LEARNING PLANETARY GEOLOGIC MAPPING AS AN UNDERGRADUATE NON-MAJOR.

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Introduction: Planetary geologic mapping requires a host of skills, including searching out imagery and other data, preparation of a base image map at appropriate scale, and interpretation of geologic features and relationships. The resulting points, lines, and polygons form the basis for a geologic map in GIS or other format.

Because geologic mapping has always been a key method for teaching students to recognize and interpret rock relationships and history, it is part of the undergraduate planetary science course, GEOS 341, at Indiana University of Pennsylvania (IUP). Students come from various science majors, mathematics, and other fields such as business. Students studying to become secondary science teachers also take the course.

Project Format: Students are assigned an area on one of the terrestrial bodies. Over the course of several weekly lab periods they learn the basics of the mapping software, searching for images, and adding point, line, and polygon features to their map layers. They do a simple crater count on at least one map unit and interpret it in terms of a numerical timescale, if available (as for Moon [1] and Mars [2, 3]). Throughout this project, other activities give experience with mapping units by hand, crater counting, and manipulating digital images.

Software. Experience has shown that full-featured GIS software (such as ArcGIS) has a learning curve that is too steep for a multi-week lab project. The use of JMARS [4, 5] has proven practical, as it combines availability for multiple platforms, is easy to install on student-owned laptop computers, and has free documentation available. Once the basic map is complete and approved by the instructor, it is exported for final editing in a graphics program. The completed map may be presented either in digital or hard copy form.

Student and Instructor Experience: Once the technical challenges were addressed, this project proved to be a great addition to an undergraduate planetary science course. Students engage in geologic thinking on a more sophisticated and analytical level than they did with lectures and traditional labs alone.

One Biology Education major commented, "I found myself looking for similar geologic settings on Earth to what I was seeing on Mars. As a biologist, I would think about what exactly is going on in these locations on Earth that allows for life to thrive (or keeps it from thriving). I often wondered, if the conditions were just right, could life be found in an area of Mars like the one I was mapping?"

Among the improvements evident from this experience were that only 3 lab periods, not 4, need be devoted to working on the project; most work after this could be done outside of class. Additional experience looking at and analyzing images of geologic relationships and examples of geologic maps would strengthen student work. The added incentive of a public display of finished work, for example to a class of geology majors, is also a potential motivator that could be added to this project in the future.

References: [1] Robbins, S. J. (2014) *EPSL, 403*, 188-198. [2] Werner, S. C. & Tanaka, K. L. (2011) *Icarus, 215*, 603-607. [3] Michael, G. G. (2013) *Icarus, 226*, 885-890. [4]. Christensen, P. R *et al*. (2009) *AGU Fall Mtg,* abs #IN22A-06. [5] https://jmars.mars.asu.edu/.

Figure 1. Example of a student map, of part of Ceraunius Fossae and the adjacent region. This example highlights the importance of interpreting onlap of lava flows, timing of fracturing and faulting, and extent of a particular unit.