EVOLVED ROCK CLAST IN LUNA-24 SOIL SAMPLES. S. I. Demidova[1], K. M. Ryazantsev[1], K. A. Badekha[1] [1]Vernadsky Institute of Geochemistry and Analytical Chemistry, Kosygin Street 19, Moscow 119991, Russia (demidova.si@yandex.ru)

Introduction: Luna-24 soil sample was delivered from south-eastern part of Mare Crisium and consists mainly of mare material with small admixture of highland component [1-3]. The rocks are characterized by extremely low content of KREEP elements [1,3]. Here we report preliminary results of petrological investigation of evolved rock fragment found in Luna 24 soil samples.

Samples and Methods: Polished thick section of Luna-24 fragments (sample 24176, fraction >200 μm) was studied using optical microscopy. Acquisition of BSE, elemental maps and chemical composition of the phases were performed using Tescan Mira 3 FEG SEM with Oxford Instruments EDS detector in Vernadsky Institute (Russia). The mapping was conducted with an electron beam accelerating voltage of 20 kV at 15 mm working distance.

Results: A small (~350x500 μm) impact melt breccia fragment of Luna-24 soil sample (grain #2026) contains a clast of an evolved rock (150x270 μm) (fig. 1).

The host impact melt has high-Al VLT basaltic composition slightly enriched in alkalis but with high MG# number (70) (see table 1). It is partly devitrified with degree of crystallinity varying from glassy at the boundary with the evolved clast to cryptocrystalline on the border with coarse plagioclase grain (An_{95}) (fig.1). Rare troilite spherules (1-5 μm) are unevenly distributed in the contact zone both in the evolved clast and in the host impact melt. Some troilites contain tiny Fe-Ni metal inclusions.

The evolved clast is a fine-grained vitrophyric rock consisting of elongate skeletal crystals of silica phase (type 1) embedded into the dominating K-feldspar glass. Another silica phase (type 2) is present mainly in outer portion of the clast and looks dark grey on BSE image (fig. 2). Type 2 silica forms idiomorphic to irregular shape crystals (1-8 μm) and has complicate interrelations with type 1 silica grains both surrounding them and forming separated tiles inside the single grains (fig. 2).

Table 1.

L-24 #2026	Impact melt	Evolved clast
Na_2O	0.58	1.31
K_2O	0.54	3.79
CaO	11.26	3.52
TiO_2	1.12	0.63
Al_2O_3	18.6	11.8
Cr_2O_3	0.23	b.d.
SiO_2	49.9	76.7
MgO	10.0	0.11
FeO	7.54	0.49
P_2O_5	0.23	0.33
ZrO_2	b.d.	0.65
Y_2O_3	b.d.	0.45
MG#	70.3	-

