U-Pb DATING OF ZIRCONS FROM THE DHOFAR 1442 LUNAR METEORITE. S. I. Demidova[1], M. A. Nazarov[1], M. O. Anosova[1], Y. A. Kostitsyn[1], F. Brandstätter[2], and Th. Ntaflos[3] [1]Vernadsky Institute of Geochemistry and Analytical Chemistry, Kosygin St. 19, Moscow 119991, Russia, demidova.si@yandex.ru; [2]Naturhistorisches Museum, A-1014 Vienna, Austria; [3]Department für Lithosphärenforschung, Universität Wien, Althanstrasse 14, 1090 Wien, Austria.

Introduction: Recently found Dhofar 1442 lunar meteorite was previously classified as an impact melt breccia [1], later it was reclassified as a glassy-matrix regolith breccia [2]. However, according to our observations it appears to be an impact melt breccia with some parts of a regolith breccia. In any case, it is one of the most KREEP-rich lunar meteorites and we searched for zircon grains appropriate for U-Pb dating. In the suite of lunar meteorites rare zircon grains were found and dated in Dho 025 [3], SaU 169 [4] and Dho 458 [5].

Methods: More than 40 zircon grains were identified in two thin sections of Dho 1442. Chemical composition and cathodoluminescence studies of the zircons were carried out using Cameca SX-100 microprobes in Vienna and Moscow. Eight zircon grains (14 analyses) were dated by the U-Th-Pb method using LA-ICPMS (Element 2) at the Vernadsky Institute (Moscow) versus GJ and 91500 zircon standards applying Zr as the inner standard. The diameter of the laser beam was 30 μm. Data reduction was carried out through Glitter and Isoplot softwares.

Results: In Dho 1442 zircon is present as an accessory phase in the lithic clasts and as fragments in the impact melt matrix. In *lithic clasts* zircons are usually <20 μm and mainly present as euhedral crystals. Most of them are anisotropic. Zircons were found in lithic clasts containing a KREEP component. These rocks are norites, gabbro-norites and gabbro having granoblastic to subophitic textures. Granulites are also present. All rocks consist of pyroxene ($En_{51-63}Wo_{3-5}$ and $En_{33-57}Wo_{5-42}$) and plagioclase ($An_{79-95}Or_{0-5}$) with minor ilmenite (2-4 wt.% MgO), apatite, K-and K-Ba-feldspar, silica and zircon. Some of them are characterized by presence of rounded coarse-exsolved pyroxene grains (up to 200 μm).

Another type of zircon-bearing clasts are granophyres which consist of plagioclase ($An_{71-83}Or_{1-2}$), silica with minor K-feldspar ($An_{17}Or_{58}$), pyroxene ($En_{27}Wo_{10}$), ilmenite (1.5 wt.% MgO) and zircon. In some areas silica, K-feldspar and plagioclase micrographically intergrowth each other.

No obvious differences were observed among KREEP rocks with or without zircon. However, no zircons were found in clasts of low-Ti basalts that differs from previous ones by more Fe-rich mafic phases and high variations in composition ($En_{48}Wo_4$, $En_{6-42}Wo_{11-36}$, Fo_{30-42} and $An_{77-94}Or_{0-4}$).

Zircon fragments are rounded, angular or irregular in shape and variable in size (2-135 μm). The grains of >20-30 μm in size are relatively abundant. Occasionally compact aggregates of small (2-5 μm) grains are present. Several large grains are partly rimmed by a late-stage zircon forming a scalloped outline. A lot of large grains are fractured, some of the fractures are healed by a silicate material. Zircon fragments are mostly anisotropic but some of them are isotropic. There are also zircon intergrowths with ilmenite and baddeleyite. Some grains contain small inclusions of Fe-Ni sulfide.

Only 40% of studied zircons show blue cathodoluminescence (CL), others give no CL signal. Two large grains (65-110 μm) are clearly zoned in CL.

