PERGAMON

Planetary and Space Science 49 (2001) 749–753

Planetary and Space Science

www.elsevier.nl/locate/planspasci

The geology and morphology of the natural reserve "Meteoryt Morasko"

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Received 3 August 2000; received in revised form 19 December 2000; accepted 13 January 2001

Abstract

The results of geological, geoelectrical and radiometric investigations of small depressions in the natural reserve "Meteoryt Morasko" are discussed. The interpretation of results suggests the impact origin of six hollows existing on the north-east slope of Morasko Hill (Moraska Góra near Poznań). The area of the reserve is unique in its combination of the occurrence of meteorites and the morphological effects of their fall. © 2001 Published by Elsevier Science Ltd.

1. Introduction

The natural reserve "Meteoryt Morasko" is located near the top of Moraska Góra, north-east of the highest elevation in the Poznań region (154 m above sea level).

Iron meteorites have been found on Moraska Góra and in the village of Morasko since 1914, when a lump of metal weighing 77.5 kg was encountered during military trenche digging (Pokrzywnicki, 1955, 1964; Pilski and Walton, 1999). The meteoritic origin of the lump has been established, and it has become a museum exhibit (Classen, 1978). Three other specimens: one 4.2 kg and two 3.5 kg were collected soon after, from the same area.

More iron meteorites, various in size were collected in 1919–1939, 1947–1960 and since 1970 up to now (more than 500 kg in total). These include numerous small pieces and few larger lumps. The biggest meteorite found up to now is ~80 kg. Unfortunately, most specimens were dispersed or lost. Some of them appeared on European market.

The meteorites from Morasko were studied by Pokrzywnicki (1955, 1956, 1964), who initiated a more comprehensive study of both the meteorites and the presumable morphological effects of their fall.

In the 1970s, the area in question was a subject of an international interdisciplinary investigation. The work resulted in a series of publications, ranging from theoretical issues through discussions of the trajectory of the meteorites' movement, their composition and structure (Hurnik, 1976; Hurnik et al., 1976; Dominik, 1976) to the studies of impact geomorphological effects. A debate on the depressions origin initiated. Two points of view were presented—Hurnik et al. (1976) and Kuźmiński (1976) construed them as a result of the impact of the meteorites fall, whereas Karczewski (1976) interpreted them as an effect of melting of dead ice blocks.

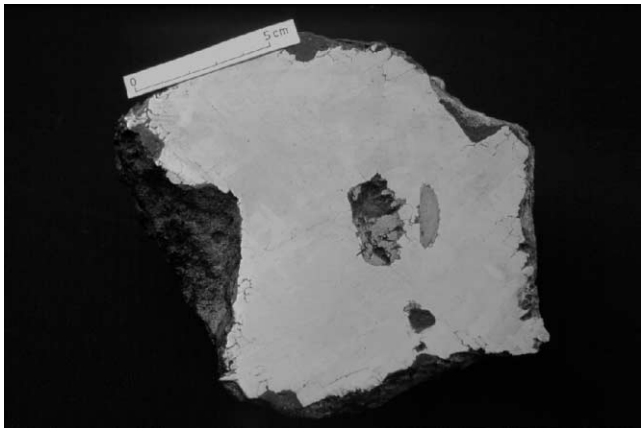

Plate 1. Morasko 7.5 kg meteorite slice showing the troilite inclusions and the Widmanstatten structures.

The geological, geoelectrical and radiometric studies, as well as searches of meteorites were performed in 1997–1999 (Stankowski and Muszyński, 1999). In the loose and loosely coherent Quaternary and Tertiary deposits neither impact breccia nor high-pressure minerals or glass have been discovered. The micro-meteorites protoliths of maghemite and goethite as well as shock-pressure structures in the quartz grains were recorded. The new meteorite lumps: 7.5 (Plate 1), ~40 and ~80 kg in weight were

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0032-0633/01/$ - see front matter © 2001 Published by Elsevier Science Ltd.
PII: S0032-0633(01)00011-3

Fig 1. The depression forms of evorsive and ice melting origin (a), also meteorite craters (b) in the neighborhood of Moraska Góra.

found. Morasko appears to be a typical inclusion-rich coarse octahedrite of group IA-Og (Buchwald, 1975; Dominik, 1976).

The Morasko meteorite not only became a subject of scientific study, but also appeared on the European market of collectors.

2. The geology and geomorphology of Moraska Góra

The Moraska Góra hills constitute a part of the postglacial landscape that achieved its final form during the Poznań stage of the Baltic Glaciation, i.e., the last ice sheet developed in the North Polish (Vistulian) glacial period.

