THE METEORITE CRATERS OF MORASKO IN POLAND

J. Classen

Sternwarte Pulsnitz
8514 Pulsnitz, East Germany, DDR

In 1914, in Morasko near Poznań, a 77.5 kg iron meteorite was found. Later there were additional findings. In 1955 seven crater-like structures, situated in the neighborhood of the meteorite finds, were identified. Until now it has been doubtful whether the iron meteorites and the craters belong together. New examinations by the author confirm beyond any doubt that the meteorites and the craters were caused by the same event.

The history of the discovery of the Morasko craters in Poland is involved. In 1914, a 77.5 kg iron meteorite (Fig. 1) was found at a depth of 5 m during the digging of rifle pits in World War I. This find was made in the southwest of the village of Morasko, 9 km north of Poznań in the valley of Warta (Fig. 2). In the following years, until 1920, a number of smaller pieces were found. Although these iron meteorites were already recognized – probably by Löbe in Berlin – as coarse octahedrites (Fig. 3), their first mention in the literature was not until 1928 (Slavik *et al.*, 1928). Farmers working their fields later found additional meteorites, among them one of about 80 kg. By 1966, 16 pieces with a weight of 211 kg were known according to Hey (1966). Most of the finds are now in the Institute for Geology in Warszawa (88 kg) and the Museum of Natural Science in Poznań (77.5 kg). Smaller samples are kept in Suchylas near Morasko (School; 6.4 kg), Pulsnitz (Observatory; nearly 1 kg), Moscow (Meteorite Committee; 0.667 kg), Dresden (Museum for Mineralogy; 0.170 kg) and Greifswald (University; 0.058 kg).

From 1950 through 1957, Pokrzywnicki (1955, 1956) investigated the Morasko meteorite find in more detail. This author reported for the first time that there were crater-like structures near the location of the finds. Previously, these holds had been completely overlooked. The biggest of these craters is situated about 100 m southwest of the place where the first meteorite was discovered in 1914.

These Morasko craters were first referred to in a publication outside of Poland in 1966, in the meteorite crater catalogue of Freeberg (1966). However, they were not labeled as "craters with associated meteorites," but as "structures for which more data are required for classification." Probably because of this conservative description, the later-appearing meteorite crater catalogues no longer list the Morasko craters, although the meteorite finds

and the craters themselves were generally known through the publications of Hey (1966) and Freeberg (1966). By this time there was little doubt about the meteoritic character of the craters.

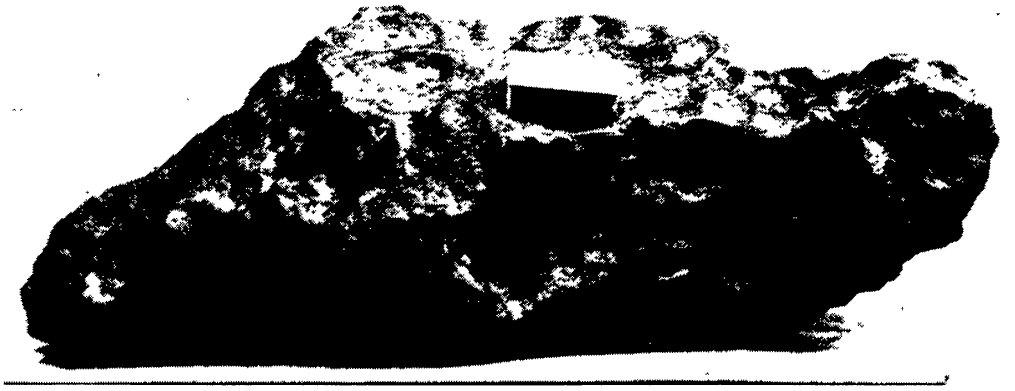

Fig. 1 Iron meteorite of Morasko weighing 77.5 kg (H. Korpikiewicz).

Fig. 2 Morasko and environs.

Fig. 3 **Slab of the Morasko meteorites.**

The long and complicated discovery history of the Morasko craters is only now nearing its completion. Hurnik *et al.* (1976), editor, published in Poznań a collection of separate reports with numerous figures on different aspects of the most recent investigations. Figure 7 in this article is from that paper. Additional summarizing publications, also with figures, are by Korpikiewicz (1976, 1977) at the University Observatory in Poznań. This writer is grateful to Korpikiewicz for her valuable scientific discussions about the Morasko meteorite case in addition to providing the Polish literature on this subject.

