# HOW WE USED NASA LUNAR SET AND NSSDC LUNAR ORBITER PHOTOGRAPHS IN A MULTI-HIERARCHICAL LUNAR SAMPLE AND STRATIGRAPHICAL LAYER STUDY.

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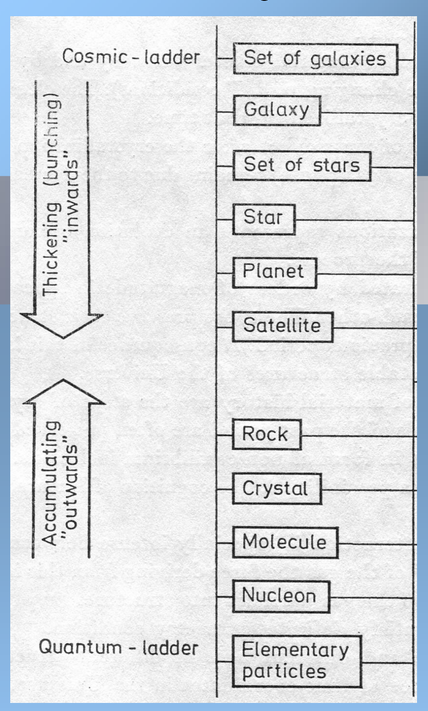
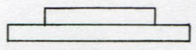
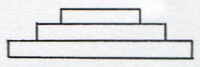
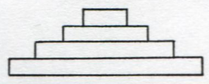
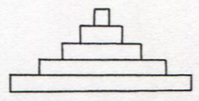
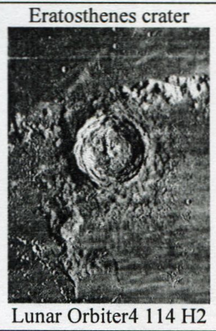
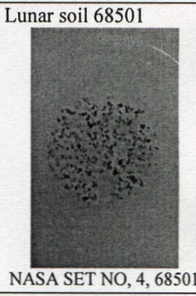
**Summary:** NASA Lunar sample educational set and the NSSDC Lunar Orbiter photography images were used to arrange some important lunar events into a structural hierarchy multilevel system and frame. Although the evolutionary steps are distinctly separated, this way lunar planetary evolution can be demonstrated with various measurements: stratigraphy (USGS maps), imaging of surface layers (Lunar Orbiter images), hand specimen samples and thin sections (NASA set). (*Table. 1.*)

**Introduction:** This year a hierarchy level arrangement of the lunar events were placed into focus in our NASA set lunar course [1] and we used the large sized (45cm x 65cm) NSSDC Lunar Orbiter photo images (from the National Space Science Data Center, Rockets and Satellites, 1973-76) and lunar geology map series of the USGS, published since the late 1960-ies years.

**Structural hierarchy for planetary research**
Structural hierarchy provides a systematic which unifies the levels from deep in materials up to planetary levels, on the basis of embedding structures *(Fig.1.)*




| PERIOD | Cratered lunar crust | Basin forming impact | Lava fill of the impact basin | Older crater without rays | Younger crater with rays |
|---|---|---|---|---|---|
| Strati-graphy | Pre-Nectarian | Nectarian | Imbrian | Eratosthenian | Copernican |
| Layer code |  |  |  |  |  |
| Planetary surface, layer morpho-logy on Lunar Orbiter images | Southwestern terrae  Lunar Orbiter4 180M d. | Nectaris basin & ejecta  Telescopic photograph | Rima Prinz region  Lunar Orbiter4 151 H1 | Eratosthenes crater  Lunar Orbiter4 114 H2 | Copernicus crater  Lunar Orbiter4 121 H2 |
| Hand specimen or NASA SET disc sample | Anorthosite 60025  Disc No. 112 | | Basalt 15555   Disc No. 112 | Breccia 15059  Disc No. 112 | Lunar soil 68501  NASA SET NO, 4, 68501 |
| Example for such type rock texture in thin sections of the NASA SET | Anorthosite 60025  | Anorth. breccia 65015  | Basalt 12002  | Soil breccia 15299  | Lunar soil 68501  |
| | | | | | |

