

THE FIRST ISOTOPIC DATING OF THE DHOFAR 025 LUNAR METEORITE BY U-Pb METHOD USING ACCESSORY ZIRCON. E. M. Leontieva¹, D. I. Matukov², M. A. Nazarov³, S. A. Sergeev² and Yu. A. Shukolyukov^{1,2,4}, ¹Department of Geology, St-Petersburg State University, 199034, Russia; ²Center of Isotopic Research, All-Russian Geological Research Institute (VSEGEI), St-Petersburg, 199106, Russia; ³Vernadsky Institute of Geochemistry and Analytical Chemistry, Moscow, 119991, Russia; ⁴Institute of Geology and Geochronology of Precambrian, St-Petersburg, 199034, Russia (e-mail: xekrarn@js10093.spb.edu).

Introduction: At present there are more than 50 known lunar meteorites found all over the world – in Antarctica, Africa and Australia. Most of them are very well studied with different methods. The isotopic composition of noble gases, oxygen, strontium, lead, and other elements was reported in these meteorites. They were dated by Rb-Sr and common U-Pb and K-Ar methods. However U-Pb zircon ages of lunar meteorites have never been measured. These ages were reported only for some Apollo lunar samples [1].

The goal of the work was to investigate the possibility of isotopic dating of single accessory zircon grains from the Dhofar 025 lunar meteorite using the SHRIMP II ion microprobe.

Samples and methods: Dhofar 025 is an impact melt highland breccia found in the Dhofar district, Oman. Main minerals are plagioclase (An₉₅₋₉₆), olivine (Fo₇₀₋₇₈, Fe/Mn=91-97) and pyroxene (En₇₄₋₈₄, Wo₃₋₆, Fe/Mn=50-70) [2]. Accessories are ilmenite, silica, zircon, chromite, troilite, and FeNi metal.

The correlation of Ne and He isotope ratios [5], as well as very high radiation age of 2000 Ma obtained from cosmogenic isotopes of Ne, Ar, Kr and Xe (we consider the age as a result of long time exposure to cosmic irradiation in a sub-surface layer on the Moon), support the classification of Dhofar 025 as a lunar meteorite [5].

Only one zircon grain large enough (20x30 µm) for isotopic dating with SHRIMP II was found (Fig. 1). Other zircon fragments were much smaller. In the vacuum cathode spraying gun Emitech 450 epoxy disc with a polished section of our sample was covered with a thin gold layer of about 100 Å in thick. Cathodoluminescent study of the zircon grain was carried out using the CamScan MX2500 scanning electron microscope. The study showed internal structural homogeneity of the zircon fragment.

Secondary-electronic multiplier operated in the mass scanning mode was employed for the ion current measurement. Analyzed secondary ions were acquired by irradiation of the zircon grain with a beam of primary O₂⁻ ions [3]. The size of the elliptical analytical point of 10x15 µm was reached by focusing the primary beam with 70 µm Keler's diaphragm. The ion current of the primary beam was equal to 0.9 nA. Secondary ions were accelerated with the voltage of 10

kV. At the width of the ion source outlet slit of 80 µm, the cross-section of the beam was only 30 µm in width. Being combined with a width of outlet slit of the multiplier (100 µm), the width of the ion source outlet slit permitted to reach the mass resolution of more than 5200, thus excluding any possibility of isobaric superposition in the analyzed mass range.

Two-minute sample cleaning procedure with the oscillating primary beam before each analysis allowed to remove any possible surface contamination (Pb etc.) from the analytical spot area. Following ions were measured: ¹⁹⁶(Zr₂O⁺), ²⁰⁴Pb⁺, background (204.2 AMU), ²⁰⁶Pb⁺, ²⁰⁷Pb⁺, ²⁰⁸Pb⁺, ²³⁸U⁺, ²⁴⁸ThO⁺, and ²⁵⁴UO⁺. ¹⁹⁶(Zr₂O⁺) and ²⁵⁴UO⁺ masses were also used for positioning the peak centre of the ion current. The SL13 zircon was used as a concentration standard (the U concentration is 238 ppm). As the standard of U-Pb ratio, the TEMORA zircon from the Middledale fold belt, East Australia [4] was used.