From the above-mentioned sources and the new investigations made by this author in 1976, the following situation prevails at Morasko: The crater field (Fig. 4) is located southwest of Morasko at the northern slope of the Morasko mountain, 153.9 m high, at 52°29′ N and 16°54′ E. The major group of craters, about 120 m high, is situated in a picturesque beech forest and consist of seven separate craters. Three of these craters are permanently, and three intermittently, filled with water. One crater is always dry.

The biggest of these seven craters (Figs. 5 and 6, also Fig. 9) has a diameter of about 100 m and a depth of about 13 m. The water depth varies

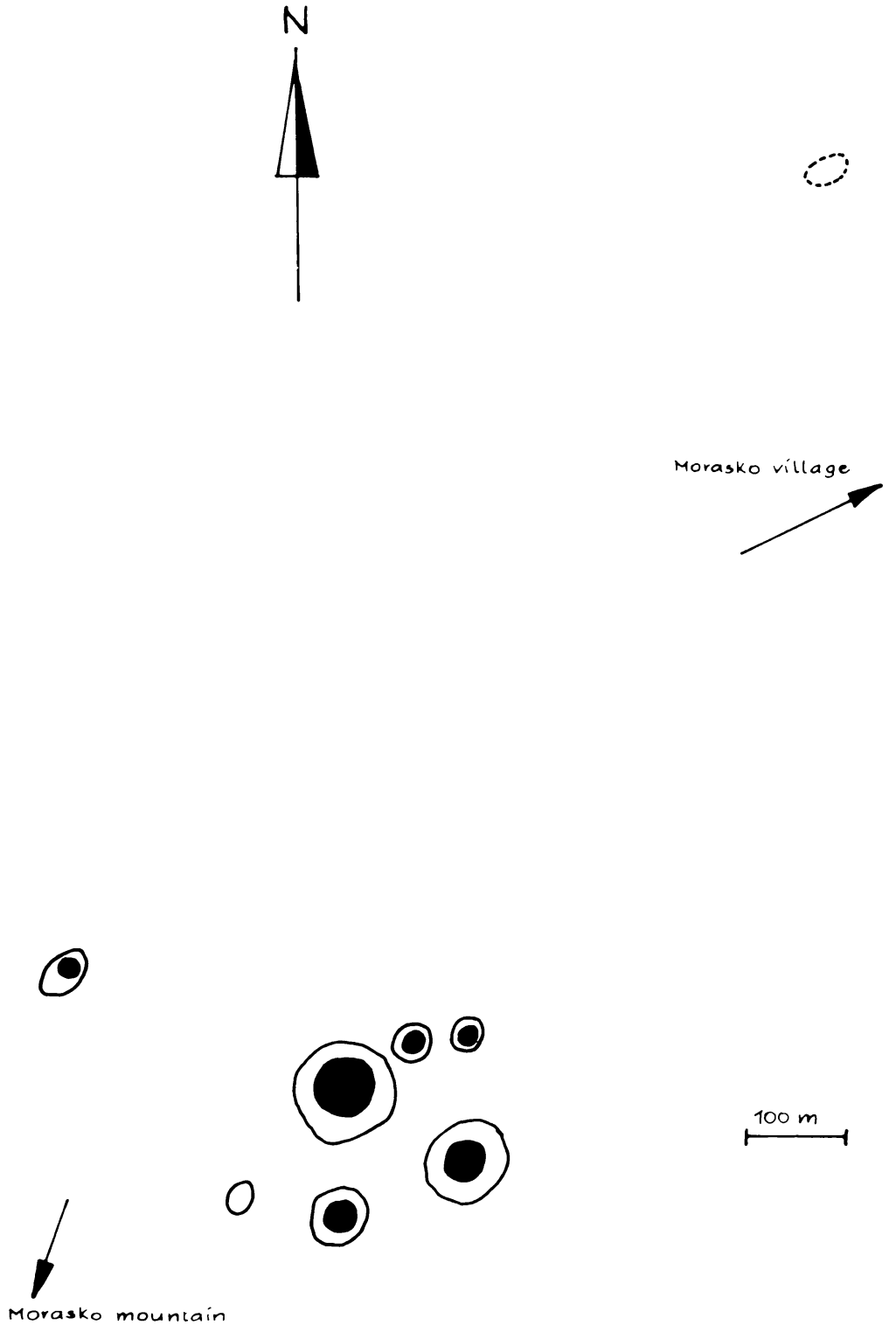

Fig. 4 The eight craters of Morasko.

