CREATION AND TESTING OF ACTIVITIES IN THE OUTREACH ATLAS OF MARS. H. Hargitai[1], Sz. Kárpáti[2, 3], A. Gucsik[4,5], M. Gede[6], Sz. Bérczi[7] [1]ELTE Eötvös Loránd University, Budapest, 1088 Múzeum krt 6-8, hargitai.henrik@btk.elte.hu, [2]Department of Geography, Eszterházy Károly Catholic University, Eger, H-3300, Eszterházy tér 1, Hungary, [3]Petőfi Sándor Roman Catholic Elementary and High School of Vecsés, H-2220, Vecsés, Petőfi tér 1, Hungary, [4]Research Group in Planetology and Geodesy, Department of Physics, Eszterházy Károly Catholic University, H-3300, Eszterházy tér 1, Hungary (E-mail: sopronianglicus@gmail.com), [5]Institute of Low Temperature Science, Hokkaido University, Kita-19, Nishi-8, Kita-ku, Sapporo, 0680-0819, Japan. [6]Institute of Cartography and Geoinformatics, ELTE Eötvös Loránd University, Pázmány P. s. 1/a, 1117 Budapest, Hungary [7]ELTE University, Budapest, 1117 Pázmány P st 1/a.

Introduction: In the last decade dozens of studies focused on generating catalogs of different geologic features of Mars. They have been published in a variety of formats and places and many if not most of these publications are not GIS-ready. We have been collecting such catalogs and integrated them into one GIS (in ArcGIS) with the aim of producing a publicly available base GIS for Mars research in the future [1]. As a spinoff of this research project, and a continuation of the creation of planetary science educational materials at ELTE Eötvös Loránd University, we have produced an outreach Pocket Atlas of Mars. The aim is to make planetary science more visible in K12 educational levels and provide an entry point into natural sciences and in particular, planetary geology.

Editions. The previous editions of the atlas was distributed among schoolchildren in schools and astronomy circles in several countries such as the Czech Republic and Hungary (*"Mars 36")* [2] (sponsored by Europlanet), Turkey, the UK (sponsored by Cornwall Sea to Stars). The *"Mars 37"* edition was commercially published in the USA. All subsequent editions all contained minor changes and by 2023 we have produced at atlas *"Mars Discoverer"* that now included most previously developed themes plus several student activities.

Cartographic approach. This atlas is the first geographic atlas of Mars. It is an *atlas* because it contains medium-scale maps split into several pages, and thematic maps. It is *geographic*, because the maps include a diverse set of geoscience and cultural layers without any special focus on one or the other. Such „unfocused" or complex maps are usually called geographic (or physical) maps, and these are best known in school atlases. The many feature catalogs developed in the last decade made it possible to produce such multithemed map of Mars. However, the surface conditions so different from our terrestrial experience make it necessary to put extra efforts on explaining the ground truth meaning of the maps. This is served by several types of explanatory texts that accompany the map pages, some in the literary style of fantasy gamebooks. Furthermore, several map pages include information on planetary scientists, planetary cartographers, and the career pathways of planetary scientists to make this profession more concrete for the students who probably have very little idea on who, how and with what background are involved in the planetary research activities.

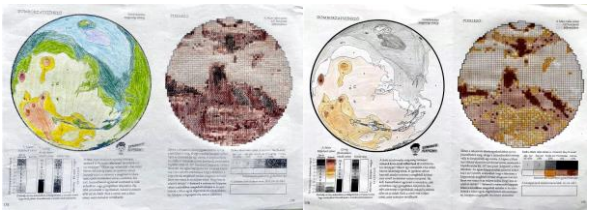

Figure 1. Two different coloring solutions, Class 5.

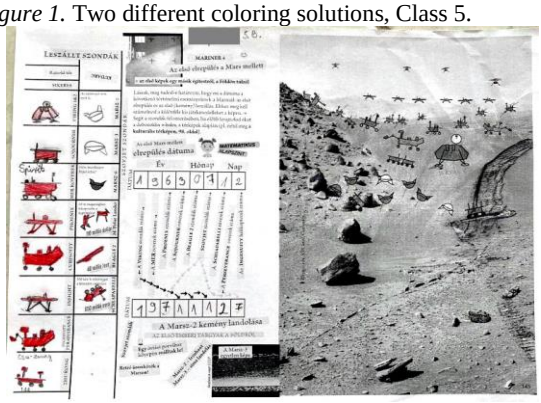

Figure 2. Rover identification solution, Class 5.

A national edition. The 2023 Edition, for Mars Year 37, was translated to Hungarian and all activities were made in Hungarian because this edition is distributed in Hungary. Unlike our previous international editions, we inserted several country or language specific elements. We could visualize distances with the border outline of the country (Hungary) using our previously developed methodology [3], based on a similar technique of early 20th century school atlases. We added one early-20th century poem about Mars; inserted short stories of Hungarian planetary geologists, who also appear as graphic novel style characters in the atlas pages; and featured Hungary-related place names on Mars. With future translations these should be modified to be relevant for the given target audience.

