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Time of fall and some properties of the Morasko meteorite

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The time of fall of a meteorite and the appearance of the impact craters in Morasko have been documented by the thermoluminescenc method, ^{14}C dating, as well as palynological estimation. The extraterrestrial effect on the lithology and morphology of Moraska Góra (Morasko Hill) took place about 5000 years BP. Morasko meteorite is composed in about 98 wt. % of Fe–Ni alloy and in about 2 wt. % of dark FeS nodules, up to 20 mm in diameter. The principal Fe–Ni alloy is kamacite with nearly 6% Ni and taenite with up to 30% of Ni. FeS occurs as troilite, being often wrapped up by rounded flakes of graphite.

Key words: *meteorite; craters; Morasko meteorite*

1. Introduction

In Morasko, located at about 9 km north of Poznań, Poland, a number of various size pieces of rare and intriguing metal have been found. They have been proved to be of extraterrestrial origin. A majority of the pieces are small size (weight in grams) although some are larger and the largest of 164 kg was found in September 2006 (Fig. 1) in the main crater rim. It seems to be the largest iron meteorite in the Central Europe. The meteorite was covered with a sinter-weathering "met-skin" up to 10 cm thick.

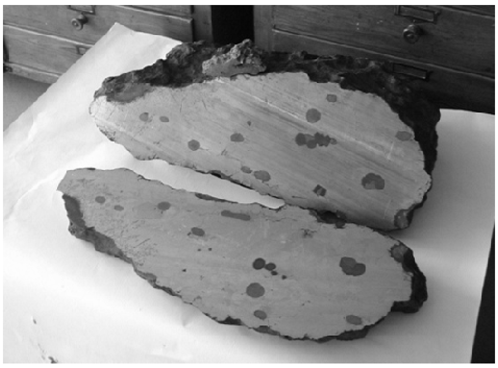

Fig. 1. The meteorite found in the main crater rim. A small fragment of the "met-skin" is placed on the top of the meteorite

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In the period 1914–2006 almost 1000 kg of metallic extraterrestrial matter were recorded to have been found in the Morasko Meteorite Reserve and its surrounding. It is impossible to estimate how many of them were found and illegally introduced on international collector's market. The known meteorite lumps were found directly on the topographic surface as well as below the surface, not deeper than about 20–80 cm. Theoretically, they can be integral components of glacigenic materials, incorporated in the ice cup in Scandinavia. Another possibility is the meteorite shower fall on the inland ice vaulting. After the ice movement and melting, the lumps were deposited in Morasko Quaternary deposits. Nevertheless the results of many years research proved the local fall of meteorites, thousands of years after Moraska Góra glacial morphogenesis and permafrost degradation on this area. These lumps of iron are treated as an evidence of the largest European iron meteorite shower [1].

2. Time of fall and morphogenesis of craters

The Moraska Góra internal structure comprises deformed Neogene (a few million years of age) and Pleistocene deposits (the oldest one is older than 0.5 million years), its palaeomorphological rise is older than the last glaciation [2]. In the last Vistulian glaciation (~20000 BP) the shallow secondary glacitectonic deformations were formed. The degradation of the permafrost in Moraska Góra and around it occurred between 14 000 and 10 000 years BP. The erosive depressions and kettle-holes, predominantly longitudinal and irregular in shape, were filled with organic deposits older than the Holocene one [3]. The age of the deepest organic infilling the thermocarst depressions is documented palynologiclly and by ^{14}C dating.

Over a small area north-east of the Moraska Góra top, there are several very regular oval depressions with circumferential ridges of various shapes. Their organic infilling are much younger than that typical of other, mainly cryogenic ones dated back to pre-Holocene time. According to Tobolski's palynological estimations [5] and ^{14}C data worked out at two laboratories: Gliwice Radioisotopes and Poznań Radiocarbon, organic accumulation in the Morasko Reserve depressions started not earlier than in the middle stage of the Atlantic period (Table 1). It seems to be an important indicator of the extraterrestrial origin of the depressions studied.

