HOW NASA LUNAR AND ANTARCTIC METEORITE SAMPLE STUDIES HELPS PLANNING NEW MEASURING COMPLEXES IN OUR PLANETARY SCIENCE EDUCATION: INSTRUMENTS FOR EXTENDED STRUCTURAL HIERARCHY TABLE WITH PARALLEL STRUCTURES. Sz. Bérczi[1], M. Polgári[2], I. Gyollai[2], I. Ságodi[3], P. G. Vizi[4], *[1]Eötvös University, Faculty of Science, Dept. of Materials Physics, Cosmic Materials Space Res. Group, 1117 Budapest, Pázmány P. s. 1/a. Hungary, (berczi szani@caesar.elte.hu), [2]Institute for Geological and Geochemical Research, RCAES, Biogeochemical Working Group, HAS, H-1112 Budapest, Budaörsi u. 45, Hungary, (rodokrozit@gmail.com), (gyildi@gmail.com),[3]Szekszárdi Garay János High School, H-7100 Szekszárd, Szent István tér 7-9. Hungary, (ibolyasagodi5@gmail.com), [4]MTA Wigner RCP H-1121 Budapest, Konkoly Th. 29-33. (vizi.pal.gabor@wigner.mta.hu).*

Introduction:
The lunar rocks form a complex system. Their internal structure is explored by material investigating methods. Material measurements affect many structural levels. Knowing them well is essential for students in planetary science. The intrinsic constants of the material allow us to trace knowledge of the structural hierarchy from macroscopic ranges to microscopy and elementary particle components, and to assign hierarchy levels fitted for parallel disciplinary studies.

Structural hierarchy for parallel systems:
We have previously written that this structural hierarchy provides a significant help in the depth of the system. In our current presentation, we have extended the system to levels that can be explored by parallel disciplines in the structure. This is especially useful when conducting material measurements are carried out for soils. The terrestrial soil is much more complex than the lunar one, yet getting to know the parallel levels can be done on simpler systems.

Branchings at textural level (Fig. 3.)
At textural level we may focus in textural hierarchy to the disciplines studying various textural units: there are shown 4 main disciplines of measurements: according to the methods in physics (here magnetic ones), geology-petrography (mineral and crystallographic ones), chemistry and microbial biology methods. The 4 branchings return to the main line at the level of atoms.

We first may teach various (combined) methods applied in the studies of Apollo 17 lunar sample 70017 and two key Martian meteorites: ALH 84001 and ALH 77005 (Fig.1). The main direction of interest is: to find evidences about life fossils. The structural hierarchy principle is also used [1]. The embedded structures of the hierarchy all belong to the same subsystem. Largest field is the thin section's textural field.

70017 NASA Lunar sample
After OM studies of chondrites and Martian meteorites we used an extremely large magnification capacity in order to see the NASA sample 70017 texture in fine details. We found a bubble-like form developed from a fissure in the 70017 sample, where the „invasion bubble" was fulfilled with microbial-like filamentous coccoid like mineralized biosignatures (Fig. 2). Being the sample from the educational set, only the optical microscopy was allowed in this [2] study.

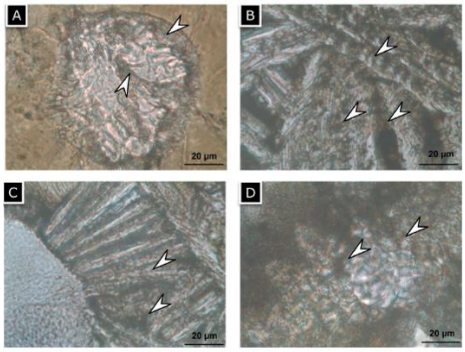

Fig. 1. Putative mineralized microbially mediated biosignatures in ALH-77005 meteorite (arrows). A: Coccoidal iron-oxiding bacteria (FeOB) in melt inclusion of brown olivine. B: Filamentous FeOB in melt pocket. C: FeOB along crystallite needles D: FeOB with organic material in melt pocket.

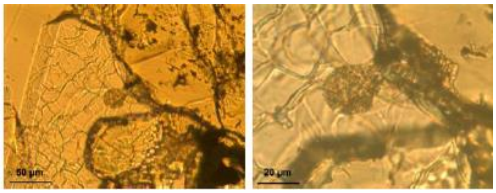

Fig. 2 Bubble-like form developed from a fissure in the 70017 sample. The invasion bubble was fulfilled with microbial-like filamentous mineralized biosignatures.

ALH 84001
Studies of McKay et al. [3] group offer a very detailed crystallographic characterization of magnetite minerals (HRTEM) including their chemistry, and a 6 point based comparison with terrestrial microbial magnetite (magnetotactic bacterial activity). Friedman *et al.* [4] produced statistics on magnetite garlands (chains, and chain fragments) in the carbonate. McKay et al. [3] Science paper found, microbial scale-like forms by the scanning electron microscopy, and identified PAHs on the broken surface.

ALH 77005
The Gyollai et al (2019) [5] study focused on ALH-77005 sample which contained mineralized microbially mediated microtexture in the form of filamentous, coc-

coid-like, vermiform structural elements in a high magnification OM images with micrometer size range.