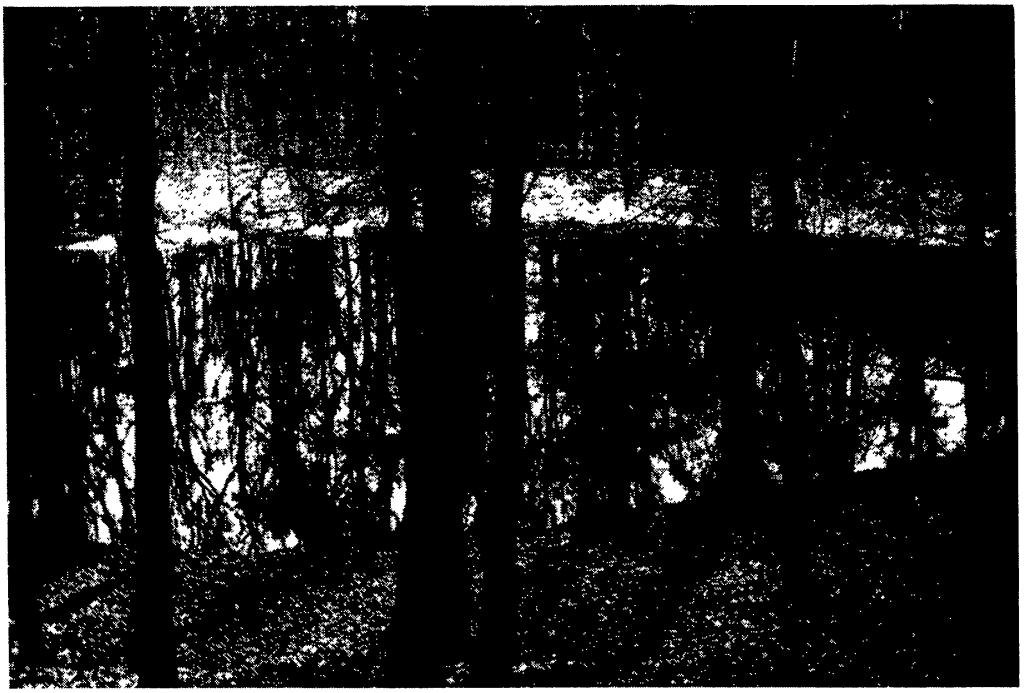

Fig. 5 The biggest crater of Morasko from south to north in spring 1977 (H. Korpikiewicz).

Fig. 6 The biggest crater of Morasko from east to west in spring 1977 (H. Korpikiewicz).

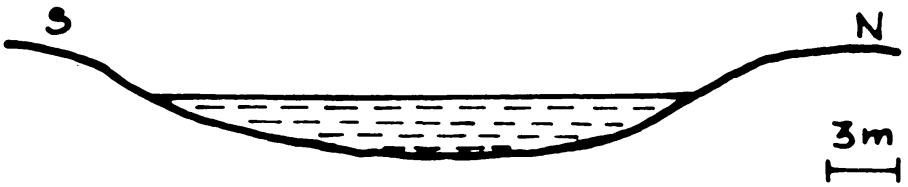

Fig. 7 **Profile of the third largest crater from south to north (H. Kuźmiński).**

between 1.8 m and 2.5 m and the angle of the crater wall is 16° to 20°. The other six craters have a diameter between 15 m and 63 m and depths between 1.5 m and 10 m. The angle of the crater wall varies between 3° and 30° within these craters. The profile of the third largest crater is shown in Figure 7 (Hurnik *et al.*, 1976, page 53). At first glance, the profile resembles the profiles of other recent meteorite craters. The other Morasko craters have similar profiles. The smaller craters are possibly only impact pits where no significant explosions occurred. The main crater, with a diameter of 100 m, may be a regular explosion crater. At some distance from the main group of craters described above, a crater may be found that probably also belongs to this crater field. It has a diameter of about 35 m and a depth of 4.5 m. The following table lists the dimensions of the Morasko craters (Korpikiewicz, 1976).