The conditions suitable for the development of organic sediments occurred in each depression at a different time. The oldest sediment was found in the deepest part of the crater B. In the shallower fragments of the depressions, sedimentation started much later. Very interesting are the data from crater E, where the organic materials developed in two levels, divided by a gravitational accumulation of a mineral matter. The Morasko Reserve depressions make a conspicuous complex of meteorite craters.

Thousands of years after glacial morphogenesis and permafrost degradation, the meteorite shower fell into loose and loosely coherent materials, producing no impact breccias, high-pressure minerals nor glass. The impact is documented by meteorites, micrometeorites, iron spherules and shock-pressure structures. The date of the fall was proved lately by the thermoluminescence (TL) technique applied to four meteorite "skin covers" – hard meteorite framing, produced as a consequence of fall of a very hot meteorite (zeroing of previous luminescence) and later weathering processes. The results of measurements are: 5.2±09 (UG-5941); 5.0±0.7 (UG-5941); 4.7±0.4 (UG-5943); 6.1± 0.7 (UG-5944). The new luminescence signal (101 OSL measurements resulted in 13% values < 5000 BP, 30% values < 10 000BP – totally 43% values < 10 000 BP) and age of craters organic infilling (radiometric dating [2, 4] and palynological estimation [5, 6]) provide convincing argument for the Morasko extraterrestrial event.

Table 1. Morasko craters. Radiometric data and palynological estimation[a]

Years BP	Beginning of crater organic infilling				
	Palynological estimation [5, 6]	^{14}C datings of craters in Gliwice and Poznań laboratories			
		A	B	C	E
0			260±80 690±95	640±90 690±150 990±160	610±75 650±110
2000	5000–5500		2690±170		
3000					3360±100
4000		4465±35 4495±35	4760±40		
10 000	Permafrost degradation not later than 10000 years BP [3]				

[a] ^{14}C data for mineral/organic boundary of different borings, elaborated by Pazdur (Gliwice) and Goslar (Poznań).

It should be added that below the plausible trajectory of the Morasko meteorite, at a site Szlaban near Oborniki situated ca. ~30 km north of Morasko, in the peat bog layer dated to 4750±40 (Poz-7004) – 5070±40 (Poz-7005) some parts rich in metallic sphereules were found [7]. Analysis of the available data has proved that the local impact of Morasko meteorite shower dates back to about 5000 years BP.

3. Mineralogical properties of meteorites

Morasko meteorite is composed in about 98 wt. % of (Fe–Ni)-alloy and in about 2 wt. % of dark FeS nodules, up to 20 mm in diameter (Figs. 1 and 3). The latter is the host of different trace minerals, which carry many trace elements.

The principal Fe–Ni minerals are kamacite with generally about 6% Ni and taenite with up to 30% Ni. FeS occurs as troilite, being often wrapped by rounded flakes of graphite (Figs. 3 and 4). Troilite is not known from Earth rocks, since pyrite, marcasite and pyrothine are dominant. Trace minerals in the troilite phase include schreibersite, cohenite, sphalerite, and graphite [8]. Additionally, tiny grains of daubreelite, altaite and silicate minerals were found, the latter being identified as the green Na-pyroxene cosmochlor (theoretically, $NaCrSi_2O_6$ [9]) and as feldspar. Most of these trace minerals occur at the margins, but some within the troilite nodules (Fig. 43).

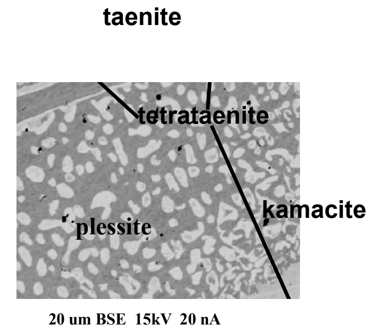

Fig. 2. Back scattered electron (BSE) image of typical relationships between taenite and kamacite. Additional phases tetrataenite and plessite are common at the border of main grains