We followed one kind of structural column according to the structural hierarchy. For example the case of mare basalts of Imbrian age are shown:
On Lunar Orbiter image LO-4, 151 H1 we studied the smooth lava flows in the vicinity of Aristarchus crater..The corresponding layers were studied on I-527 USGS map of Seleucus Quadrangle [3]. The (logically) corresponding mare basalt in the NASA set is the disc basalt sample (15555). The even deeper layer is the texture of a basaltic thin section from the set (here we used 12002). The paragenetic sequence of the texture showed the process of crystallization during the cooling. The crystallization process involved the TTT diagrams for textural study, and Bowen, Taylor etc. diagrams. WE followed the hierarchical sequence with the measurement methods, to. Finally a mineral component (for example plagioclase feldspar) was selected with its oxide component to exhibit the deeper hierarchy level. Such series of the structural hierarchy framework was followed in several cases, where we had Lunar Orbiter images, corresponding USGS stratigraphical maps, disc NASA lunar samples, and thin section with a more or less corresponding surface material and mineral components.
**Benefits of multi-hierarchical teaching strategy**: The benefit of such a hierarchy sequence framework is that students can connect structural levels not only in a horizontal ways (i.e. various crystallization processes), but in a so called vertical way, too. In this respect various geological references were built onto a larger system from the LO-images, USGS maps, NASA Set disc and thin section samples, and chemical compositional knowledge of the crystallization processes of a multicomponent system.
**Summary:** After studies on structural hierarchy of materials [4], the corresponding processes (planetary and industrial) [5-7], planetary analog field trips [8] this year we focused our studies on the overview of the structural hierarchy of planetary materials from large scale ones (stratigraphic units) down to the mineral composition of the lunar samples. This vertical view (a complex concept in teaching [9]) played important role in cross-weaving the knowledge of students on planetary processes, evolution, materials.

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**References: [1] Meyer, C. (1987*) The Lunar Petrographic Thin Section Set*. NASA JSC, Houston, [2] Bérczi Sz. (1980): Cyclicity in the Evolution of Matter and its Application to the Evolution of the Solar System. *Acta Geologica Acad. Sci. Hung.* Tom. 23. Fasc. 1-4. p. 163-171; [3] Moore, H. J. (1967): Geologic map of the Seleucus Quadrangle of the Moon. I-527. USGS, Washington D.C. [4] Kabai, S., Bérczi Sz. (2004): 35th LPSC, #1081; [5] Bérczi Sz., Szakmány Gy., Józsa S., Kubovics I., Puskás Z., Unger Z. (2003): 34th LPSC, #1115; [6] Bérczi Sz., Józsa S., Szakmány Gy., Dimén A., Deák F., Borbéi F., Florea N., Peter A., Fabriczy A., Földi T., Gál A., Kubovics I., Puskás Z., Unger Z. (2001): *26th NIPR Symposium Antarctic Meteorites*, Tokyo, [7] Bérczi Sz., Cech V., Józsa S., Szakmány Gy., Fabriczy A., Földi T., Varga T. (2005): 36th LPSC, #1282; [8] Sz. Bérczi, Gy. Hudoba, A. Lang, T. P. Varga, S. Józsa, Gy. Szakmány, I. Erdélyi, D. Kiss, I. Nickl, T. Panyi, T. N. Varga, S. Hegyi, T.. Pataki. (2010): 41st LPSC, #1358; [9] Sz. Bérczi, S. Józsa, S. Kabai, I. Kubovics, Z. Puskás, Gy. Szakmány. (1999): NASA Lunar Sample Set in Forming Complex Concepts in Petrography and Planetary Petrology. In *Lunar and Planetary Science XXX*, #1038, Lunar and Planetary Institute, Houston (CD-ROM)**