	1	2	3	4	5	6	7	8
Diameter (in meters)	100	63	50	35	45	25	24	15
Depth (in meters)	13	5	10	4.5	4.5	4	2.5	1.5

The crater field of Morasko resembles the crater field of Kaalijarv (Saaremaa, Ösel) discovered in 1927 in the Estonian Republic of the USSR at 58°24′ N and 22°40′ E (Classen, 1977). This field is 750 km away from Morasko and consists of seven meteorite craters. The largest of these craters has a diameter of 110 m and a depth of 16 m. The smallest crater at Kaalijarv has a diameter of 15 m and a depth of 4 m. Several iron meteorites, total weight 100 g, have been discovered at Kaalijarv.

As already reported, the iron meteorite of Morasko belongs to the group of coarse octahedrites (Dominik, 1976). Lamellae widths are up to 2.45 mm. Figure 3 shows a 50 mm × 83 mm, 127 g plate of the Morasko meteorites from the meteorite collection of the Pulsnitz Observatory. According to Pokrzywnicki (1955, 1956) the iron contains 6.65% Ni and according to Kuźmiński (Hurnik *et al.*, 1976, page 57) about 10% Ni. Precise chemical analyses have been carried out by Borowiak and Hurnik (Hurnik *et al.*, 1976, page 40). They determined the composition of the Morasko meteorites to be:

Element	%
Fe	92.00
Ni	7.15
Co	0.52
Cu	0.02
P	0.21
S, C and other elements	0.10

Kuźmiński (Hurnik *et al.*, 1976, page 57) reports the density of the nickel iron as 8 g/cm^3 on the basis of a Ni content of about 10%. The entire find amounts to 300 kg. It should also be mentioned that from 1933 to 1945 the term "Nordheim" or "Posen-Nordheim" was in use in the German-speaking areas for the Morasko meteorite find.

A few additional words about the origin of the Morasko craters are warranted. The most important feature of the craters is the meteoritic nickel-iron that can be found in the immediate vicinity of the craters. The existence of nickel-iron prompts the immediate conclusion that the Morasko craters were formed through the impact of meteorites. Any other theory has little initial credibility. One might question what sort of coincidence it would have been that a find of meteoritic nickel-iron – a phenomenon of extreme rarity on earth – would have exactly collided with a non-meteoritically-formed crater field. Such crater fields are known on earth in only very small numbers; at least if one considers crater fields of a comparable size to that of Morasko, with eight craters with diameters ranging from 15 m to 100 m.

The Morasko craters could also be viewed at a first glance as postglacial lakes. The uniformly round or relatively slight elliptic form of the craters, which may be seen in Figure 4, makes this supposition improbable. Furthermore, the Morasko craters cannot be sink holes because only clay has been found during geological examinations of the soil at depth in this morainal area. There have been no suggestions that the Morasko craters were built by man. On the contrary, man-made features such as craters produced by bomb explosions from the world wars, ditches constructed to catch wolves, the remains of mining operations, artificial fish lakes, pits mined for clay, or similar depressions, definitely do not qualify.

Such ideas may be further refuted by considering additional factors in support of the meteoritic formation of the craters. First, the diameter-to-depth ratio is on the average 8.2 : 1. This is a value that may be considered normal for meteorite craters. Furthermore, the rims of all craters without exception are elevated to the same side, *viz* to the south and southwest

(Hurnik *et al.*, 1976, page 53). From this observation one may determine the flight direction of the meteorites. The meteorites are believed to have originated from a point located 30° east of north. This observation may also be derived from the elliptical form of the craters, since the longitudinal axes of the ellipses run predominantly from northeast to southwest (Fig. 4).

The best proof that the Morasko craters are impact craters is the presence of meteoritic and meteor dust (Fig. 8). This may be found at the widely dispersed locations of the meteoritic finds, as well as in and around the craters. Predominantly, this dust is found in the center of the craters. A circumstance that may also be related to the subsequent in-filling of the craters. Precise maps of the density and the quality of the dust sediment have been prepared by Korpikiewicz (Hurnik *et al.*, 1976, page 27).