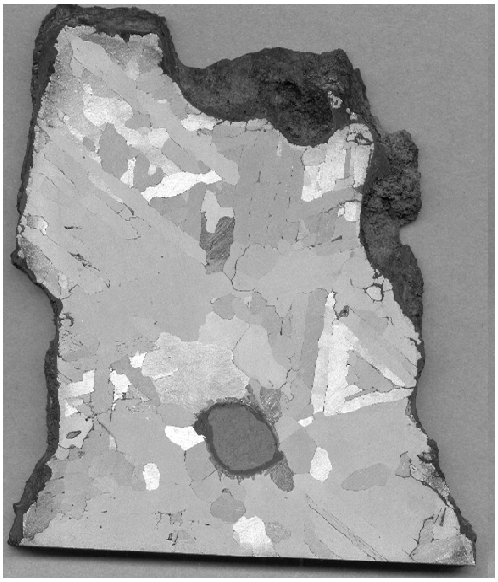

Fig. 3. Cut and etched piece of Morasko meteorite (ca. 8 cm wide). Note typical Widmanstaetten pattern of kamacite and taenite with different crystal orientations. Rounded troilite nodule is rimmed by a thin layer of dark graphite

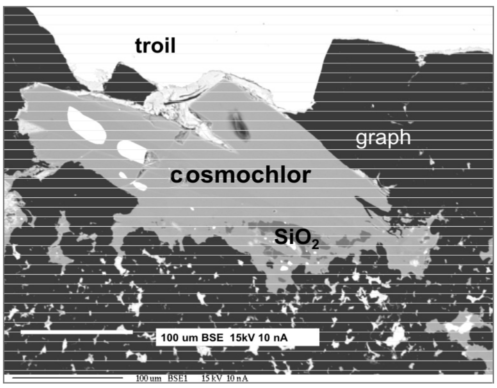

Fig. 4. Back scattered electron (BSE) image of troilite nodule with silicates and graphite. Scale bar is 100 µm (*troil* is trolilite, *graph* is graphite, *cpx* is pyroxene of cosmochlor composition)

Recent study of many Morasko iron pieces [10] has shown the presence of graphite–troilite and troilite nodules with minor silicate and phosphate phases. Silicate phases are represented by pyroxene, olivine, alkali feldspar and silica (Fig. 4). These are accompanied by Na, Ca, Mg and Fe phosphates. Diversity of pyroxenes suggests complex origins of silicates, a conjecture confirmed by the considerable share of cosmochlor and the presence of cosmochlor–augite formed in reaction of residual melt with enstatite and crystallizes within chromite. The genesis of pyroxenes within nodules in Morasko type meteorites seems to be much more complex than is conjectured by Benedix et al. [11].

The origin of this group Fe-meteorites and their genetic conditions is discussed in literature (cf. e.g., Mittlefehldt et al. [12]). The condensation of extraterrestrial matter to solid metallic or silicate phases from nebula is not consistent with the exsolution processes and fractionations of the elements in the meteoric material. Similarly, molten pools generated by impact processes cannot adequately explain the formation of the irons. Because of their reduced dimension such pools must have been quickly quenched and therefore would not allow fractional crystallization and element fractionation, as it is documented by the chemistry of the Morasko meteorite.

4. Conclusions

The meteorites fell in Morasko about 5000 years BP as proved by the radiometric datings and palynological estimations. At the same time impact craters were generated. The Morasko is the specific site, one of ten to twenty on the Earth, where extraterrestrial materials and morphological effects of fall occur. Morasko meteorite is composed in about 98 wt. % of (Fe–Ni) alloy and in about 2 wt. % of dark FeS nodules, up to 20 mm in diameter. The latter is the host of different trace minerals, carrying many trace elements. The principal Fe-Ni minerals are kamacite with generally about 6% Ni and taenite with up to 30% of Ni. FeS occurs as troilite, being often wrapped by rounded flakes of graphite. The trolilte is not known from Earth rocks. A recent study of many Morasko iron pieces has shown the presence of graphite –troilite and troilite nodules with minor silicate and phosphate phases. Silicate phases are represented by pyroxene, olivine, alkali feldspar and silica, accompanied by Na, Ca, Mg and Fe phosphates.

Acknowledgements

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