In chemical composition zircons of mineral fragments and lithic clasts contain 0.9-1.7 wt.% HfO_2, up to1.3 wt.% Y_2O_3 and up to 0.8 wt.% FeO. Th and U contents (ppm) in dated zircons vary from 22 to 655 and from 49 to 917, respectively. The same ranges were reported for zircons from lunar granophyres and mafic rocks [6].

U-Th-Pb isotopic measurements All dated zircon grains are represented by fragments located in the impact melt matrix. Most data are concordant or nearly concordant (Fig. 1). The ages of zircons from the Dho 1442 breccia vary from 4.31 to 3.91 Ga (Table 1).

There are two zircon groups of different age – old and young. The old group includes 6 fragments of 4309±13 Ma age. This age value was reported for zircons from Apollo 14, 15 and 17 samples [6]. There is a slight reverse discordance (up to 9.1%) in the group. The discordance cannot be explained by admixture of terrestrial or ancient cosmic Pb (Fig. 2) and might be related to some different mobility of Pb and U in the impacted grains. A weak correlation between U content and discordance is observed in zircons.

In a single grain (70-105 μm in size) two parts of different ages were measured. The central part has the age of the old group whereas a small adjacent fragment shows the age of 4130±34 Ma (discordance 2.4%) suggesting two episodes of formation.

The young group comprises only 2 grains with a concordant age varying from 3934±19 to 3.998±32

Table 1. U-Pb results for the zircons of Dho 1442.

	Th, ppm	U, ppm	Pb, ppm	$^{238}U/^{206}Pb\pm1\sigma$	$^{207}Pb/^{206}Pb\pm1\sigma$	$^{207}Pb/^{235}U\pm1\sigma$	$^{206}Pb/^{238}U\pm1\sigma$	Rho	$^{208}Pb/^{232}Th\pm1\sigma$	$^{207}Pb/^{206}Pb$ age, Ma	%disc.
18N-1	21	40	47	1.157±0.013	0.424±0.004	50.6±0.6	0.864±0.001	0.69	0.288±0.005	3998±32	0.4
-2	22	49	54	1.190±0.013	0.404±0.004	46.8±0.5	0.840±0.010	0.69	0.235±0.003	3925±32	0.2
21N	83	167	187	1.199±0.014	0.409±0.004	47.1±0.6	0.834±0.010	0.70	0.235±0.004	3933±32	-0.8
22N-1	255	269	408	1.012±0.012	0.529±0.006	72.1±0.9	0.988±0.011	0.68	0.258±0.005	4324±33	2.5
-2	209	248	379	0.988±0.011	0.527±0.006	73.5±0.9	1.012±0.012	0.68	0.260±0.005	4318±33	4.4
-3	268	393	520	1.08±0.01	0.464±0.005	59.3±0.7	0.927±0.012	0.68	0.257±0.006	4130±34	2.4
24N-1	653	917	1289	1.043±0.013	0.523±0.006	69.2±0.9	0.959±0.012	0.69	0.233±0.005	4308±33	0.6
-2	896	1266	1946	0.954±0.012	0.521±0.007	75.3±1.1	1.048±0.013	0.68	0.259±0.082	4302±39	7.4
-3	327	373	594	0.943±0.012	0.512±0.007	74.7±1.1	1.061±0.0135	0.67	0.271±0.009	4272±40	9.1
18NN	215	258	375	1.034±0.012	0.518±0.006	69.1±0.8	0.968±0.011	0.68	0.251±0.005	4293±32	1.6
19N-1	300	342	490	1.054±0.012	0.524±0.005	68.5±0.8	0.949±0.012	0.69	0.243±0.004	4309±31	-0.2
-2	301	336	501	1.015±0.011	0.524±0.005	71.1±0.8	0.985±0.011	0.69	0.248±0.004	4309±31	2.5
23N	46	87	126	1.00±0.01	0.530±0.007	73.1±1.1	1.001±0.012	0.67	0.286±0.009	4326±39	3.4
25N	110	150	220	1.010±0.013	0.529±0.008	72.3±1.2	0.990±0.013	0.67	0.247±0.009	4325±42	2.6

Ma. Zircons of the same age are present in SaU 169 lunar meteorite [4].