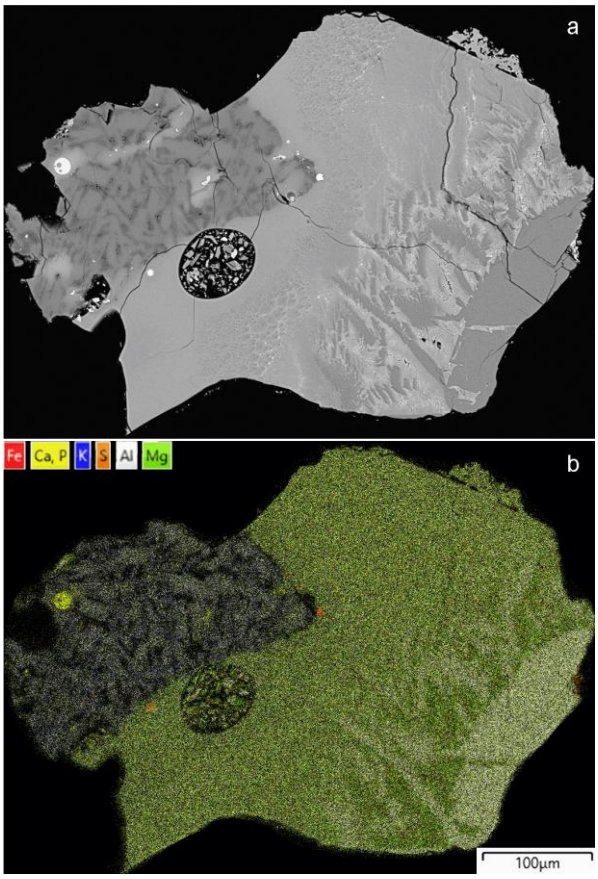

Fig. 1. Photomicrographs of Luna-24 impact melt breccia #2026: a) BSE image, b) false colour map

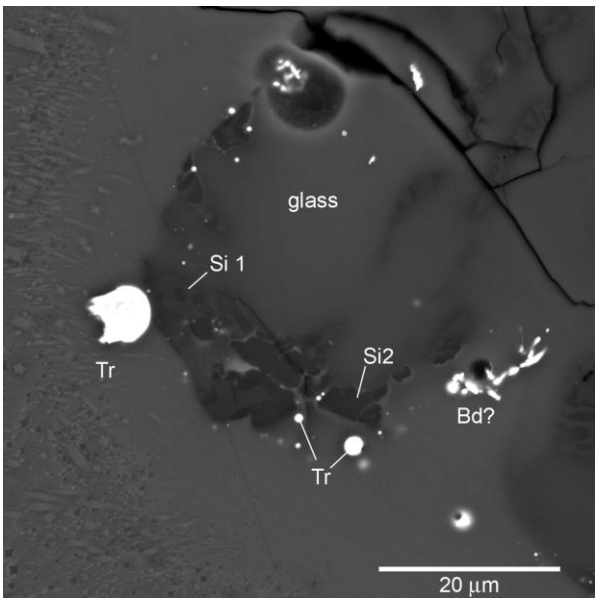

Fig. 2. A fragment of the evolved clast in contact with the host impact melt, grain #2026 from Luna-24 sample (BSE image).

One of two types of silica may represent either diaplectic silica glass or high-pressure polymorph (koesite) similar to that of observed in terrestrial impact rocks [4,5]. Additional investigation is required for accurate identification of the phases.

The clast has highly silicic composition enriched in alkalis (see table 1). Some areas in the matrix glass have elevated contents of P, Zr, Y and REEs. They are unevenly distributed in the clast forming vein and patches. These are the areas that are saturated with nanosize droplets of phosphate glass and contain rare polycrystalline aggregates (2-5 μm in size) of tiny isometric grains of Zr-phase, presumably baddeleyite (fig. 3). Similar objects have been reported in Apollo 15 breccia and may represent the products of zircon transformation and following reaction with surrounding impact melt [6]. However impact-induced zircon granulation was also noted in lunar rocks [7].

Single coarse spherule of phosphate glass (15 μm in diameter) is present in the vein glass. It is devitrified and consists of the finest mixture of Ca-phosphate, Zr-phase and Si-phase. Small round feldspathic glass inclusions (1-4 μm) are present in the spherule as well (fig. 4).

Discussion: High-Al Mg-rich composition of the basaltic impact melt and the presence of the evolved clast clearly distinguish the fragment #2026 from Luna-24 mare rocks, dominated by ferrobasalts or fragments of disintegrated cumulative rocks [1,8]. This suggests its highland origin or mixing with highland material which is comparatively abundant among impact glasses of Luna-24 [4].

No KREEP rocks have been reported in Luna-24 soil samples except for the single fragment of cristoballite gabbro (#1506) having some KREEP affinities [1]. It contains K-Si glass and Zr-phases, shows enrichment in plagioclase with high MG# number of the mafics [1] and may have some relation to the studied fragment #2026.

However the find of the evolved rock clast in the fragment #2026 may also indicate the presence of highly-silicic lithologies in the region of Luna 24 site or nearby which in turn could serve as a source for enigmatic coarse silica fragments rarely found in a soil fraction 120-250 μm [8].

