PLANETARY ANALOG METARIALS STUDIES: MARTIAN SHERGOTTITES AND THEIR COUNTERPARTS FROM THE SZENTBÉKKÁLLA SERIES OF MANTLE LHERZOLITE INCLUSIONS AND THE HOST BASALTS IN HUNGARY. ***Sz. Bérczi[1], S. Hegyi[2], Gy. Hudoba[3], S. Józsa.[4], Gy. Szakmány[4]*** [1]Eötvös Loránd University, Institute of Physics, H-1117 Budapest, Pázmány P. s. 1/a., Hungary (berczisza ni@ludens.elte.hu), [2]Pécs University, Dept. Informatics and G. Technology, H-7624 Pécs, Ifjúság u. 6. Hungary, [3]Budapest Polytechnik, Kandó Kálmán College of Electric Engineering, Faculty of Computer Science, H-6000, Székesfehérvár, Budai út, Hungary, [4]Eötvös University, Dept. Petrology and Geochemistry, H-1117 Budapest, Pázmány 1/c. Hungary.

Introduction: Among the SNC (Shergotty, Nakhla and Chassigny) Martian meteorites there is a group which has several analogies with terrestrial basalt-with-xenolith rocks. These rocks are the shergottites. They form three main subgroups: the basaltic-shergottites (i.e. Shergotty itself), the picritic-shergottites or olivine-phyric shergottites (i.e. Northwest Africa 1068) and the lherzolitic or peridotitic shergottites (i.e. ALHA-77005. The three groups of shergottites have formation ages between 170 and 500 Mys.

Genetic and textural characteristics of the host basalt and some of its inclusions are analog from Szentbékkálla, North-Balaton Mountains, Hungary, to the range of the shergottites. Here several types of peridotitic rocks (lherzolites, websteries and harzburgites) can be found as inculsions in the basalt of tuff and the olivine-phyric basalts also can be found among the basalts of the Little Hungarian Plain and Tapolca Basin.

Model for origin of shergottites: Considering geochemistry of shergottites Warren and Bridges [1] suggested a classification to the three subgroups. In this model the degree of assimilation of the crust components distinct those magmas coming from Martian mantle. This model is similar to that we proposed in 1984 for the Szentbékkálla series of inclusions. When the Martian basaltic partial melts leave their source regions they exhaust it in some geochemical components, mainly REEs. According to the exhausting level they defined strongly (S), median (M) and lightly (L) exhausted shergottites. The S-shergottites are represented by QUE94201, the M-shergottites are by ALHA77005, and the L-shergottites by Shergotty and Zagami. (Although the L-shergottites can be also be derived from the S-shergottites so, that uprising lava assimilated crust components with large REE content.)

Suggested source regions for olivine-phyric shergottites: The MER rovers discovered that a shergottite type may exist in the form of surface boulders along the trip way of Spirit in Gusev crater. McSween reported on the 36th LPSC that the olivine rich Martian basalts may be the counterparts of the olivine-phyric shergotties on the basis of the Pancam textural images, the miniTES and Mössbauer spectrometer data [2]. The olivines (phenocrysts) occur in visible sized porphyric form as (25 %) textural component of rocks Humphrey, Adirondack, and Mazatzal in the Gusev-crater. The Fe/Mg ratio of these olivines was also similar to that of olivin-phyric shergottites. Because of the spectral similarities of these rocks to the southern terra rocks on Mars, Spirit MER Team suggested that mainly such basalt that is the olivine-phyric shergottite forms the Noachian terra. According to Irving et al. (2005) the Tharsis Volcano Mountains are the sources of the olivine-phyric basalts.

The Szentbékkálla series: Several basalt volcanic units in the North-Balaton Mountains, in the Little Hungarian Plain and other parts of the Carpathian Basin (Nógrád-Gömör Mts, Persány Mountains in Transylvania, Romania) contain mantle xenoliths. We selected the Szentbékkálla locality as example counterparts for shergottites. Mantle xenoliths were collected and studied from the Szentbékkálla basalt tuff and also from other basalts and tuffs of the North-Balaton Mountains region [3]. Mantle xenoliths specimens, however, from Kapolcs, Szigliget, and Sitke were also studied.

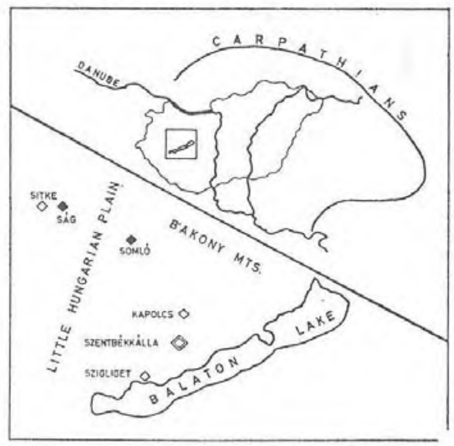

Fig. 1. The basalt tuffs with lherzolite xenoliths and other ultramafic inclusions from Szentbékkálla, North-Balaton region, Hungary.

Two types of lherzolites are the main ultramafic inclusion types in Szentbékkálla: exhausted lherzolites with smaller grains size and protogranular lherzolites with lightly exhausted REE content. The first group is more harzburgitic in mineral composition because olivine and orthopyroxene are their main mineral constituents. The second – protogranular – group is composed of the four main mineral phases of the lherolites: olivine, orthopyroxene, clinopyroxene and spinel. The exhausted lherzolites group is a good petrographic analog to the peridotitic-(lherzolitic)-shergottites, because they are similar to these harzburgitic-lherzolitic rocks. The series contains basalts with large olivine xenocrysts, too. These rocks are good mineralogical counterparts of the olivine-phyric shergottites also containing large olivine xenocrysts.

