

# **PLANETARY ROVER ROBOTICS EXPERIMENT IN EDUCATION: CARBONATE ROCK COLLECTING EXPERIMENT OF THE HUSAR-5 ROVER OF THE SZÉCHENYI ISTVÁN HIGH SCHOOL, SOPRON, HUNGARY.** Lang Á.<sup>1</sup>, Szalay K.<sup>1</sup>, Horváth T.<sup>1</sup>, Prajczér P.<sup>1</sup>, Bérczi Sz.<sup>2</sup>,

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**Introduction:** The new experiment for the Husar-5 educational space probe rover consists of steps of the technology of procedure of finding carbonate specimens among the rocks on the field. 3 main steps were robotized: 1) identification of carbonate by acid test, 2) measuring the gases liberated by acid, and 3) magnetic test.

**Background:** The triggering sources for this experiment are the following. Spirit has found carbonates (by APXS measurements) at Comanche Spur rock comprised from magnesite, siderite, calcite, and rhodochrosite components. Also the Spirit, the mini-TES measurement of Sauppitt showed lines of the carbonates (Morris et al, 2010) [1]. Earlier carbonates were identified in the Martian dust spectra of TES (Bandfield et al, 2003) [2]. And also carbonates were found in the vicinity of Isidis Basin at regions in Nili Fossae by Ehlmann et al (2008) [3], Wray et al (2011) [4] and Viviano et al (2012) [5]. Finally the discovery of the first carbonate meteorite (Bérczi et al. 2012) [6] which have fallen at Nagykövácsi, focused our attention to this type of rocks for identification by robotics methods on planetary surfaces.

**Experimental technology steps:** It is known that dropping acids produce rather quick reactions with carbonate rocks. This is the first robotic work to realize by electronics. The CO<sub>2</sub> gas produced will be observed by gas sensors. This is the second act to be robotized. Of the carbonates some are paramagnetic, especially siderite (iron-carbonate). This results in a third step: magnet contact and attraction of siderite by magnet.

**Construction of the experiment:** The basis of the robotic realization of the experiment is a remote-controlled rover which can move on the field. Onto this rover the mechanism of the experiments were built from Technics LEGO elements and we used LEGO-motors for making move these experiments. The operation was coordinated by an NXT-brick which was suitable to programming. For the acetic-test the drops should be passed to the selected area.

Passing a drop to a locality: From the small holder of the acid using densified gas we pump some drop onto the selected rock. We promote this process by pumping the atmospheric gas into another small gas-

container, so we have another higher pressure gas there. This is pumped into the acid-holder.

The effect of the reaction is observed by a wireless onboard camera, which transfers the image to the lander, and to the terrestrial control. In order to identify that the surface acid is bubbly we need human observation, because we could not automatize it.

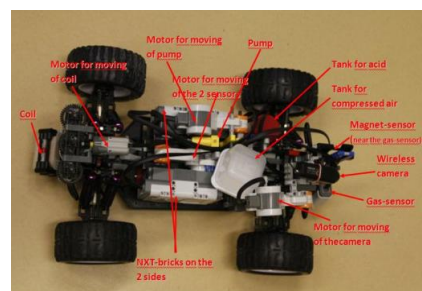


Fig. 1. The Husar-5 rover with the Carbonate experiment instruments.

In the next step we can identify the the liberated gas by the gas sensor. This is not a typical LEGO-sensor, but it is a gas sensor measuring by the electric resistance change. LEGO compatibility was reached by soldering it into the box of the LEGO-sound-sensor. This way we could attach it to one of the sensor-ports of the NXT. (to that port, where originally the microphone was planned, because the operation of that instrument was also based in measuring the resistance). Using our gas sensor we can confirm the liberation of the CO<sub>2</sub> gas without outer observer.

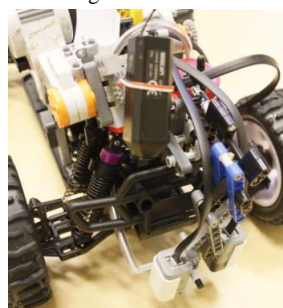


Fig. 2. The Husar-5 rover with the Carbonate experiment when gas-sensor is in lowered position.

