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THE ACTUAL STATE OF RESEARCH INTO THE MORASKO METEORITE AND THE REGION OF ITS FALL

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Результаты исследований метеорита Мораско и места его падения

В этой статье представлены результаты исследований метеорита Мораско и места его падения. Метеорит принадлежит к грубоструктурным октаэдритам и содержит Fe 92%, Ni 6,7% а также менее 1% Co, P, S, Cu, C. Удельный вес равен 7.07—7.71 г/см^3. Главным минералом является камасит 90%. Сейчас в коллек ции находятся 7 образцов метеорита, которые весят 170 кг. Существуют две гипотезы о происхождении кратеров Мораско, одна метеоритная и вторая ледниковая. Большинство результатов исследований свидетельствует об метеоритном происхождении кратеров. Является однако необходимым провести дальнейшие исследования с целю получения конечного ответа относительно происхождения кратеров Мораско.

The paper contains the basic results of research into the Morasko meteorite and the region of its fall. The meteorite belongs to the coarse octahedrite (Ogg) group and contains 92% Fe, 6·7% Ni as well as less than 1% Co, P, S, Cu and C. The specific weight varies from 7·04 to 7·71 g/cm^3. The main mineral is kamycite, the α-phase of iron-nickel content of about 90%. At present 7 specimens of the meteorite have been collected, weighing a total of about 170 kg. The heaviest of them weighs 78 kg. There are two hypotheses concerning the origin of the Morasko craters: meteoritic and glacial. The majority of results indicate meteoritic origin, but it is necessary to carry out more detailed investigations in order to solve this problem definitely.

1. Introduction

On October 12th, 1914 the first specimen (I) of the Morasko meteorite was dug out during the construction of military fortifications in the vicinity of Morasko situated 9 km north of Poznań. It was found at a depth of about 0·5 m and weighed 77·5 kg. The specimen was transported to a museum in Poznań (J. W. Szulczewski, 1923).

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Preliminary chemical investigations were carried out in the Geologische Landesanstalt in Berlin in 1915 giving a content of 6·65% Ni and Neumann lines (J. Pokrzywnicki, 1964). For a long time neither detailed chemical nor mineralogical investigations of the meteorite were carried out, and, therefore, it was omitted from meteorite catalogues, or at most was mentioned as a doubtful case. We have no evidence about the time of fall of the Morasko meteorite, hence it probably happened in the pre-historic period.

2. Chemical and Mineralogical Investigations of the Morasko Meteorite

The first chemical investigations of a sample from specimen I were carried out by Stanisław Rossoł in 1957 (J. Pokrzywnicki, 1964). Table 1 presents the results.

Table 1

Chemical composition of the Morasko meteorite (in wt. %)

Fe	Ni	Co	P	S	Cu	C	Total
92·20	6·75	0·53	0·18	0·008	0·15	0·02	99·838

At the beginning of the seventies chemical and mineralogical investigations were carried out in several institutes.

Chemical and crystallographical investigations of a sample from specimen VII were carried out in the Chemical Institute of the A. Mickiewicz University in Poznań (T. Borowiak and B. Hurnik, 1976). Tables 2 and 3 present some results.

Table 2

Chemical composition of specimen VII (in wt. %)

Fe	Ni	Co	Cu	P	S, C and other el.	Total
92·00	7·15	0·52	0·02	0·21	0·10	100·00

Table 3

Chemical coomposition of troilite (in wt. %)

Fe	S	Total
63·9	35·5	99·4

Detailed chemical and mineralogical investigations were carried out in France (B. Cervelle et al., 1974). Some results are presented in Tabs 4–7.