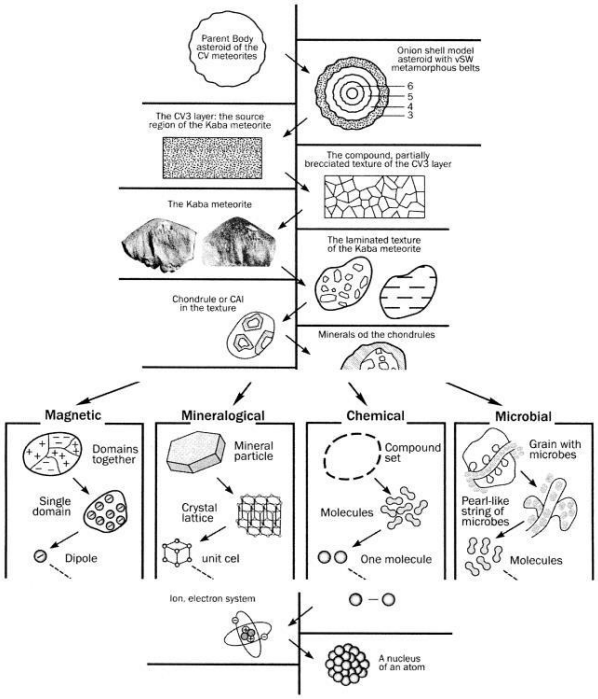

Fig. 3. Combined structural hierarchy table of the decomposition of the Kaba meteorite. The asteroid is assumed to have an onion shell structure. Decomposition begins with those layers. Branching of the structural hierarchy is initiated at the level of textural units, for example at a mineral grain. Branching is shown for 4 disciplines: physics, geology-petrography, chemistry and microbial biology. The branching is returned to the main line at the level of atoms, and finally closed at the nucleus level.

These structural elements and their mineral environments in the texture were measured on *in-situ* FTIR and Raman spectroscopy. The study used methods to determine micromineralogy (main element composition) and embedded organic matter in the given microtexture *in situ*, and concluded that mineralized microbially produced texture forms a multihierarchical coherent measurement system (Fig. 3), because the measurements were applied in an embedding (hierarchical) sequence. The deepest structural level data, the delta 13 C data were taken from the literature; Douglas et al. 1992, [7]). In ALH-77005 meteorite exhibited a coherent view for microtexture, micromineralogy, embedded organic compounds, and enrichment, of bioessential elements, which effected most of the mass of the melted pocket of the sample. Also, strongly negative 13C values as "vital effect" support the microbial alteration scenario. The well-fitting of the 5 hierarchical levels (Fig. 3) (isotope, element, molecule, mineral and texture) with complex terrestrial biogenicity features give the suggestion for students to plan measuring units (pairs, or triple–instrument unifications) for experimental space probes (Hunveyor).

Combined measurements by nano-pico units

We showed in situ and remote sensors suitable in Nano Probes [8] Swarm Streams and their possibilities [9].

In situ measuring: Nano Probe contains a multipurpose Sensor Chamber Complex, which can collect, hold and analyze samples collected from the target field. Measuring have three phases starting from a noninvasive measuring, without modifying the sample. Light spectrum analyzing, acoustic and capacitive chirping. (Fig. 4.)

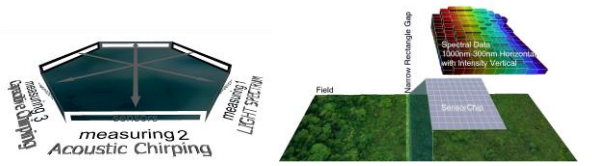

Fig. 4. Remote sensing: A Full Spectrum Scanner Field Scanning. A narrow gap with a prism and a CCD on which the full spectrum is mapped.

References:

[1] Bérczi, Sz. 2017, Planning Science Experiments According to the Multihierarchical Structural System of Planetary Objects, In: *Planetary Science Vision 2050 Workshop* (Vol. 1989). abs#8003. [2] Sz. Bérczi, M. Polgári, I. Gyollai, A. Gucsik 2019, Putative microbial mediation in NASA lunar sample set: microtextural features at high magnification. EPSC-DPS Joint Meeting 2019, held 15-20 September 2019 in Geneva, Switzerland, id. EPSC-DPS2019-1 [3] McKay, D. S., Gibson, E. K. Jr., Thomas-Keprta, K. L., Vali, H., Romanek, C. S., Clemett, S. J. Et al. 1996, Search for past life on Mars: Possible relic biogenic activity in Martian meteorite ALH84001, *Science*, ***273***, 924–930. [4] Friedman I., E., Wierzchos, J., Ascaso, C., and Winklhofer, M. 2001, Chains of magnetite crystals in the meteorite ALH84001: Evidenceof biological origin. *XXXII LPSC*, abs#1996. [5] Gyollai, I., Polgári, M., Bérczi, S., Gucsik, A. and Pál-Molnár, E. 2019, Mineralized biosignatures in ALH-77005 Shergottite – Clues to Martian Life? *Open Astronomy*, ***28(1)***, 32-39. [6] Polgári, M., Gyollai, I., Bérczi, S., Veres, M., Gucsik, A., & Elemér, P. M. (2019). Microbial mediation of textures and minerals–terrestrial or parent body processes?. Open Astronomy, 28(1), 40-60. [7] Douglas, C.; Wright, I. P.; Yates, P. D.; Pillinger, C. T. 1992, The Carbon Isotopic Composition of LEW88516, the Fifth Shergottite. *Meteoritics*, ***27(3)***, 215. [8] Vizi et al. (2012) IPM No. 1683, p.1122. [9] Vizi et al. (2017) LPSC 48 #3007.