THE VAPORIZATION OF ANORTHOSITIC MELT: EXPERIMENTAL DATA; O.M. Markova, O.I. Yakovlev, and K.I. Ignatenko, V.I. Vernadsky Inst. of Geochemistry and Analytical Chemistry, Moscow 117234, USSR.

INTRODUCTION. Meteorite bombardment of the lunar surface may cause the formation of high temperature melts and liquid-vapor fractionation. Depending on the composition of the target matter and the quantity of vapor formed, a spectrum of secondary rocks and glasses carrying the memory of impact in their "unusual" composition can be formed. The composition of HASP glasses, which have high Al_2O_3 (and CaO) and low SiO_2 content, may confirm the possibility of strong compositional change during evaporation. The possibility of HASP formation from highland compositions in the process of selective vaporization was discussed in works (1,2,3,4). As anorthosites are one of the main lunar highland components, the author's aim was to study the possible trend of anorthositic melt evolution during the evaporation and to make clear the HASP source material and their formation conditions.

TECHNIQUE. A series of experiments was carried out in the vacuum chamber to study the change of anorthositic melt during evaporation. The composition of the earth anorthosite chosen as a start material was as follows (wt.%): SiO_2=54,1;Al_2O_3=25.8;CaO=12.0;FeO=0.95;MgO=0,46;TiO_2=0.26;Na_2O=3.0;K_2O=0.56. The experiments were conducted in Mo-crucibles at the temperature range (1650-2000°C) ± 20°C. The time of experiments was 10 minutes. The temperature measurements were made by the optical pyrometer. The pressure in the vacuum chamber was in the range of $(2\div8)\times10^{-5}$torr. After the experiments samples of homogeneous glasses were analysed with the microprobe. Mass losses during evaporation were determined.

RESULTS. Compositional changes in residual glasses as a function of mass loss (temperatures) shows (Fig. 1) that Al_2O_3 and CaO enrich glasses and Na_2O, K_2O, FeO and SiO_2 - vapor. At a lower degree residual glasses depleted in MgO and enriched in TiO_2. At the same time, enrichment of residual glasses by Al_2O_3 is practically identical to that for CaO. So far as three petrogenic oxides (SiO_2, Al_2O_3 and CaO) are the main anorthositic components which compose more than 90 wt.% of the sample they determine the transformation of its composition during the vaporization. The enrichment of residual glasses in Al_2O_3 and CaO and depletion in SiO_2 take place during the vaporization of the anorthositic melt. The analyses of residual glasses show that they don't contain any Na_2O and K_2O under the mass losses of about 10% (T^o = 1700°C) and any FeO and SiO_2 under that of about 70% (T^o = 2000°C).

The composition of vapor over the anorthositic melt in our experiments have been calculated. In the considerable range of mass losses vapor (Fig. 2) is enriched in SiO_2 and Na_2O. The content of Al_2O_3 in it is more than 5%. With the increase of mass losses the vapor becomes more rich in SiO_2, at a lower degree - in Al_2O_3 and CaO, and it becomes less rich in Na_2O, K_2O and FeO. The content of SiO_2 in vapor increases from 65 to 80% with the increase of mass losses in the experiment from 20 to 70% and the composition of vapor deplaces to the range of acid and ultra acid compositions. The knowledge of vapor's composition which formed in the process of selective vaporization is important for the interpretation of number of natural formations with condensation origin.

DISCUSSION. The experimental data demonstrate the proximity of residual glasses and HASP glass compositions, confirming the impact-vaporization genesis of latter (Fig, 3,4). The change of anorthositic melt composition during the evaporation and the compositions of HASP (1,2,3) when the sum CaO, Al_2O_3 and SiO_2 oxides is more than 90% and $TiO_2 \leqslant 0.25$ wt.%, that is its mean content in anorthositic lunar rocks, are shown on Fig. 3. HASP compositions are in good agreement with the trend of anorthositic rock change during the evaporation process. The approximate estimation shows that all the pointed HASP compositions lie in the mass losses range from 25 to 46%, that in our experiments corresponds to temperatures 1750-1850°C. These data demonstrate the possible evaporation parameters of anorthositic rocks which may tend to the formation of HASP glasses compositions under about 20-percent vaporization. The fact that there are not any analyses of HASP in the literature, lying below the compositions of taken glasses, indicates that processes on the lunar surface resulting in stronger change of compositions are rare.