Table 4

Chemical composition of kamacite (in wt. %)

Fe	Ni	Co	Total
92—93·3	7·3—6·8	0·5	99·8—100·6

Table 5

Chemical composition of tenite (in wt. %)

Fe	Ni	Co	Total
58·5—60	41—40·5	0·1	99·6—100·6

Table 6

Chemical composition of cohenite (in wt. %)

Fe	Ni	Co	C	Total
91	1·8	0·2	6·0—6·5	99·0—99·5

Table 7

Chemical composition of schreibersite (in wt. %)

Fe	Ni	Co	P	Total
45·7—45·9	40·3—40·0	0·1	14·5—14·8	100·6—100·8

Table 8

Contents of Ni (in wt. %)

Specimen No.	Ni % ±0·5
I	6·8
II	6·7
III	6·7
IV	6·8
V	6·9
VI	6·6

Table 9

Chemical composition of kamacite (in wt. %)

Fe	Ni	Co	Total
92—95	7—4·9	0·2—0·8	99·2—100·7

Table 10

Chemical composition of troilite (in wt. %)

Fe	S	Cr	Ti	Total
63·0	35·0	0·8	0·05	99·3

Table 11

Chemical composition of schreibersite (in wt. %)

Fe	Ni	P	Co	Total
50—61	32—22	14	1—0·3	97—97·3

Table 12

Chemical composition of rhabdite (in wt. %)

Fe	Ni	P	Co	Total
45·8—46·0	42·6—43·6	9·6—10·4	0·1	98·1—99·1

Table 13

Chemical composition of cohenite (in wt. %)

Fe	Ni	C	Total
92·0	2·9	4·9	99·8

Most detailed chemical and mineralogical investigations were carried out in the Mineralogical Institute of the Academy of Mining in Cracov by Bogna Dominik (B. Dominik, 1976). Some results are presented in Tabs 8–13.

The specific weight of the Morasko meteorite varies, ranging in the individual specimens from 7·04 to 7·71 g/cm^3 (J. Pokrzywnicki, 1964).

Widmandstätten structure and Neumann lines are observed in all the samples examined. The Morasko meteorite contains the following minerals: kamacite, the α-phase of iron-nickel about 90%, tenite, the γ-phase of iron-nickel 0·5%, troilite several per cent, graphite about 1%, cloftonite, schreibersite about 1·5%, rhabdite about 1%, cohenite, sphalerite about 0·2%, whitlockite, as well as secondary minerals magnetite and geothite (B. Dominik, 1976).

The Morasko meteorite belongs to the coarse octahedrite (Ogg) group (J. Pokrzywnicki, 1964; B. Dominik, 1976).

3. A Research into the Region of Fall of the Morasko Meteorite

3.1. *Search for the Meteorites*

In the twenties new specimens of the meteorite were found by the inhabitants of the village of Morasko. One of the specimens weighed 4·2 kg and two others 3·5 kg (J. Pokrzywnicki, 1964). In 1956 three specimens joined the meteorite collection. The first one weighed 4·17 kg, the second (from the Suchy Las village school) – 6·38 kg and the third (from the museum in Gorzów) – 3 kg. All meteorites were found in the same area as specimen I. The specimen weighing 78 kg (VII) was found in the courtyard of Józef Oleksy, an inhabitant of the village of Morasko. This meteorite was ploughed up by him in 1947. The top part of the meteorite was at a depth of about 15 cm and the bottom part at a depth of about 50 cm (J. Pokrzywnicki, 1957; Z. Pniewski, 1979). The distribution of the meteorites is presented in Fig. 1.