The third step is the control of the paramagnetic properties. Paramagnetic magnetism means that the body exhibits magnetic features by the effect of an outer magnetic field. In measuring this feature a LEGO-compass is our instrumentation. If we carry a permanent magnet, however, then our sensor will fix a direction from which our magnetized siderite can not move out the LEGO-compass. That is why we use an electric current generated magnet. The magnetic test has the following operations in the measuring procedure: first the program gets the position of the compass-sensor (this is angle) and this value is stored in the memory. Then we close the circuit of the coil by a relay. Opening the circuit we read the position of the compass-sensor simultaneously with the circuit opening. The program calculates the difference between that position and the initial position and places this value into another list. Then the rover turns a little and repeats this measuring process. (After rover rotation the coil remains in an almost identical position over the rock sample. This turning process is repeated 2-3 times. Calculating the average of the differences the program compares it with a given limit, and decides that the sample has paramagnetic property, or not.



Fig. 1. The Husar-5 rover with the Carbonate experiment when coil of the magnetic experiment is in lowered position.

During the measurements both the coil and the gas-sensor should be positioned to be near to the surface. This means, that a lowering and an uplifting machinery should be constructed. Without this machinery the motion of the rover over the undulating surface should bulldoze the measuring instruments.

**Summary:** The sequence of the measurement is the following. 1) the camera – after giving panorama images – turns toward the soil surface, 2) the dropping onto the rock surface 3) at the same time the gas-sensor starts to move down above the rock 4) the compass sensor also moves down on the arm which holds both

the gas-sensor and the compass-sensor 5) evaluation of the gas-sensor data 6) if CO<sub>2</sub> is present the magnet-test begins, therefore the rover moves forward into a good position for the coil lowering 7) after magnetization the rover moves backward in order to be in the position that the compass-sensor can measure the angle. 8) the last 2 operations are repeated in a small turned position of the rover 9) final calculation of the paramagnetic measurement 10) summary of the 3 tests.

**Application and future test in Antarctica:** In principle siderite (and any carbonate) meteorite search by a rover may be a useful collecting test in Antarctica. Robotic way of collecting great number of carbonate samples makes it possible that from the carbonate samples the baked rimmed pieces can be selected [7]. This needs only a sawing them to two parts in order to the darker baked rim become visible. Collecting by robots, sawing the collected carbonate samples in the laboratory is a process which opens the possibility of discovery of several other carbonate meteorites within reasonable time.

**References:** [1] Morris, R.V. et al. (2010): Identification of Carbonate-Rich Outcrops on Mars by the Spirit Rover. *Science*, **329**, No. 5990, pp. 421-424. DOI: 10.1126/science.1189667; [2] Bandfield, J. L.; Glotch, T. D.; Christensen, P. R. (2003): Spectroscopic Identification of Carbonates in the Martian Dust. *34th LPSC*, #1723; [3] Ehlmann, B.L.; Mustard, J.F.; Murchie, S.L.; Poulet, F.; Bishop, J.L.; Brown, A.J.; Calvin, W.M.; Clark, R.N.; Des Marais, D.J.; Milliken, R.E.; Roach, L.H.; Roush, T.L.; Swayze, G.A.; Wray, J.J. (2008): Orbital Identification of Carbonate-Bearing Rocks on Mars. *Science*, **322**, Issue No. 5909, pp. 1828; [4] Wray, J.J.; Murchie, S.L.; Ehlmann, B.L.; Milliken, R.E.; Seelos, K.D.; Noe Dobrea, E.Z.; Mustard, J.F.; Squyres, S.W. (2011): Evidence for Regional Deeply Buried Carbonate-Bearing Rocks on Mars. *42nd LPSC*, #2635; [5] Viviano, C. E.; Moersch, J. E.; McSween, H. Y. (2012): Spectral Evidence for the Carbonation of Serpentine in Nili Fossae, Mars. *43rd LPSC*, #2682; [6] Bérczi Sz. et al. (2012): Discovery of the First Iron-Carbonate Meteorite, Observed Fall of a Sedimentary Rock with Regmaglypts, Hot State and No Radioactive Carbon 14 Inside, At Nagykovácsi, Hungary. (this volume). [7] Brack, A.; et al. (2002): Do meteoroids of sedimentary origin survive terrestrial atmospheric entry? The ESA artificial meteorite experiment STONE. *Planet. Space Sci.*, **50/7-8**, pp. 763-772.