melting and differentiation, and impact brecciation and melting, and show textures and minerals in terrestrial rocks. Teachers then identify the processes that have affected the meteorites in the kits. The objective is to help the teachers connect the meteorites in hand to real asteroidal “parent bodies” in space, such as Vesta, and infer what geologic processes have occurred on these bodies.

We are presently creating information sheets and web-based materials that are similar to the materials that we have generated for the Impact Rock Kits. We are also planning training sessions for teachers and informal educators in the care and examination of the meteorites as a prerequisite for borrowing the kits for use in their classrooms or other outreach events. Lesson plans will integrate student-friendly information materials to accompany the science content.

Kits under Development: We currently are developing two more rock kits: The Volcanic Rock Kit and The Rocks of Southern Arizona Kit.

The Volcanic Rock Kit is being created to represent the diversity of volcanic materials on Earth and will include: 1) intrusive igneous rocks and their extrusive equivalents, 2) lava samples of similar composition but with differences in vesicularity, glass content, and crystal content, 3) lava samples of the same composition but different surface texture (i.e., aa, various forms of pahoehoe, and blocky lava), and 4) a variety of pyroclastic rocks (e.g., cinder, spatter, pumice, accretionary lapilli, reticulate) to illustrate the diversity of explosive volcanic phenomena. This kit will initially be used in support of the *Volcanoes of the Solar System* workshop which provides an introduction to volcanic landforms and eruptive processes, includes hands-on activities with volcanic rocks and simple experiments to illustrate properties of volcanic systems, and provides an opportunity to experience how scientists approach the study of volcanoes on other planetary bodies. Teachers will relate physical and chemical processes in volcanic systems to their expression (e.g., gas bubbles, crystals, glass) in natural volcanic rock samples.

The Rocks of Southern Arizona Kit will provide teachers and students hands-on awareness of the geology of deserts and of the region in which they

live, southern Arizona. The kit will support the *Deserts of the Solar System* workshop, currently under development at PSI. We envision that this kit will be especially useful in preparation for field trips to some of the many local outdoor attractions that Tucson offers, either through formal school activities or informally. The virtual tour of the Tucson region that we are generating will indicate the sample collection sites and link individual samples to the story of Tucson’s geologic history. These kits will include representative samples of the local mountain ranges and their altered forms (igneous and metamorphic rocks) as well as their representation in desert landforms, such as landslides and river gravels.



Impact Rock Kit



Meteorite Rock Kit

References: [1] Croft, S. K. et al. (2011) *this volume*. [2] Lebofsky, L. A. et al. (2010) *LPS XLI*, Abstract #1192. [3] Chuang F. C. et al. (2005) *LPS XXXVI*, Abstract #2390. [4] Croft, S. K. et al. (2010) *LPS XLI*, Abstract #1460.

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