MARE BASALTS FROM THE HIGHLAND REGION: PETROCHEMICAL VARIETIES AND GEOCHEMICAL FEATURES (LUNA 20).


PROBLEM AND OBJECTS. Mare type basalts from highland lunar region were undergone by intensive investigation for the last years /1-9/. The interest to these rocks are connected with their unusual location and possible more ancient age than the age of basalts from lunar maria /2-5/.

In connection with this one can suppose that the investigation of mare type basalts from highland regions will lead to new geochemical data on preore evolution of lunar basalt magmas. For example, the geochemical criteria obtained by XFA-SR technique have shown the presence of VLT type basalts in Appoloniis highland region /6-7/. This indicates the existing VLT magmas in the early evolution of the lunar basalt magmas. The importance of searching and geochemical investigation of such basalts for understanding of mare basalt evolution is evident.

This work is the continuation of these researches on the basis of neutron-activation technique. 37 fragments of various basaltic and feldspar rocks from Luna 20 soil have been picked out. The distribution of Al, Na, Fe, Ti, K, Cr, Sc, Co, Ho, Ta, Th and REE in these rocks have been investigated. Mineralogical and petrological studies of these rock fragments will be made after analytical investigations. That's why our conclusions are based only on chemical compositions.

RESULTS. Six rock groups were established on petrochemical and geochemical data. They are different in Al2O3 content, level of Fe, Sc, Na, FeO, TiO2 and REE contents and in the type of REE patterns.

Three groups (I, II, III) belong to low-aluminous basalts (LA) of mare type having high Fe content. Al2O3 content ranges from 8 to 13 wt.%. Groups IV and V are represented by high- and very high-aluminous rocks (HA and VHA) which have Al2O3 content 28% and FeO - 6 to 10 wt.%. Group VI includes two AMT fragments. According to TiO2 content one fragment from I-VI groups can be identified as high-titania (HT) basalt (sample No. 19 has 7.9 wt.% TiO2), and the others belong to LT-VLT rocks (they have 1.3 to 3.7 wt.% TiO2). Ti content in VLT Luna 24 rock series does not exceed 1x5 wt.% TiO2.

Thus, in contrast to Luna 24, the clear boundary between VLT and LT mare type of Luna 20 rocks does not exist. Therefore, it is necessary to involve REE pattern and the distribution of Hf, La, Ta, etc. to distinguish their varieties. The plot Hf/La (Fig. 1), as well as in the work /3/, permits to determine rich (groups I, IV, V) and poor (groups II, III, VI) in Hf and La (REE) groups. But opposite to mare basalts of Apollo 14 /3/, our groups have variable petrochemical composition. This indicates different parent geological bodies from which investigated fragments have been derived. The character of Sm and Eu distribution (Fig. 2) and especially the REE patterns (Fig. 3), confirm this supposition. Rich in FeO (mean content FeO = 19.6 wt.%) and in REE basalts of group I belong to mare type rock. They differ from the mare basalts of groups II and III (average FeO content is 15.2% and 16.9% wt.%, respectively), which are poorer in REE, especially group III. However, the REE pattern type of group II (pattern 4, Fig. 3) is similar to REE pattern of Apollo 12 and 15 basalts. This doesn't permit the sample No. 4 from group II to attribute to VLT basalts (as has been supposed on XFA-SR data /6-7/) although it has low TiO2 (1.7 TI O2) and the level of REE; Hf and Ta content is near to VLT rocks. Pattern REE of group III (pattern No. 23 and 31, Fig. 3) no doubt belongs to VLT type, but more to VLT of Apollo 17 /10/ than to VLT of Luna 24. This is confirmed by the enrichment in heavy REE and small Eu minima in these samples. For comparison, the REE pattern of Apollo 17 VLT sample No. 70007, 289B /10/ is shown in Fig. 3.

The basalts of groups IV and V are enriched in REE and other elements (Hf, Ta, Th, W) and depleted in FeO, Sc, Cr. These rocks belong to high-aluminous (HA) and very high-aluminous (VHA) basalts but their level of REE content is lower than KREEP level. The REE patterns (No. 24, 34, 36 of group IV and No. 6 of group V, Fig. 3) enriched in light REE and having deep Eu minima indicate genetic relationship of these HA and VHA rocks. REE patterns of group VI are AMT typical patterns (Fig. 3).

DISCUSSION. The observed geochemical range variations of basalt rock from highland Appoloniis region indicate the presence of four varieties of mare type basalts: high-titania (HT); low-titania enriched in rare elements (LT, group I); low-titania depleted in rare elements (LT, group II) and low titanium -very low titanium (LT-VLT, group 3). As Cs is not determined the correction in Ti (TiO2) contents for Ca con-
The correction for Ca will decrease TiO₂ content to about 0.2-0.3 wt.%. Thus some samples of LT-type are of VLT-type indeed. This confirms the assumption of our works /6,7/. We see that there is no clear boundary between LT and VLT basalts in group III. Perhaps, the basalts of group II can continue this range. As for them, it is important to note that the content levels of rare elements are close to VLT basalts but TiO₂ content and REE patterns correspond to LT basalts. This is petrologically important as the gradual change of VLT and LT types in group II and III may be connected with genetic unity of these rocks in Apollonius region. The rocks of II and III groups may have originated from one or different but genetically related basaltic bodies. This is important for the understanding of the position of VLT basalt in evolution range. The distinction between Luna 20 and Luna 24 VLT basalt can be connected with various sources and the time gap between their formation. Mare basalts of group I and sample of HT basalt indicate variety of mare basalt type in Apollonius region and on possible age diversity of these rocks. The presence of VLT-type basalts being poor in rare elements, indicates that a depleted source had been existing for a long time before VLT basalt eruption in Mare Cylasim.


Fig. 1. Plot of Hf vs La (ppm) for various groups of Luna 20 basalts. I-VI - groups of basalts.
Fig. 2. Plot of Sr vs Eu (ppm) for various groups of Luna 20 basalts.
Fig. 3. Chondrite-normalized REE distribution patterns for various groups of Luna 20 basalts.