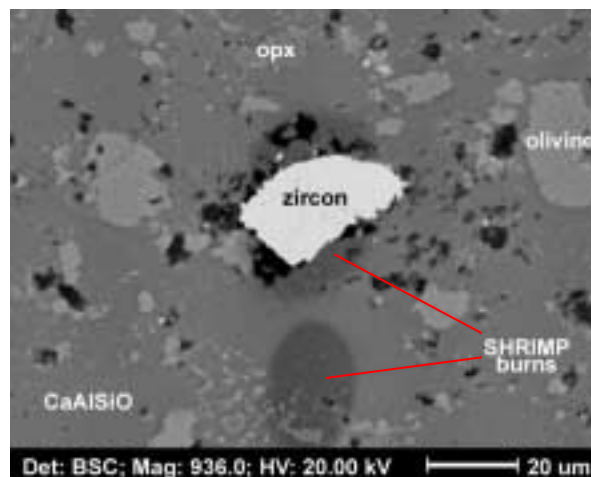


Fig. 1. The studied zircon grain.

Only two shots were carried out because the primary beam crater and the zircon grain are similar in size.

Results and discussion: Acquired data were processed with the SQUID v1.08 and ISOPLOT/Ex 3.0 programs. Final results are plotted on the Ahrens-Wetherill diagram (Fig. 2). Isotopic ages calculated by analytic points are discordant. It suggests that the primary U-Pb isotopic system of the zircon grain was

disturbed by the breccia-forming event. Therefore, a lower estimate of the primary zircon age can be obtained assuming that the breccia-forming event has a zero age. It gives a value of 4.36 Ga, which should correspond to an age of crystallization of a granitic melt because lunar zircons are believed to be related with granitic lunar rocks [e.g., 1].

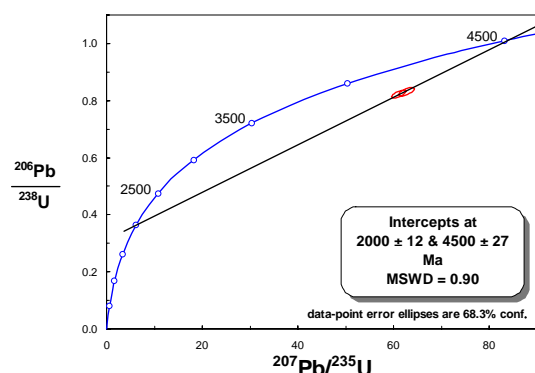


Fig. 2. Ahrense-Wetherill concordia with plotted measurement points.

On the other hand, the upper age estimate of the breccia-forming event can be evaluated suggesting that the primary zircon age is equal to the age of the Moon, i.e., 4.5 Ga. The age value is shown by dating of lunar samples and lunar meteorites using the conventional U-Th-Pb method [7 - 13]. Then, the upper age value of the breccia forming event can be computed using the location of the experimental points on the Ahrense-Wetherill diagram and the lower crossing with the concordia. It leads to a value of about 2 Ga. This age coincides with the radiation age of Dhofar 025 obtained from cosmogenic isotopes of noble gasses. This radiation age is also about 2 Ga [5], while such ages of stone meteorites exceed 50 Ma rarely, except for lunar and SNC meteorites. We consider the high radiation age as a result of long irradiation of Dhofar 025 on the lunar surface, but not as a result of irradiation in the interplanetary space. It assumes that the Dhofar 025 breccia was originated in near surface conditions in which irradiation of its material could be possible.

Conclusions: In summary we conclude:

1. Granitic rocks appeared more than 4.36 Ga in the lunar highland crust. The study supports therefore the results of zircon dating from lunar samples [1].
2. The Dhofar 025 breccia was formed ≤ 2000 Ma. Thus the rock is significantly younger than highland breccias of the lunar nearside, which are believed to be formed by the lunar cataclysm of about 3.9 Ga [6]. It suggests that Dhofar 025 could be ejected from the lunar farside.

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