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# What we know about Oslo meteorite from cosmogenic isotope analysis

**Z. Tymiński** (1,2), M. Stolarz (1), T. Kubalczak (1), P. Zaręba (1), M. Burski, E. Miśta (2), K. Tymińska (2), E. Kołakowska (2), A. Burakowska (2), P. Żołądek (1), P. Saganowski (2), A. Listkowska (2), A. Olech (1,3) M. Wiśniewski (1,4)

(1) Polish Fireball Network, Comets and Meteors Workshop, ul. Bartycka 18, 00-716 Warsaw, Poland, (2) National Centre for Nuclear Research, ul. A. Soltana 7, 05-400 Otwock, Poland, (3) Copernicus Astronomical Center, Polish Academy of Sciences, ul. Bartycka 18, 00-716 Warsaw, Poland, (4) Central Office of Measures, ul. Elektoralna 2, 00-139 Warsaw, Poland

(z.tyminski@polatom.pl)

## Abstract

The fragments of an asteroid that had crashed over Norway were found in a few locations in Oslo at the beginning of March 2012. Later on some pieces of meteorite from the most South area were collected by the Meteoritical Section members of Comet and Meteor Workshop (PKiM) with the help of local meteoritical authorities. One meteorite fragment of 32g was used to measure cosmogenic radionuclides using non-destructive high-resolution gamma spectrometry technique. Five radioisotopes such as Al-26, Na-22, Mn-54, Co-57 and Co-60 were detected.

## 1. Introduction

The Oslo meteorite which fall was not observed is still a puzzle. We collected information about the meteorite and analyzed the data to bring us closer to this unknown Norwegian phenomenon.

## 2. Meteorite finds

The first meteorite that had crashed through the roof of a cottage house was found in the central Oslo quarter Rodeløkka. Some days later the second discovery occurred in the melting snow of Ekebergsletta hilltop plateau. Pieces of the third meteorite, broken by cars and spread out by snowplow, were discovered on an asphalt road side by Maciek Burski, the member of Polish Meteoritical Society and by members of Meteoritical Section of PKiM. The last known pieces of the largest broken specimen were found in April 2012 in Grefsen approx. 2.5 km North from the cottage in Rodeløkka [1],[3],[4].

The total known mass of this unobserved fall of the ordinary chondrite (OC) is about 6.22 kg in five known findings spread out in the eight km-long N-S strewnfield with ~4.65kg and ~178g meteorites on the opposite ends. The list of meteorites with the location (listed from N to S) is shown in Table 1.

Table 1: List of known meteorite finds in Oslo

| Location | Mass (g) | Notes |
|---|---|---|
| Grefsen | ~4650 | main mass ~3.5kg |
| Rodeløkka | ~550 | in 2 fit pieces |
| Ekeberg | ~700+26 | in 2 fit pieces |
| Frierveien - - kindergarten | 178 | many fragments |
| “Unknown” | 115 | complete stone |
| TOTAL : | ~6219 g | |

## 3. Measurements and analysis

Measurements and interpretation of gamma spectra were performed in the laboratories of National Centre for Nuclear Research suited in Otwock near Warsaw, in the Laboratory of Radioactivity Standards (RC POLATOM) and in the Laboratory of Environmental Analysis. The activity of samples was measured using a non-destructive method with the high resolution gamma ray spectrometers equipped with semi-conductor high purity germanium crystals cooled with $LN_2$ (-196$^oC$). The detectors with 20% - 45% relative efficiency and typical 2.0 keV energy resolution at 1332.5 keV have been used. To minimalize the background counting rate of measurements the detectors were enclosed in Pb-based shielding chambers. The acquisition system was realized by DSP analyzer connected to PC. The identification of radionuclides was obtained by analysis of spectra with GENIE-2K software. Detector efficiencies were calibrated for 1.0 ml vial by the series of radioactive solutions. To calculate the real efficiencies of the measurement geometries the

Monte Carlo methods were used. The corrections were obtained by PENELOPE and MCNP codes [2],[8]. The measurements of whole meteorite sample weighting 32g were carried out at distance of 1cm from detector top and acquisition time up to 200 hours [2],[8]. The list of isotopes usually detected in the meteorite samples is shown in Table 2. The analysis of the collected spectra does not indicate the presence of short live isotopes. Preliminary results of selected isotopes are presented on Fig.1 (on right).

Table 2: Isotopes expected in 32g Oslo sample

| Isotope | Half-life | Detected |
|---|---|---|
| Cr-51 | 27.2 d | NO |
| Be-7 | 53.2 d | NO |
| Co-56 | 77.3 d | NO |
| Co-57 | 278.1 d | YES |
| Mn-51 | 312.1 d | YES |
| Na-22 | 2.60 y | YES |
| Co-60 | 5.21 y | YES |
| Al-26 | $7.2 \times 10^5$ y | YES |

## 4. Summary and Conclusions

The studies of "fresh fallen" meteorites show that the content of Be-7 always reaches quite high value [2],[5],[6],[7]. Since we could not get the signal from this isotope we can conclude that it had decayed to a level undetectable by the techniques used. Assuming its highest "invisible" final content it can be possible to estimate the approximate minimal terrestrial age of the meteorite. The analysis are presented in Figure 1. where the extrapolation of specific radioactivity level for selected isotopes is shown for two meteorites: Oslo and Ghopij L3-5 breccia. We chose Ghopij breccia chondrite for comparison because Oslo meteorite is very similar to OC type breccia [1]. The comparisons started with the Be-7 MDA (Minimal Detectable Activity) value calculated as ~3 dpm/kg (decays/ minute/ kg) for Oslo. Tracking back in time the activity to the observed minimal value of Be-7 as measured in Ghopij chondrite we obtained the period of 170 days. The estimates calculated with the contents of other isotopes observed in Oslo (Fig.1) confirm the corresponding isotopes concentrations in Ghopij. The content of Mn-54 and within the limits of uncertainty, the level of Co-57, fit to the proposed terrestrial age of about 3 half-lives of Be-7. On the other hand the result of Na-22 calculation shows to low concentration in Oslo comparing to Ghopij. This may indicate the several months stay on Earth or very low initial Na-22 concentrations in Oslo meteorite.

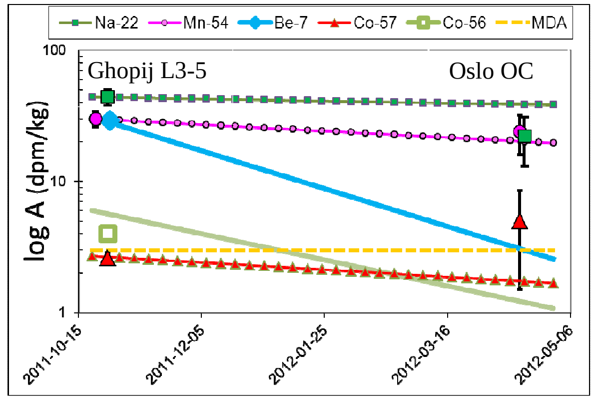


Figure 1: Extrapolation of logarithm radionuclide activity (log A) change in time in Oslo and Ghopij meteorites for selected isotopes based on the decay law. The preliminary results obtained for Oslo are presented on right (ref. date 15.04.2012) and for Ghopij L3-6 on left-side (ref. date = time of fall) [5]. Dashed orange line presents the MDA - Minimal Detectable Activity, the minimum threshold of Be-7 detection in measurement conditions.

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