Based on these investigations of the dust, Polish researchers have attempted to draw conclusions about the flight path of the meteorites (from north to south with 10% eastward deviation from north) as well as about the height of the first and second explosions of the main meteorite body (220 m and 120 m). However, the results are not yet final. The angle of the meteorite's trajectory was 20° according to Kuźmiński (Hurnik *et al.*, 1976, page 58). The mass of the original meteorite is estimated to be 10^5 t (metric tons).

In order to get new data about the origin of the Morasko craters this author re-examined the territory around Morasko in June, 1977. At present six craters in the main group are filled with water (Fig. 4). Only the small crater southwest of the largest crater is dry. Formerly the water depth of the craters was greater but excavations, probably in 1914, removed some of the water.

Voytek Lewinski, University of Warszawa, Soil Science Department, believes that the largest crater was rather elongated on German maps produced in 1890 and that the configuration had changed to become more irregular on recent aerial photographs (letter from Prof. Dr. David Krinsley, May 4, 1977, Arizona State University, Department of Geology). It is true that today this crater is somewhat elliptical, but it is not irregular. The part of the crater which is filled with water is perfectly circular (Fig. 4). It is possible that recent aerial photographs are affected by the dense vegetation surrounding the crater today.

The largest crater has a typical rim, particularly in the south (Fig. 9). This rim suggests that this crater is a regular explosion crater. An elliptical form running from northeast to southwest is also well preserved at this crater. All other craters have only fragments of a rim, again particularly in the south. These craters are probably impact pits, formed without the explosion of meteoritic material. Therefore the meteorites which produced these structures are possibly still buried underground. It would be difficult to recover these meteorites because the craters are filled with water. Negative results of

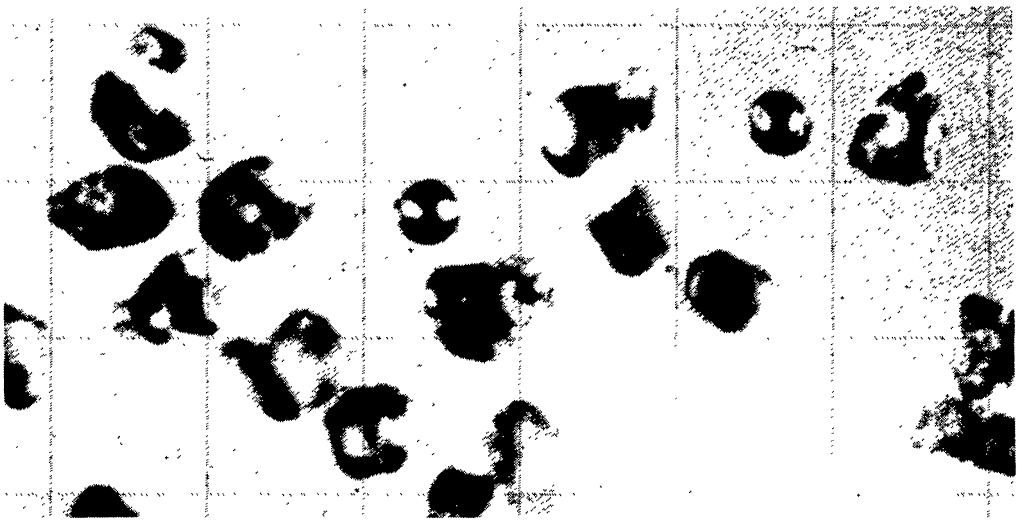

Fig. 8 Meteorite dust and meteor dust of Morasko. Exaggeration 50 × (B. Kielczewski).

Fig. 9 Profile of the biggest crater from south to north (J. Classen).

magnetometric measurements made in 1960 (Hurnik *et al.*, 1976, page 4) have shown that probably no very large specimens are lying in the soil.

The exact position of the eighth crater, which lies apart from the main group, was previously unknown. It is now known to be located about 1 km, 30° east of north from the main group (Fig. 4). This is also in the probable flight direction of the meteorites. The eighth crater, when connected with the others, forms a splendid scatter ellipse from northeast to southwest. Unfortunately the eighth crater is located in a large field that was destroyed by ploughing; in spite of the fact that the area of the Morasko craters is to be declared a national park (Dzieczkowski *et al.*, 1971).