Petrological and textural features of the evolved clast, such as: occurrence of silica polymorphs; presence of P, Zr, Y, REEs-rich glass veins and patches with Zr-phase polycrystalline aggregates; phosphate melt liquation features - point to complicate history of the evolved clast accompanied by impact melting and post-shock interaction of silicic melt with hot impact melt of basaltic composition. Following phase identification may shed light to the impact conditions and post-shock kinetics.

References: [1] Tarasov L. S., et al. (1977) *Proc. 8th LPSC*, 3333-3356. [2] Barsukov V. L., et al. (1977) *Proc. 8th LPSC*, 3303-3318. [3] Bence A. E. and Grove T. L. (1978) *GCA, suppl. 9*, 429-444. [4] Stoffler D. and Langerhorst F. (1994) *Meteoritics, 29*, 155-181.[5] Glass B. P. et al. (2020) *Meteoritics & Planet. Sci., 55*, 253-273. [6] Grange M. L. et al. (2013) *JGR, 118*, 2180-2197. [7] Crow C. A., et al. (2017) *GCA, 202*, 264-284. [7] Basu A., et al. (1978) *GCA, suppl. 9*, 321-337.

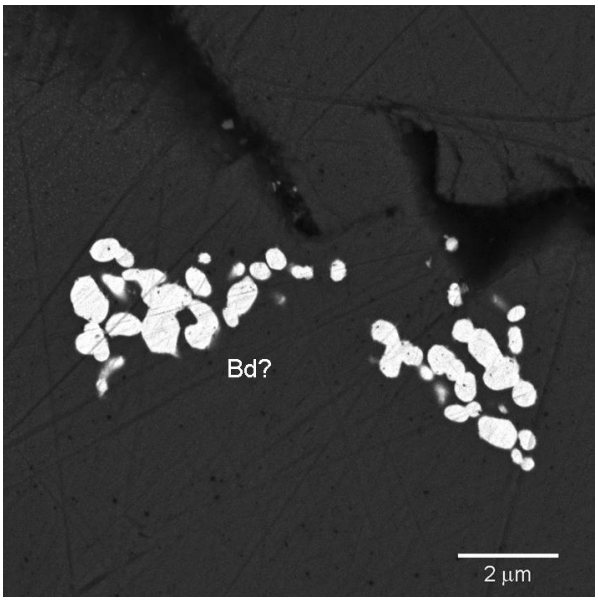

Fig. 3. Polycrystalline aggregates of isometric grains of Zr-phase (baddeleyite?) from the evolved clast in Luna-24 fragment #2026 (BSE image).

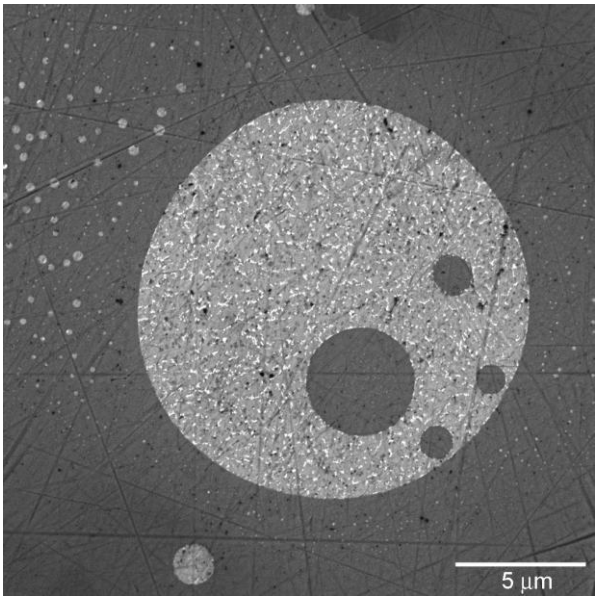

Fig. 4. Devitrified spherule of phosphate glass from the evolved clast in Luna-24 fragment #2026 (BSE image).