CREATING THE STUDENT ATLAS OF MARS GEOGRAPHY – AN ACTIVE LEARNING PROJECT.

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Introduction: Student atlases are common parts of the textbook pack of students from elementary to high school in many countries. They serve multiple purposes including learning about how to read a map to physical and political geography. They also help develop skills of the classification of things, understanding symbols and connecting those to the physical world's unique features. In this project, we assume that the student is already familiar with the structure and content of a geographic student atlas and we build on this experience. The goal is to engage the student with an active learning exercise in which the create and use planetary maps. Most of the tasks can be carried out independently from the others, depending on the available time, from elementary school to university levels. The entire atlas can be made by a group of students over many classes. These tasks are also suitable as a theme for Astronomy clubs.

Aims. The Atlas is designed for students attending an imaginary school located in a future base on Mars. Although this setting may not be very realistic even in the long term, it provides an exciting background story and makes the aims of the atlas clear.

We model the structure of the Atlas after early 20th-century Hungarian school atlases (Fig. 1).

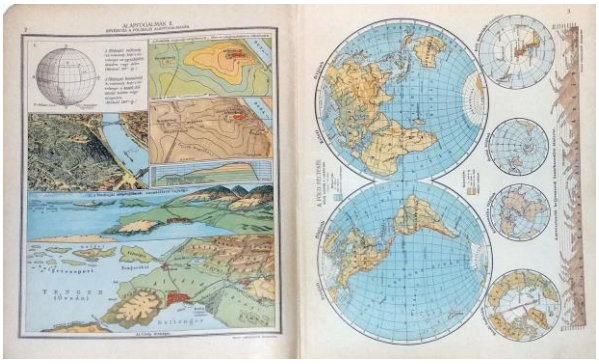

Figure 1. Example of a double page from a Geographic School Atlas [5]

In this paper, we describe the classroom task where students design and draw the pages (or a mock-up) of the Atlas. These tasks can be used in teaching geography, cartography and planetary sciences and can be adapted to various levels or grades. The tasks can be conducted during classes (Fig. 2) or as home assignments with subsequent classroom discussions. Materials needed include paper, color and graphite pencil, marker pen and transparent film.

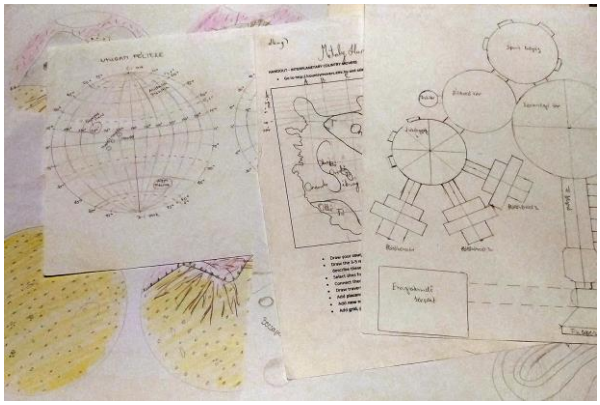

Figure 2. Examples of student works (university BSc level)

Parts of the Atlas. *Local map and map scales (hierarchies):* students design a human base (settlement), with all necessary elements for living. They draw the base plan and label the units (Fig. 2). They "zoom out" from the classroom in one of the units to the school building and so on until the base is just a little dot on the next page: the local environment.

Local-scale photointerpretation: The students receive a full-page spacecraft image (examples in [1], Fig. 3), and identify the following parameters: direction of illumination (and cast shadows), albedo units, positive and negative relief units and structures; then draw contact lines between the units, name the units and place labels into the units. An advanced task is to reconstruct the geologic evolution using the superposition of the units. This page would show the immediate surrounding of the "Base".

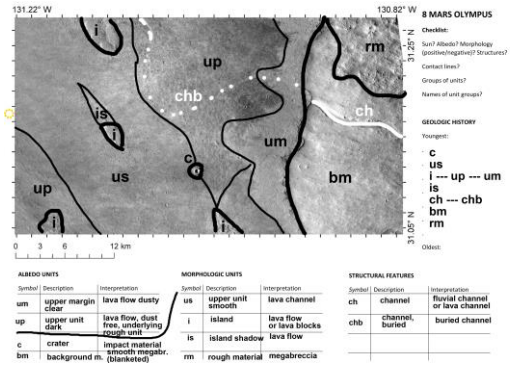

Figure 3. Example of photointerpretation. [1]

Multilayer maps: The base layer is a printed regional scale photomosaic where craters and valley networks are visible near the dichotomy boundary. The same region is also shown with MOLA topographic coloring. The task is to trace valley networks (and create a channel/lake layer) using a certain line symbol on one transparent film (or tracing paper) and trace crater rims on another. Finally, names (invented by the student) are added on a third film. The task demonstrates how multilayer GIS maps are produced, and includes the concept of thematic maps, complex multilayer maps, and the choice of proper symbols that enable distinguishing between two line features.

