

MARTIAN AND “TERRESTRIAL” SHERGOTTITES: COMPARISON OF THE LHERZOLITE (INCLUSION), OLIVINE-PHYRIC BASALT AND ALKALINE BASALTS ROCKS. Sz. Bérczi¹, A. Gucsik², H. Hargitai³; A. Kereszturi³, Sz. Nagy³, ¹Eötvös University, Institute of Physics, Dept. Materials Physics, H-1117 Budapest, Pázmány Péter sétány 1/c., Hungary; (berczisani@ludens.elte.hu), ²Max Planck Institute for Chemistry, Department of Geochemistry, Becherweg 27, D-55128, Mainz, Germany, (gucsik@mpch-mainz.mpg.de), ³Eötvös Loránd University, Institute of Geography and Geology, H-1117 Budapest, Pázmány Péter sétány 1/c., Hungary.

Introduction: Because of the genetic, petrographic and geochemical similarities between shergottites and terrestrial basalts containing mantle xenolith rocks we may study several parallel effects on the “terrestrial shergottites” and Martian shergottites. The Martian shergottites 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. The corresponding terrestrial counterparts (here we studied those from Szentbékállá, North-Balaton Mountains, Hungary) are the host basalt, which is sometimes olivine-phyric, some of its inclusions (lherzolite, wehrlite, websterite and harzburgite). Such basalts also can be found in the North-Balaton Highland vicinity basaltic region and in Little Hungarian Plain and Tapolca Basin basalts.

The study of Martian meteorites is the main joint program of the HAS-JSPS group from Okayama University, Japan and of Eötvös University, Budapest and West Hungary University, Sopron, Hungary. In this framework we plan to carry out shergottite comparisons focused this paper on.

Hungarian Terrestrial “shergottites”: the Szentbékállá 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 Szentbékállá locality as example counterparts for shergottites. Mantle xenoliths were collected and studied from the Szentbékállá basalt tuff and also from other basalts and tuffs of the North-Balaton Mountains region [1, 2]. Mantle xenoliths specimens, however, from Kapolcs, Szigliget, and Sitke were also studied.

Two types of lherzolites are the main ultramafic inclusion types in Szentbékállá: 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 lherzolites: 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 Szentbékállá, 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.

Geochemical model for origin of Martian shergottites: Considering REE geochemistry of Martian shergottites Warren and Bridges [3] 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 Szentbékállá 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 shergottites on the basis of the Pancam textural images, the miniTES and Mössbauer spectrometer data [4]. 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 olivine-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.

Discussion of “Terrestrial” shergottites:

Peridotite is the basic component of both terrestrial and Martian mantle. From these mantles 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. Along their way they assimilate or lose some components. At the same time these lavas may convey fragments of the layers penetrated and the broken boulders are embedded as xenoliths in the host rocks. This transporting mechanism makes it possible to collect xenolith samples of deeper layers of upper mantle, too.

The various xenoliths represent different formation mechanisms. On the basis of mineral composition and REE abundance pattern in the Szentbékállá series it is

possible to sketch the formation history of various xenolith types. On the basis of INAA REE measurements the petrologic genetics of the Progran, the Average-Lherzolite, the Spinel-pyroxenite (and the Dunite and the Layered-Lherzolite sample) were derived. Three main factors have affected the REE abundances of these ultramafic inclusions, also as shown for Martian shergottites by Warren and Bridges.

Sometimes, melt separates totally from its parental environment. In those localities, where it had been retained, the REE concentration increased. After separation, the REE concentration decreased exhausting the source region both in main minerals of partial melting, and REE elements in the whole parental region. In localities, where partial melts crystallized, the rock has elevated REE concentration. Finally, assimilation of components from the penetrated rocks may also change liquid composition [6].

The Szentbékállá 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.

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 [5].

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 Szentbékállá.

Summary:

Comparative studies between the “terrestrial shergottites” and Martian shergottites will give new dataset about the processes which formed Martian genetic sequence of igneous shergottite type rocks. During the studies of Martian meteorites in the joint program of the HAS-JSPS group from Okayama, Japan and Budapest-Sopron, Hungary will focus on this work in the next two years.

Acknowledgments: Thanks for HAS-JSPS/104 Fund for supporting our work.

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Fig. 1. Chondrite normalized REE abundances in the members of the Szentbékállá ultramafic inclusions. X – basalt, y – wehrlite, □ – spinel-pyroxenite, ● – dunite, ○ – layered lherzolite.

Fig. 2. A basalt tuff with lherzolite xenolith ultramafic inclusion from Szentbékállá, North-Balaton region, Hungary.

Fig. 3. Arrangement of the Szentbékállá series of ultramafic inclusions according to separation of the melt from the parental environment, enrichment and exhausted nature of their REE abundances.