Discussion: Obviously Dho 1442 breccia was formed <3.9 Ga ago and the event did not destroy significantly the age pattern of zircon ages which retained their diversity. The source rocks of the dated zircon fragments in the breccia should be relatively coarse-grained KREEP gabbro-norites and granophyres because zircon is present in lithic clasts of this type and is not seen in basalts. However the zircon fragments with low Th and U contents typical for the mafic rocks [6] are present.

Dho 1442 population of zircon fragments is very similar in U-Th-Pb ages to zircons of Apollo 14 [7]. In contrast, Apollo 17 samples contain only old zircons (4.35-4.20 Ga) [7]. Lunar meteorites contain zircons of ages between 3.43–4.36 Ga [3,4,5]. There are a lot of KREEP rocks in Dho 1442. Such rocks are very abundant in the Apollo 14 landing site located near the Imbrium basin. The impact basin which is the largest on the Moon nearside was formed at 3.91±0.01 Ga [8]. Therefore we can suggest that young zircons of Dho 1442 could be formed or reset their primary age in a huge impact event. The ages of the ancient zircon group should date events of KREEP magmatic activity. The age of the oldest lunar zircon from the 72215 melt breccia is 4.42±0.06 Ga [9]. Thus, the duration of the KREEP magmatism could be about from 4.42 to 4.20 Ga. Noteworthy the old ages of zircon-containing KREEP and granitic rocks coincide with the recently measured age of the 60025 ferroan anorthosite [10].

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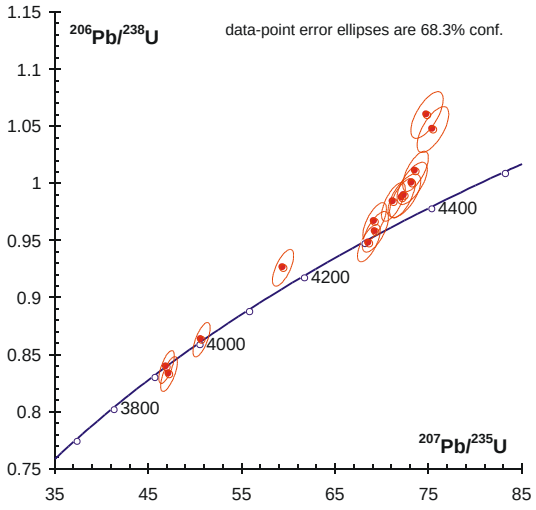

Fig. 1. Wetherill concordia plot with the zircon data of Dho 1442.

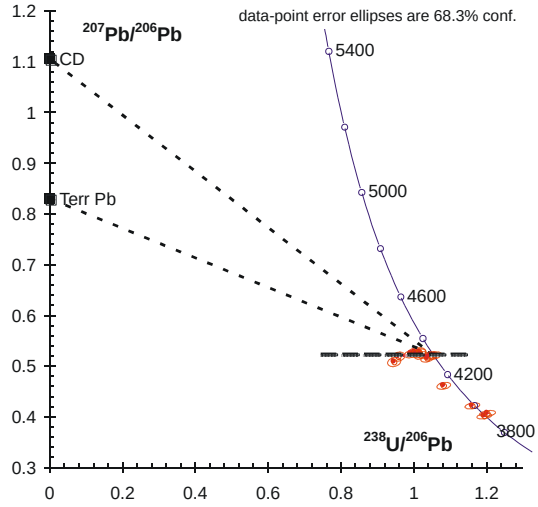

Fig. 2. Tera-Wasserburg concordia plot of the zircon data of Dho 1442.