Activity book. The activities were made in several levels, from elementary school up to university levels

and they were tested in the appropriate target ages in Petőfi Sándor Roman Catholic Elementary and High School of Vecsés and ELTE University as parts of regular classroom activities. The simplest task is to color the topographic map of Mars, and the most complex tasks are crater counting and calculation of the greenhouse effect. All tasks are created with instructions that include all information needed to solve the problems either in the task description or somewhere in the map pages of the atlas. The testing showed that the wording of the tasks was the most problematic in the original version (understanding the task, the problem, with sufficiently simple words). The other problem was that it was difficult or impossible for the students to find the exact places in the book where the solution is found (for example, exactly which map page contains the answer). It was therefore essential that we tested the manuscript in classrooms before printing. The activity instructions were rewritten several times until most of the students (or non-professional instructors) could understand and solve them without external help. For most of the activities, the solutions are also included in the book. Since the topic of planetary geology hardly appears in formal education, the instructions had to be worded in a way that it contained all necessary information for the solution, mostly in the forms of maps. The most popular tasks at Elementary level were also the easiest: coloring the relief where the students could choose from several color ramps and coloring the pixels of the low-resolution albedo map of Mars *(Fig. 1)*. Additionally, the task of labeling an unlabeled map page, drawing, and recognizing rovers' shapes *(Fig. 2)*, and „geodetective" activities of identifying geologic units in a photomosaic were also popular (this activity is also submitted to AstroEdu online respository).

The atlas has experimental map designs, including the supplement. This design was originally "proposed" by the Stable Diffusion artificial intelligence and is based on greek black figure vases *(Fig. 3)*.

Links to National Curriculum. To be compatible with formal education requirements, all activities were linked to "key competences" in the National Curriculum (of Hungary, NAT) [4]. While most activities can be used in geography classes, several are also good for physics, mathematics, and even literature and language classes in the form of during-class extra activities, specialized clubs, project days, or talent development. Planetary geology is firmly attached to "Astronomy" in the terminology of formal education. The Mars calendar and the maps included in the book give a good opportunity to use the material when students learn about navigation in time (timekeeping – Class 5 Science, Class 9 Physics) and space (Cartography – Class 9 Geography).

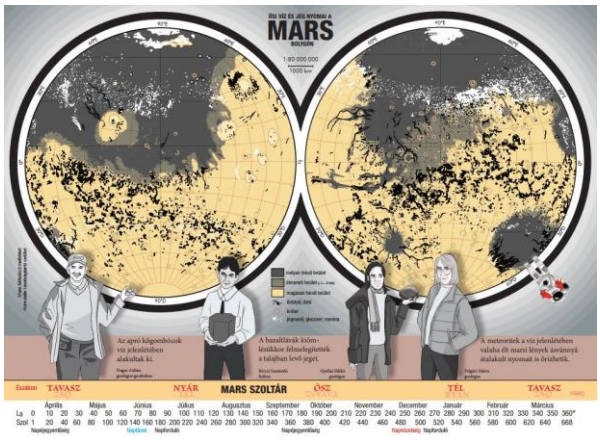

Figure 3. Map supplement with Hungarian planetary scientists, showing reachable career paths for the students.

Key competences of NAT covered in the Atlas include the followings (with page numbers): *Communication* (writing Mars haikus (based on LPSC haikus, [5]) – p. 199; storywriting for AI-generated images – p. 184); *Foreign language* (nomenclature, naming places – p. 162); Mathematics (crater counting – p. 168, calculation of the greenhouse effect – p. 181, calculation of angular diameter of the Mars disk in the Atlas – p. 208); *Science* (tasks about a Mars habitat - based on Mars Society's Mars Desert Research Station layout – p. 192); *Digital competences* (links to planetary maps online – p. 208); *Society and Citizenship* (Hungarian planetary scientists – p. 176 and map supplement); *Autonomous learning* (photogeological maps – p. 161, rover redesign – p. 171, arguments for and against settling on Mars – p. 201); *Entrepreneurial initiative* (Selling plots of lands on Mars – p. 150; planning family trips 196); *Esthetic expression* (coloring – p. 178, map design – p. 162).

The atlas is available only in printed form and will be distributed in Hungary in schools and astronomy circles and for free of charge. On request we are happy to send a pdf copy to the members of the planetary community.

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References: [1] Hargitai H 2016, DPS 48/ EPSC 11 Meeting #426.23, Pasadena, CA. [2] Hargitai, HI 2021. 52nd LPSC No 2548, Houston, TX. [3] Gede, M., & Hargitai, H. (2017) Acta Astronautica, 137, 334–344. doi:10.1016/j.actaastro.2017.04.028 [4] 110/2012. (VI. 4.) Hungarian Government Decree, [5] Kumar M 2013 Haiku Highlight the Existential Mysteries of Planetary Science. Smithsonian magazine.