SECOND UNUSUAL GUIDEBOOK TO TERRESTRIAL FIELD WORK STUDIES: ASTRONAUTS WITH ROVING VEHICLE, ROBOTIC ROVERS ON PLANETARY SURFACES (SEVENTH CONCISE ATLAS IN THE SOLAR SYSTEM SERIES OF TEXTBOOKS AT EÖTVÖS UNIVERSITY, HUNGARY). Mészáros I.[1], Hargitai H.[1,2], Horváth A.[3], Kereszturi A.[1,2], Sik A.[1,2], Bérczi Sz.[1], [1]Eötvös University, Dept. G. Physics, Cosmic Materials Space Research Group, Budapest, Pázmány P. s. 1/a, Hungary, (bercziszani@ludens.elte.hu) [2]Eötvös University, Dept. Phys. Geography, Budapest, Pázmány P. 1/c, Hungary, [3]Konkoly Observatory, H-1525 Budapest, Pf. 67. Hungary.

Introduction: The next new concise atlas we compiled in the series of the Solar System Research [1] deals with Environmental Studies by Apollo astronauts with cars, and by rovers on Planetary Surfaces. The main chapters were a) Apollo field works in lunar rock deserts, b) Lunokhod Russian Rover field works, c) Pathfinder's Sojourner's works around the Sagan Station, and d) field works of MER rovers till summer of 2004 in the two landing sites [1-6].

After works by landers [2] This 7th member of our lecture note series [3] gives background studies for works with rovers, a moving car of experiments on the basis till now 4 successful car and rover programs: Apollos and Lunokhods (on the Moon), and Pathfinder and MERs (on the Mars) [6]. When we overview the details of some of their main experiments we also focus on the main benefits to terrestrial geological and petrologic field work studies in this human size and the several days/months “walking scale” robotics-helped activities.

There were some possibilities for comparisons in this second booklet: 1) between lander works and rover (or car-helped) works on planetary surfaces, 2) between terrestrial walking field works and robotics-helped field works, and 3) car-helped longer distance discovering field trips. In comparisons to the observations of the planetary rovers: panorama studies, rock size frequency, visible textures of hand specimens, positions reached by geological process, etc. we could follow the changing landscape, the variance of rocks together with changing localities. This second atlas introducing changing microenvironments around the geologist is also an unusual guidebook to terrestrial field works studies in geology.

A) The 6 field trips of the Apollo astronauts:

Aa) The first 3 Apollo trips without car.

Till today it is the most developed field work of human geology, carried out in extraterrestrial environment. **Apollo-11**'s Eagle's Tranquillity Base works are shown with experiments of solar wind collector (SWC), and the EASEP package's experiments of passive seismic experiment (PSE), lunar dust detector (LDD), laser reflector (LRRR), and the first sample of 10023, from the 21 kgs of rocks. The single event of **Apollo-12** mission is the landing by the Surveyor-3, visiting it and returning its camera. The Intrepid landed not only on the Eastern Oceanus Procellarum but on a ray of the Copernicus crater, about 350 kilometers from the crater. The Apollo-12's ALSEP experiment package contained 15 experiments over the 3 of EASEO of Apollo-11. The experiment package may be representative of engineering art of arrangement of the instruments, too. Active seismometer (ASE), heat-flow experiment (HFE), solar wind spectrometer (SWS), various particle detectors, magnetometer, gravimeter, and lunar "atmosphere" measuring experiments (LACE) were involved together with those of the earlier PSE, LDD and LRRR ones. All the ALSEP worked till 1977. The **Apollo-14** mission was the first when astronauts used a lunar pull-cart or "rickshaw" (MET) on which they carried the equipments and returned the collected rock samples. They used the lunar portable magnetometer (LPM) on their trips, collected ancient breccias of the Fra Mauro Formation at Cone crater (C1 station, 14321-sample) where they walked up a 10 degrees slope.

Ab) The second 3 Apollo trips with lunar car.