Earlier it was stated that the main group of craters is situated in a forest. North of the main group, at a distance of about 200 m, the forest ends and a large field extending many kilometers begins. It is possible that many other craters have been destroyed by farmers ploughing in this field.

Much effort has been made to define the locations of the finds of the iron meteorites. The only find that is exactly known is the 77.5 kg Poznań meteorite of 1914. It is situated 100 m to the northeast of the largest crater,

just inside the forest (Fig. 4). All other meteorites were found northward, in the large field between the forest and the eighth crater, which no longer exists. Thus the exact locations of the other finds have been destroyed. It is very unfortunate that the locations of all these meteorites cannot be ascertained.

In reference to the nickel-iron and the meteoritic and meteor dust the following information has been determined: (1) shock and thermal transformations were recently discovered in the nickel-iron (Dominik, 1977); (2) meteoritic and meteor dust particles in the soil may now be obtained by a strong electromagnet (Hurnik *et al.*, 1976, page 28). The recovered magnetic material includes both irregular and perfectly rounded fragments (Fig. 8). The irregular material is meteoritic dust (oxidized fragments of meteorites) deposited in the soil during impact of the meteorites with the earth. The perfectly round material (spherules) is meteor dust formed in the air during evaporation of meteoritical material. Samples of this magnetic material are preserved in a great quantity at the Obserwatorium Astronomiczne, 60-286 Poznań, Poland (Dr. Honorata Korpikiewicz). A small quantity is preserved at the Pulsnitz Observatory, 8514 Pulsnitz, DDR.

Meteoritic dust and meteor dust occurs everywhere between the main group and the eighth crater. This observation again confirms the thesis of a scatter ellipse at least one kilometer long from northeast to southwest. Therefore, it is suggested that a large meteorite fall occurred at Morasko in the Pleistocene-Recent which was perhaps equivalent to the meteorite fall of Sikhote Alin, USSR, 46°10′ N, 134°39′ E, of February 12, 1947 (Classen, 1977). At Sikhote Alin 122 small craters were discovered, the largest having a diameter of 27 m. At Morasko most of these craters are not explosion craters. Twenty-seven metric tons of iron meteorites were collected at Sikhote Alin. The locations of the finds indicate a scatter ellipse 1 × 2 km. The craters themselves are ordered in two scatter ellipses, which taken together are about 1 km long (Krinov, 1974).

Unlike Sikhote Alin, most of the craters at Morasko probably have been destroyed by agriculture, and the meteorites buried. It has become impossible to recognize the ploughed craters at Morasko. Therefore, it is impossible to collect the meteorites in a systematic manner such as at Sikhote Alin.

REFERENCES

Classen, J., 1977. Catalogue of 230 meteorite craters. Veröff. Sternwarte Pulsnitz Nr. 12. *Meteoritics* **12**, 61-78.

Dominik, B., 1976. Mineralogical and chemical study of coarse octahedrite Morasko. Prace Mineralogizcne, 47, PAN Oddz. Krakow, Poland.

Dominik, B., 1977. Shock and thermal transformations in meteorites from the Morasko crater field. *Meteoritics* **12**, 207-208.

Dzieczkowski, A. and Z. Pniewski, 1971. Projekt rezerwatu geologiczno-florystycznego na Górze Moraskiej pod Poznaniem-Przyroda Polski Zachodniej IX (1-4), Poznań.

Freeberg, J.H., 1966. Terrestrial impact structures – a bibliography. *Geol. Survey Bull.* **1220**, Washington.

Hey, M.H., 1966. Catalogue of Meteorites. 317, London.

Hurnik, H. (editor), 1977. Meteorite "Morasko" and the region of its fall. Poznań.

Korpikiewicz, H., 1976. Goście z Nieba. *Urania* **4**, 106-112, Warszawa.

Korpikiewicz, H., 1977. Desczc meteorytowy Morasko. *Wszechświat* **7/8.**

Krinov, E.L., 1974. Fragmentation of the Sikhote Alin meteorite body. *Meteoritics* **9**, 255-262.

Pokrzywnicki, J., 1955. *Acta Geologica Polonica* **5**, 427.

Pokrzywnicki, J., 1956. *Acta Geophys. Polonica* **4**, 21.

Slavik, F. and L.J. Spencer, 1928. *Min. Mag.* **21**, 478.

Manuscript received 1/11/77