^{26}Al ISOTOPE IN PULTUSK METEORITE FRAGMENTS

Z. Tymiński[1,2], A.M. Krzesińska[3,4], A. Burakowska[1], M. Stępisiewicz[5], K. Tymińska[1], T. Dziel[1], A. Olech[6] and P. Żołądek[1], [1]National Centre for Nuclear Research RC POLATOM, A. Sołtan 7, 05-400 Otwock, Poland, e-mail: z.tyminski@polatom.pl, [2]Polish Fireball Network, Poland, [3]Dept. Earth Sciences Natural History Museum, London SW7 5BD, UK, [4]ING PAN, Podwale 75, Wrocław, Poland, [5]Muzeum Geologiczne im. Stanisława Józefa Thugutta, Faculty of Geology Uniwersity of Warsaw, Poland, [6]Nicolaus Copernicus Astronomical Center, PAN, Bartycka 18, 00-716 Warsaw, Poland.

Introduction: The Pultusk meteorite is one of the largest witnessed meteorite falls. Pieces of this meteorite fell in 1868 and created the 15 km long strewn field from village Obryte to Św. Rozlia and Rzewnie. 276 kg of material was recovered in the area immediately after the fall and more fragments are now being detected and found with using advanced prospecting methods [1]. Pultusk is a brecciated H4-5 chondrite, regolith breccia [2] enclosing carbonaceous CM xenoliths [3]. Witnesses of the fall reported that actually two large bolides passed through atmosphere sequentially. Such bolides were already registered by Polish Fireball Netwok [4-5]. Both facts altogether, brecciation and sequential passage of two bolides, raise the question whether the meteoroid had been beeing fragmented before it entered the Earth's atmosphere.

Approach: We have examined distribution of ^{26}Al isotope concentration in various fragments of the Pultusk meteorite and combined the results with data from textural analysis. The production of ^{26}Al is induced by nuclear reactions with the galactic cosmic rays and modulated by solar activity. It depends on pre-atmospheric size of meteoroid and the location of a sample inside the meteoroid [6-8]. As such, analysis of ^{26}Al concentrations in meteorite fragments has potential to address the question of pre-atmospheric fragmentation of meteoroid. However, additional anomalies may be caused by textural inhomogeneities of meteorites. Since the Pultusk is a complex breccia, we interpret the results in terms of the texture of the fragments [2-3][9].

Methodology: We studied seven fragments of the Pultusk chondrite. Four of them, with the following assigned numbers: #008810 (weight 253.2 g), #008815 (66.1 g), #008812 (91.6 g) and #008820 (93.4 g), come from the collections of the S.J. Thugutt Geological Museum. Three others: 87 g, 130 g and 600 g are recent finds that have been supllied by polish meteorite hunters from their private collections. The ^{26}Al activity has been measured by gamma-ray spectrometry at the National Center for Nuclear Research in Otwock-Świerk. The study utilizes a non-destructive method of gamma spectrometry using high purity germanium detectors HPGe with good energy resolution and relative efficiency at 1332 keV line of about 45%. The results were analyzed with association to Monte Carlo simulations allowing the correction of measurement geometry and coincidence summing of the gamma lines [10]. Measurements were carried out for 3–5 days by placing the samples at a distance of 2.0 cm above the detector head.Textures of the samples were studied by high-resolution X-ray tomography (μ-CT). Polychromatic X-ray beam with 155 kV accelerating voltage and 135 μA current was applied. X-ray attenuation projections were taken at every 0.15º during 180º rotation of specimens. The effective voxel size is in the range of 15–25 μm.

Results & Discussion: The measurements show that the typical specific activities of ^{26}Al in chondrites are in the range of 45–60 dpm·kg^{-1}. The measured differences of specific activity of the ^{26}Al in investigated samples are in the range of ± 15 % of the mean value. However, the fragment #008815 reveals the deviation from the mean activity of ^{26}Al of about 37%. This is maximum deviation of the mean activity of ^{26}Al calculated for analyzed meteorites in this work. The above mentioned fragment reveals most significant record of brecciation as identified by μ-CT.

Other samples yield values that are in agreement with the measurement uncertainty. They are in the range 14–26 % (expanded uncertainty corresponds to a probability of 95% and $k = 2$) depending on the sample weight. For the sample #008815 which is the smallest one (66.1 g) the uncertainty is highest. It has to be taken into account in the interpretation of the measurement meaning. Relatively low deviations in ^{26}Al distribution between majority of analysed Pultusk meteorite fragments may indicate that fragments have come from the same region of meteoroid. One exception, sample #008815, may record either the pre-atmospheric fragmentation of meteoroid or reflect complex brecciated texture of the fragment. More samples need to be investigated. The results show usefulness of the method in testing the pottential pre-atmospheric fragmentation of meteoroid.

References: [1] Tymiński Z. et al. (2016) *Proceedings of the International Meteor Conference, Egmond, Netherlands,* pp.298-301. [2] Krzesińska A. et al. (2015) *Meteoritics & Planetary Science* 50:401–417. [3] Krzesińska A. et al. (2014) *Meteoritics & Planetary Science* 49: 595–610. [4] Wiśniewski M. et al., 2017., *Planetary and Space Science*, DOI: 10.1016/j.pss.2017.03.013, in Press. [5] Olech A. et al. (2016) *Monthly Notices of the Royal Astronomical Society* 461:674-683. [6] Cameron I.R, Top Z. (1974) *Geochimica et Cosmochimica Acta* 38:899–909. [7] Herzog G.F. (1974) *Geochimica et Cosmochimica Acta* 38:1827-1841. [8] Leya I. and Masarik J. (2009) *Meteoritics & Planetary Science* 44:1061–1086. [9] Krzesińska A.M. (2016) *Geological Quarterly* 60:211–224. [10] Tymiński Z. et al. (2016) *Meteoritics& Planetary Science* 51: A634.