Apollo-15 was the first mission which carried a lunar roving vehicle (LRV). At Rima Hadley and Mt. Apenninus they found beautiful landscape, at the bank of the valley they found layered deposits, they found exciting rock samples (for example the Genesis rock: 15415 at Spur crater, or a green-glassy breccias at 6A station). They deposited the new ALSEP, but repeated an old experiment of Stevin and Galilei: falling of a feather and a hammer. In vacuum they arrived to the ground simultaneously. **Apollo-16** was the first mission which visited terra at Descartes. After depositing the new ALSEP and setting for the first time an astronomical telescope, then they used their LRV on their 3 EVA and collected 95 kgs of lunar rock samples, among them the Big Muley (61016) with 11.7 kgs weight, the largest of the Apollo Missions. They also made deep drilling to 2,6 meters for soil samples. **Apollo-17** was the last mission, visited the Taurus-Littrow mare-terra boundary. The first geologist worked in this mission. After depositing ALSEP they placed 3 other instruments, too: lunar surface cosmic radiation experiment, (LSCRE), the traverse gravimeter experiment (TGE) and surface electric properties experiment (SEP). They also deposited explosive charges for the lunar seismic profiling experiments. Because of the LRV fender breaking they substituted it with some papers (maps). They collected landslide-deposited samples at South Massif, then visited a mare wrinkle ridge at Lara crater and found the famous Orange Soil at Shorty crater. To the events and experiments of this part of the textbook we could attache petrographic studies of the NASA Lunar Sample Educational thin section set.

B) Lunokhod missions to the Moon

During the manned Apollo missions of NASA there were two successful lunar rover missions by RSA. The Luna-17 (Lunokhod-1) visited NW Mare Imbrium (in the Sinus Iridum vicinity). It covered 11 kilometers distance during its 10 months work. Luna-21 (Lunokhod-2) visited NE Serenitatis, a month later than Apollo-17 visited SE Serenitatis. It covered 37 kilometers distance during its 4 months work. Over cameras and panoramic scanners magnetometric and X-ray spectrographic instruments were on the board of Lunokhods. They also carried laser-mirrors.

C) Pathfinder's Sojourner's mission to Mars

The Pathfinder and its Sojourner rover were specific in planetary missions because their measurements were almost

equally distributed on lander and rover. Cameras of Sagan Memorial Station (the fixed lander) studied various rock types and the field around [4,5]. When the Sojourner rover rolled down and moved in this field, the stations camera could follow its works. When get over a micro-dune, for example, where the wheels exposed the darker material of the dunes, station sent the image to the control center. Station's images made it possible to find vesicular rocks (probably igneous origin) stratified textures (metamorphic or sedimentary origin) and brecciated textures (impact brecciation?). This hierarchy of the lander-rover system contains interesting possibilities for the future mission planning. They may represent two (or even more, when not only one rover works) point observation viewpoints which may be useful for moving object observations, for example dust devils.

D) MER's 2 field trips on Mars:

Both rovers' landing site was planned to find the sites of water on Mars. Spirit landed in a lake, Opportunity in an earlier shoreline [6]. The MER rover had solar panel surface, camera mast, and central front arm with the measuring and rock preparing instruments. The landing platform had been left by them and no further scientific work was placed on them. This is a new strategy as compared to Pathfinder.

Da) Spirit: landed in the Gusev crater in 2004 early January. The crater wall of Gusev is open toward North, to the plains around Elysium. When water covered Mars in early times the crater was fulfilled it forming a lake or a bay. A rocky desert surface surrounded Spirit when opened its cameras. Far East a mountain was visible: the Columbia mountains. The number of rock fragments increased when approached a near Bonneville crater of about 200 meters diameter. Many of the rocks were polished to have planar surfaces by the wind. Such rocks are know from the terrestrial ice ages, from similar processes (i.e. in the vicinity of Nógrád Mt. in Hungary). Other rocks had sharp edges marking the breaking from a near impact crater. However, it was found that even these sharp edged rocks had suffered weathering. Many rock samples were studied by the instruments. For example Adirondack, Humphrey (and many other rocks) were measured for composition. They were found to be more mafic then those of Pathfinder's andesites. We stopped to follow the trip of Spirit in July, while it approached to the Columbia Hills [6].