SiO_2/Al_2O_3 vs (Al_2O_3+CaO) for lunar highland rocks (5,6) HASP glasses (1,2,3,4) and products of evaporation from the anorthositic melt are demonstrated on Fig. 4. The line SiO_2: Al_2O_3=1.17 corresponds to the minimum ratio of these oxides for all possible lunar magmatic rocks and reflects the ratio of these oxides in anorthite. As one of the main melt changes during the evaporation is the decreasing of SiO_2/Al_2O_3 ratio, all compositions lying below this line are the obviously evaporated ones. However, this fact doesn't mean that compositions lying above this line were not fractionated during such a process. It is important that HASP compositions in our disposal with the only exception for mean composition of HASP Luna-24 (4), lie in the field of "evidently evaporated" compositions. Contents of petrogenic oxides such as SiO_2, Al_2O_3 and CaO demonstrate that the highland material was a source material for HASP (only in the case of HASP Luna-24 can we suppose some little admixture of mare material like ferrobasalt). The content of TiO_2 (less than 1.5%) also indicates to the connection of HASP with the highland component. The tendency of TiO_2 to enrich residual glasses allows us to make the conclusion that the TiO_2 content in initial material must be less than in HASP. This excludes the possibility of HASP formation in the process of deep reworking of high-Ti component of lunar regolith. It is likely, however, that HASP compositions cannot be characterized as a relict of evaporation of any single group from highland population of lunar rocks. This point of view is confirmed by the variations, at first, such oxides as FeO, MgO and TiO_2 in HASP compositions.

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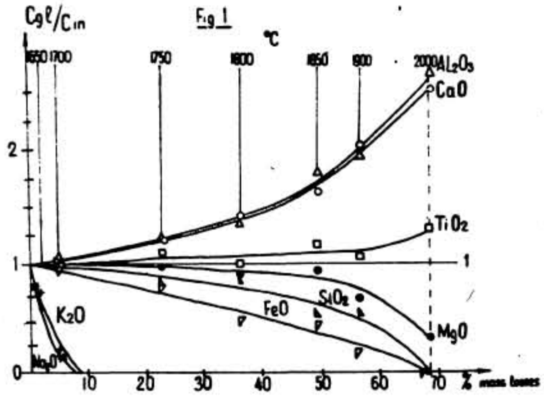

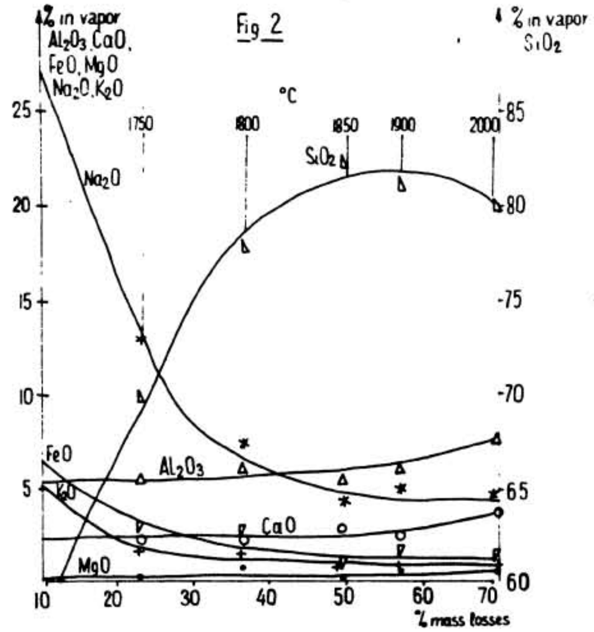

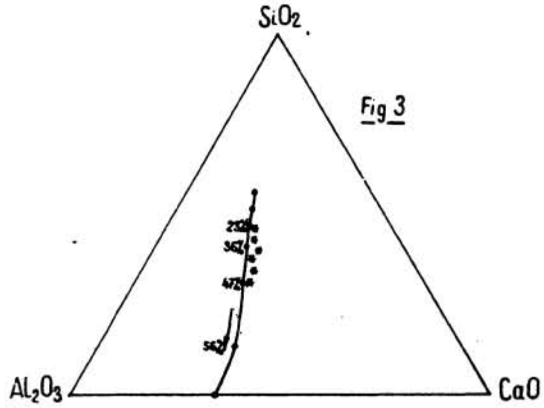

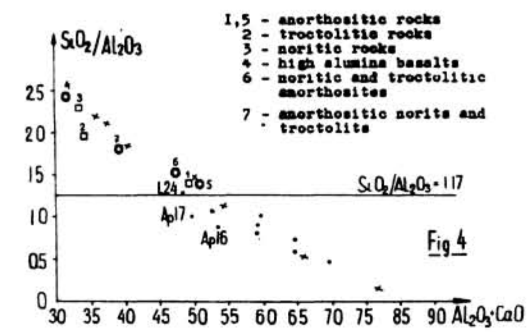

Fig. 1. Variations in the content of petrogenic oxides in residual glasses vs. mass losses (C_{gl} - concentration of oxide in glass, C_{in} - concentration of it in initial anorthosite).

Fig. 2. Weight percents of oxides in vapor vs. mass losses.

Fig. 3. Compositions of experimental residual glasses (·) and some HASP glasses (*).

Fig. 4. SiO_2/Al_2O_3 vs. (Al_2O_3 + CaO) for lunar highland rocks {⊡ - (5), ⊖ - (6)}, HASP glasses (·) and experimental residual glasses (x).

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