Storymap of Mars mapping: This task demonstrates how data quality corresponds to scientific evidence-based conclusion. In this task the starting material is a global Earth-based (e.g., HST) photograph of Mars that the students have to "vectorize" manually and create an outline unit map, practicing the creation of discrete line units from blurred boundary grayscale patches (Fig. 4). This task is followed by a discussion on what the units may represent (three units: dark, bright and polar) and what geologic story may be constructed building on this information. As a sample, Fig. 4 may be shown. Students create a one-word description/interpretation legend, explaining the nature of the units.

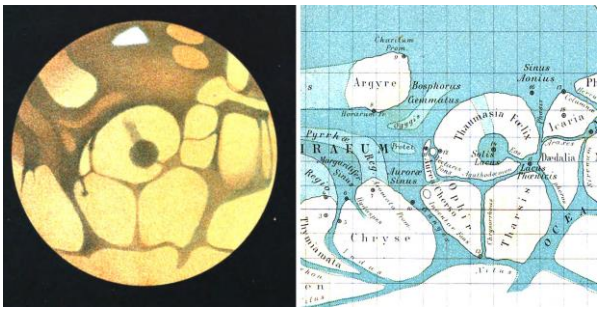

Figure 4. Illustration of the difference between a simplified drawing of the telescopic view (left) and a map (right) [6].

Following this task, a global topographic map is shown of the same region (hemisphere). Students are asked to find any connection between the two maps and elaborate their previous interpretations on Mars's surface conditions.

Correspondence between thematic maps: the students use the multilayer map they produced previously and find correspondence between the layers. The goal is to identify the relation between crater density, valley density and relief. Then students write a caption, explaining the geologic implications of their findings. At an advanced level, they may carry out a manual crater counting on the two units (highland/lowland).

Comparing sizes and distances: The students receive a transparent film with the outline of their country or state at the same scale as the multilayer map. They cut it out, move it over the map and find their favorite position. Then they describe the geography of this "country" and add names, places and roads, taking topography into account. This task is a manual version of a previous online tool we called "Country Movers" [2].

Evolution of Mars: in this task, students reconstruct how Mars looked like in previous times, on a one-hemisphere global cartoon map adding the following elements: 1) craters, 2) hemispheric dichotomy, 3) basins, 4) valley networks, 5) volcanic rise + tectonic graben, 6) outflow channels and lava flows.

Climatic map: Students are shown a Mars Climate Database [3] temperature maps in two seasons (winter, summer). Students are asked to produce outlines for climatic zones, name and characterize the climate zones they identified and compare them to Earth.

Mars Grid: Students draw a grid on a blank map of Mars, showing major circles of latitude. In this task students learn about the coordinate systems.

Regional maps may be drawn by each student in a group, tracing (and creating) relief map units from a regional CTX+MOLA (or USGS nomenclature reference) map but adding imaginary settlements and roads with names. The placement of the settlements and roads should be justified based on relief, geologic or other criteria. This task simulates special region selection [4] and students practice generalization and classification.

Nomenclature: When the Atlas is completed, the pages are numbered, and a final task is to review all names and labels and list them is the "Gazetteer" page in alphabetical order.

The final work may be fastened with spiral binding.

References:

[1] Hargitai H. (2019) Introduction to planetary mapping https://hargitaihenrik.files.wordpress.com /2019/10/introduction-to-planetary-geologic-mapping.pptx [2] Gede M., Hargitai H. (2017) Acta Astronautica. https://doi.org/10.1016/j.actaastro.2017.04.028 [3] Forget et al. (1999) JGR doi:10.1029/1999JE001025 http://www-mars.lmd.jussieu.fr [4] Rummel et al. (2014) Astrobiology 14, 11, doi: 10.1089/ast.2014.1227 [5] Kozma Gy, Körösi A (1926) Rendszeres földrajzi atlasz. Singer and Wolfner.[6] Schiaparelli (1877-78) Mappa Areographica