Db) Opportunity: landed in the Meridiani Terra in 2004 late January. Here the gray hematite spectral lines marked the presence of the materials of water origin in the past. Opportunity landed in a little, 22 meters diameter crater, Eagle, and it found a bonanza of phenomena foreseen when landing site was planned. The soil was covered with spherules. From the dark soil light colored rocks emerged and formed a well protruding crater wall, first not to able to see around the plain. Approaching to the wall Opportunity measured the rocks' compositions. NASA scientists analysed them and suggested jarosite as main component of the sedimentary type light colored wall rocks. After roving around inside the crater Opportunity came out from it and traveled toward an interesting object, a larger crater. On its way it found chains of pits which followed each other in a sequence forming a trench. Somewhere between them the light colored rocks also were exposed. Opportunity also found a rather fresh small, 3 meters diameter crater and finally it arrived to the larger Endurance crater with 200 meters diameter. We followed its way till July, but many new discoveries were succeeded till that time and involved into this little atlas, too.

E) Simulated EVA on Mars analog terrain: The last chapter of the textbook describes terrestrial analog study. One of us (A.K.) realized a simulated EVAs (field trips inside spacesuit) at MDRS (Mars Desert Research Station) and at FMARS (Flashline Mars Arctic Research Station) maintained by the Mars Society. Based on these trips, theoretical calculations and topographic data of Mars the participants planned hypothetical EVAs for various terrains of Mars. During the planning distance, topography, walking and driving speed, mass of equipment and potential scientific output were taken into account. In the same time this planning served as helpful practice for students, forcing them toward complex analysis of certain tasks. Based on our first results EVAs can be divided into two basic types: 1. long distance EVA with short stops on relative homogeneous terrain reconstructing possible horizontal facies (and past environment) changes, and 2. short distance EVA with longer stops on heterogeneous terrain reconstructing facies changes in time.

Summary: This seventh Concise Atlas of the Solar System deals with the rover missions to the planets. We studied the movements on the planetary surface and the accompanying petrographic and geologic field works gives a new approach possibility to the recent terrestrial geologic field work guidebooks which teach the students to study terrestrial geology as if it were a planetary surface. At the same time it gives new ideas to Hunveyor [7] and its Husar rover robotic construction program.

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References: [1] Bérczi Sz. Hargitai H., Kereszturi Á., Mészáros I., Sik A. (2004): *Kis Atlasz a Naprendszerrõl (7): Bolygófelszíni barangolások. (Concise Atlas of the Solar System (7): Roverings on Planetary Surfaces*). ELTE-UNICONSTANT, Budapest-Püspökladány;] [1] Bérczi Sz. Hargitai H., Illés E., Kereszturi Á., Sik A., Földi T., Hegyi S., Kovács Zs., Mörtl M., Weidinger T. (2003): *(Concise atlas of the Solar System (6): Microenvironmental Studies of landers on Planetary Surfaces, in Hungarian*). ELTE-UNICONSTANT, Budapest-Püspökladány; [3] Bérczi Sz., Fabriczy A., Hargitai H., Hegyi S., Illés E., Kabai S., Kovács Zs., Kereszturi A., Opitz A., Sik A., Varga T., Weidinger T. (2003): Atlas Series of the Solar System (5 booklets) and other Works for Education and Public Outreach by Cosmic Materials, Planetology and Hunveyor Groups of the Eötvös University, Budapest. *LPSC XXXIV*, #1305, LPI Houston; [4] Yingst, R.A., Haldemann, A.F.C., Lemmon, M.T. (2003): Classification of Mars pathfinder Rock Surfaces ... *LPSC XXXIV*, #1081, LPI, Houston; [5] Bridges, N.T., Greeley, R., Kuzmin, R.O., Laity, J.E. (2000): Comparison of Terrestrial Aeolian Rock Textures to those at the Mars Pathfinder Landing Site. *LPSC XXXI*, #2066, LPI, Houston; [6] NASA JPL MARSROVERS homepage (http://marsrovers.jpl.nasa.gov/); [7] Sz. Bérczi, B. Drommer, V. Cech, S. Hegyi, J. Herbert, Sz. Tóth, T. Diósy, F. Roskó, T. Borbola. (1999): New Programs with the Hunveyor Experimental Lander in the Universities and High Schools in Hungary. *LPSC XXX*, #1332, LPI, Houston.