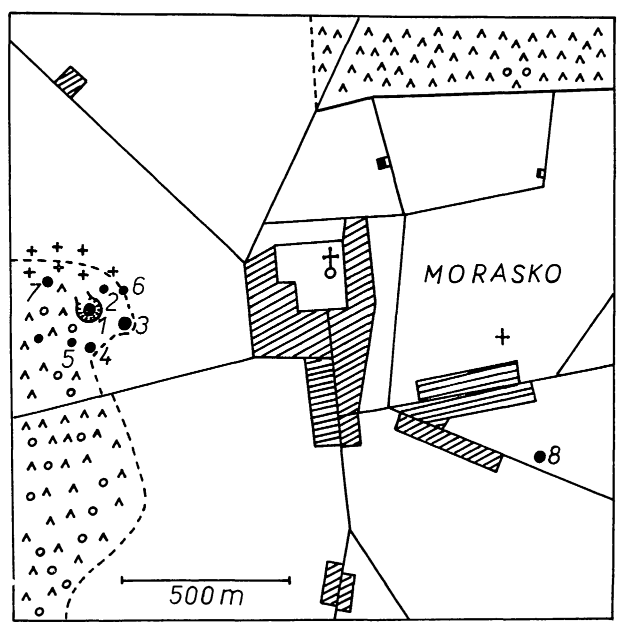

Fig. 1. Distribution of the meteorites after J. Pokrzywnicki (1964) with corrections made by the author (two meteorites were omitted as they were identified as pieces of slag). Black points with numbers — Morasko craters. Crosses — the places where meteorites have been found.

The specimens mentioned above were found accidentally by the inhabitants of Morasko. In September 1956 J. Pokrzywnicki organized a search for the meteorites by means of mine detectors. The search was carried out the forests and fields nearby Morasko. Unfortunately no specimen was found (J. Pokrzywnicki, 1957; Z. Pniewski, 1979). J. Pokrzywnicki has established, by interviewing the inhabitants of Morasko, that the following specimens weighing 75 kg, 4 kg and 8 others weighing from 1·5 to 8 kg had been ploughed up. Many of them were probably lost during World War II. All of these meteorites were found in the vicinity of Morasko (J. Pokrzywnicki, 1957 and 1964). Five specimens of a total weight of 8 kg, mentioned by J. Pokrzywnicki (1964), were later identified as pieces of slag (Z. Pniewski, 1979).

Before World War II two pieces of iron were found in a forest near Oborniki, a town situated about 22 km north of Morasko. These specimens were lost during the war. Pokrzywnicki suggested they belonged to the Morasko meteorite (J. Pokrzywnicki, 1955 and 1964). On the basis of this hypothesis and the shape of the craters Pokrzywnicki has determined approximately that the meteorite came from the north. In 1958 and 1959 magnetic investigations of an area near Morasko were carried out by A. Dąbrowski and K. Karaczun from the Institute of Geology in Warsaw. No new specimen was found but several magnetic anomalies were localized, among others in crater 2 (J. Pokrzywnicki, 1964).

3.2. *Morasko Craters*

In the region where meteorites have been found there are 8 depressions with diameters from 15 m to 100 m and depths from 1 m to 12 m. All depressions are located on the north slope of the Morasko Hill in the area of Baltic glaciation (10 000 to 12 000 years ago). In this region the bed rocks are at a depth of about 150 to 200 m (B. Krygowski, 1958), so that it is impossible to find rock flour or other evidence of rock destruction. The moraine belts are mainly built of Pliocene clay and moraine clay.

In 1957 J. Pokrzywnicki presented the hypothesis of explosive or impact origin of the depressions, but in 1961 A. Karczewski presented the hypothesis of glacial origin. In order to explain the origin of the depressions the first investigations were organized by the Institute of Geography of the A. Mickiewicz University in Poznań. On the basis of the data he collected, K. Warchoł suggested that the depressions could have been formed by melting or as a result of erosion caused by water from a melting glacier (K. Warchoł, 1965). At a depth of 90 cm, while excavating the wall of crater 1, A. Dzięczkowski and Z. Pniewski found a thin layer of brown-black soil. Investigation of the soil indicated the presence of charcoal (A. Dzięczkowski and Z. Pniewski, 1971). In the author's opinion the charcoal could have been formed by human activity, lightning or the fall of a meteorite.

At the beginning of the seventies new investigatins were conducted. On the basis of morphological and lithological investigations, A. Karczewski disproved the conclusion that the results do not indicate a violent dislocation of ground. He suggested, however, the necessity of carrying out investigations of a deeper layer of bed sediments in crater 1 and in the other craters (Karczewski, 1976).

Paleontological investigations, carried out by T. Tobolski (1972), indicated that the bed sediments in crater 4 began to accumulate 5500–5000 years ago (K. Tobolski, 1976). The bed sediments in the other depressions near Morasko began to accumulate at the end of the Pleistocene, about 10 000 years ago (A. Karczewski and K. Tobolski, 1978; K. Tobolski, 1976).