In this study the following specimens were our **samples**: Progran, Average-Lherzolite, Wehrlite and Spinel-pyroxenite. (A Dunite and a Layered-Lherzolite sample were also included from the xenoliths.) The host basalt samples of Szentbékkálla, Szigliget and Kapolcs were also studied. INAA, electron microprobe and petrographic microscopic studies were carried out on the samples.

We measured the REE content of the various xenolith types, of separated mineral components of the average lherzolite and the spinel-pyroxenite and of host basalts or tuffs.

Discussion: Peridotite is the basic component of both terrestrial and Martian mantle. From this mantle partial melts are separated and pour on the surface or crystallize in the upper crust. Basaltic or picritic lavas penetrate through the upper mantle and crust and assimilate some components. At the same time these lavas may convey broken fragments of the layers penetrated and they are embedded as xenoliths in the host rocks. This transporting mechanism makes it possible to collect xenoliths samples of deeper layers of upper mantle, too.

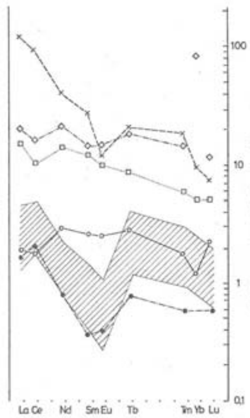

Fig. 2. Chondrite normalized REE abundances in the members of the Szentbékkálla ultramafic inclusions. X – basalt, – wehrlite, □ – spinel-pyroxenite, ● – dunite, ○ – layered lherzolite.

The various xenoliths represent different formation mechanisms. On the basis of mineral composition and REE abundance pattern it is possible to sketch the formation history of various xenoliths. On the basis of such measurements the petrologic genetics of the Progran, the Average-Lherzolite, the Wehrlite, the Spinel-pyroxenite (and the Dunite and the Layered-Lherzolite sample) were derived. Three factors have affected the REE abundances of these ultramafic inclusions.

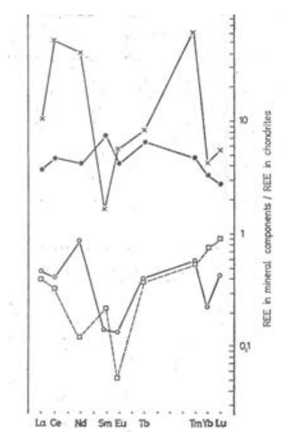

Fig. 3. Chondrite normalized REE abundances of the 4 mineral separates of average lherzolite from Szentbékkálla. X – spinel, ● – diopside, ○ – olivine, □ – enstatite.

But melt rarely separates totally from its parental environment. In localities, where it had been retained, the REE concentration increased. On the whole parental region the REE concentration decreased exhausting the source region both in main minerals of partial melting, and REE elements. In localities, here partial melts crystallized, the host rock has elevated REE concentration. Finally, assimilation of components from the penetrated rocks may also change liquid composition [5].

The Szentbékkálla series of ultramafic inclusions can be arranged according to these processes. The highest REE abundances characterize those samples which have originated by separation of the melt from the parental environment. Both basalt lavas poured onto surface and Spinel-pyroxenite samples crystallized in depths has such high REE abundances. The second group of samples consists of xenoliths which retained more (i.e. Layered lherzolites) or less (Wehrlite) of their lherzolitic composition in spite of the fact that more partial melts had accumulated – and later crystallized – in them, as compared those which had separated from them partially.

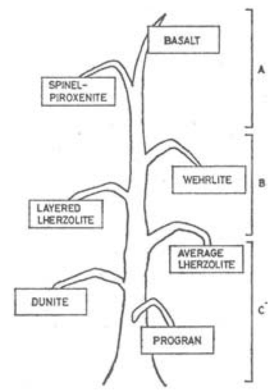

Fig 4. Arrangement of the Szentbékkálla series of ultramafic inclusions according to separation of the melt from the parental environment, enrichment and exhausted nature of their REE abundances.

These factors are: partial melting from the mantle source, partial separation of the melted liquids from the source environment and assimilation on their way from mantle source to the surface.

REE almost totally partition into the melt during the partial melting process. The high REE concentrations originated in this way are transported with the melt. If the melt separates from the source region, moves away and crystallizes, the degree of partial melting is inversely related to the degree of partial melting [4].

The third group of mantle xenoliths consists of lherzolitic inclusions which in some degree has depleted in components (as REE) which had gone into partial melts. The Average lherzolite, the Dunite sample may belong to this group. Probably the Progran sample is the less exhausted one among xenolith inclusions of Szentbékkálla.

Acknowledgments: Thanks for J. Bérczi for the INAA measurements at the Nuclear Reactor of the Budapest Technology University.

References: [1] Warren, P. H., Bridges, J. C. (2005): Geochemical Subclassification of Shergottites and the Crustal Assimilation Model. *36th LPSC*, #2098. LPI, Houston; [2] McSween, H. Y., Jr., Milam, K. A. (2005): Comparison of Olivine-rich Martian Basalts and Olivine-Phyric Shergottites. *36th LPSC*, #1202. LPI, Houston; [3] Bérczi Sz., Bérczi J. (1986): REE Content in the Szentbékkálla Series of Peridotite Inclusions. *Acta Mineralogica et Petrologica Szeged*. **XXVIII**. p.61-74, [4] Ringwood, A. E. (1975): Some aspects of the minor element chemistry of lunar mare basalts. *The Moon*. **12.** 127-157. [5] Bérczi Sz. (1991): *Kristályoktól Bolygótestekig*. 210. old. Akadémiai Kiadó, Budapest.