The dispersion of magnetic spherules indicate a concentration along the azimuth about N 15 °E and a connection with crater 1 (H. Hurnik et al., 1976). On the basis of the heights of the rims, as well as the inclinations of the walls inside the craters the azimuth of the meteorite flight path through the atmosphere was estimated. It was about N 30° E (H. Kuźmiński, 1976). Some dynamic parameters of the Morasko meteoritic shower were estimated as follows: fall energy -10^{12} J (10^{19} ergs), assuming a final velocity of 5 km/s – final mass 80×10^3 kg (80 metric tons), assuming an initial velocity (no-atmosphere velocity) of 20 km/s – initial mass 14×10^5 kg (1400 metric tons) and geocentric velocity – 16·5 km/s (H. Kuźmiński, 1976).

Craters Nos 1, 3, 4 and 7 are presented on the photographs 1 to 7 (see Plates 3–4).

4. Conclusions

The majority of the results indicate the meteoritic origin of the Morasko craters, but the problem has not been solved conclusively. It is necessary to carry out the following investigations:

1. Determine the cosmic and terrestrial age of the meteorite in order to compare it with the age of the craters.
2. Detailed magnetometric measurements in order to find new specimens of the meteorite. This should enable the scattering ellipse of the Morasko meteorite shower to be determined.
3. Further geomorphological and paleontological investigations.

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PAPERS FROM OTHER JOURNALS

THE REDUCED INTENSITIES OF THE CORONAL LINE 530·3 nm OBSERVED AT MT. LOMNICKÝ ŠTÍT, 1965—1970

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1979, Contr. Astron. Obs. Skalnaté Pleso **8**, 7.

The reduced intensities of the coronal line 530·3 nm, observed at Lomnický štít in the years 1965—1970, are presented.

CORONAL INDEX OF THE SOLAR ACTIVITY Ia, 1971

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1979, Contr. Astron. Obs. Skalnaté Pleso **8**, 41.

The values of the coronal index are the supplement to an earlier paper of Rybanský (*Rybanský, M.*: 1975, Bull. Astron. Inst. Czechosl. **26**, 367).

OBSERVATIONS OF THE GEMINIDS 1974 AT THE SKALNATÉ PLESO OBSERVATORY. INTERCOSMOS PROGRAM

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1979, Contr. Astron. Obs. Skalnaté Pleso **8**, 71.

The visual observations of the Geminid shower, carried out at the Skalnaté Pleso Observatory in 1974 according to a special Intercosmos program, have been analysed to determine the activity and the magnitude distribution of the shower. Total of the data amounts to 1006 individual records of 734 meteors, including 868 records of 634 Geminid meteors. Corrected hourly rates show a maximum at the solar longitude $\odot_{1950.0} = 261{\cdot}32$. The activity of the bright meteors ($m \leqq 2$) is, however, more complex and shows two maxima occurring around the main maximum of the Geminids. The first maximum is also confirmed by the course of the mean magnitudes of the Geminid meteors, corresponding to lower values of their population index. The magnitude distribution of the Geminids is otherwise not showing any significant variation. The probable error of the magnitude estimation was $e = \pm 0{\cdot}37$.

OBSERVATIONS OF THE ORIONIDS 1974

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M. Šimek, Astronomical Institute of the Czechoslovak Academy of Sciences, Ondřejov, Czechoslovakia
1979, Contr. Astron. Obs. Skalnaté Pleso **8**, 81.

Radar meteor echo data from the period of Oct. 14—30, 1964, as observed at the Ondřejov Observatory are given. Hourly rates of different categories of echo duration and other data are tabulated. The mass distribution factor is determined.

CLUSTERING OF PARTICLES WITHIN METEOR STREAMS

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1979, Contr. Astron. Obs. Skalnaté Pleso **8**, 89.

A number of visual and radar data analyses dealing with the time distribution of meteor particles within the meteor population is presented and checked. A verification of those