The hills are composed of Quaternary tills, sand-and-gravel sediments, and fine-grained sediments of the Poznań series of late Miocene. These sediments were deformed by glacitectonic processes. The time of deformations has not been established precisely, but apparently they occurred before the last glacial advance (Baltic Glaciation, see Fig. 2). The base of Moraska Góra, in terms of both the formation of its internal structure and the existence of the palaeomorphological rise, must also be dated to the Middle Polish glacial at latest (Saale). This postulate is based on Krygowski's concept (1960, 1961, 1964) of the existence of old geological structures inside a young glacial relief.

During the maximum advance of the Vistulian ice-sheet and the initial stage of its recession, the existing glacitectonic structures underwent shallow secondary deformations, while the morphological features similar to those of the present day were formed. The degradation of the permafrost in Moraska Góra and around it, which occurred between 13,000 and 11,000 yr BP, brought melt-out forms to the surface (Kozarski, 1963). Since that time the depressions have been filling, largely with organic deposits.

The geological investigation conducted in the 1990s in the Morasko Natural Reserve and in its neighborhood (including surface mapping and geoelectric studies) not only confirmed the considerable diversity of the superficial and internal structure of the area, but also established a wide range of the thickness of Quaternary sediments, from more than 20 m to none.

The topography of Moraska Góra and the area around it abounds in depressions, mostly of evorsive origin (subglacial water erosion under hydrostatic preasure) and produced by ice melting processes. Their shapes are predominantly irregular, often markedly elongated (Fig. 1). Only in a small area north-east of the top of Moraska Góra there are several very regular oval depressions with fairly distinct circumferential ridges. Six of these (designated by Karczewski, 1976 as A through E), constitute a conspicuous complex of meteorite craters. The seventh one (G) located at some distance from the formers, occurs at the begining of a larger, elongated depression form, most likely of evorsional origin.

The recent studies were focused on the cluster of six depressions, mentioned above. Their strongly varied areas, diameters and depth were measured between upper edges and mineral floors. Three larger ones are: (A) 4657 sqm, 90 m in diameter and 11.5 m in depth; (B) 1195 sqm, 50 m and 9.0 m; and (C) 661 sqm, 30 m and 4.3 m. All are filled with water (to a depth 1 – 2.5 m) and organic sediments of thickness; ~4, ~3.5 and ~2 m, respectively. Smaller depressions : (D) 616 sqm, 20–35 m, and 2.1 m; and (E) 415 sqm, 25 m and 2.2 m are intermittently filled with water and contain thin covers of mineral-and-organic sediments. The smallest depression (F; 284 sqm, 20 m and 3.0 m) is permanently dry.

The age of organic sediments found at the bottom of depressions may provide some useful information on their origin. Palynological tests of two profiles of organic sediments collected from depressions (A) and (C) (Tobolski, 1976) indicated the beginning of the accumulation not earlier than in the middle stage of the Atlantic period, and more specifically, between 5500 and 5000 yr BP. Unfortunately, the palynological tests were not supported by radiometric datings.

Table 1
The C^{14} age of bottom organic sediments from Morasko craters

Hollow	(depth of sample)	Sample	Laboratory no.	Age (yr BP)
(B) (a)	(4.8–4.95)	MM-Bo'	Pilot attempt	690 ± 95
(B) (b)	(3.5–3.7)	MM-B"	Gd-10895	260 ± 80
(B) (c)	(4.0–4.2)	MM-B	Gd-14030	2690 ± 170
(C) (a)	(2.4–2.5)	MM-C	Gd-13028	690 ± 150, 990 ±160
(b)	(3.0–3.05)	MM-C1	Gd-10900	640 ± 90
(E)	(1.2–1.4)	MM-E	Gd-10898	610 ± 75, 650 ± 110
	(1.8–1.9)	MM-E	Gd-10894	3360 ± 100

The author repeated the sounding of the bottoms of the depressions in order to establish the properties of the accumulated sediments and to date their floors by means of the radiocarbon method. The preliminary geological study of the sediments which fill the depressions suggests that these features underwent considerable paleoenvironmental changes. Conditions suitable for the development of organic sediments, including peat, developed in each depression at different times and lasted for various periods of time. For instance in the hollow (E), the organic materials were accumulated in two levels, divided by a gravitational accumulation of a mineral matter.

3. The radiocarbon dating

The C^{14} dating of the bottom layers of organic sediments from the depressions, performed in Gliwice Radiocarbon Laboratory of the Silesian Technical University, proved young and in most cases very young age of these sediments (Table 1).

The most interesting are the data of the organic layers in the depresion (E). The upper one is dated to 610 ± 75 yr BP, and the lower one, to 3360 ±100 yr BP. The latter is the oldest of all the ages obtained in this study. The second oldest age, 2690 ± 170 yr BP, was that of the bottom organic sediments from the depression (B). Both data are considerably younger than the age of the oldest organic sediments in the depression (A), which were estimated by palynological method (Tobolski, 1976). The remaining four data are not older than 1000 yr BP. Out of these, three belong to the same period as the age of the shallower organic interbedding in the depression (E). It is possible that only around 700 yr BP, a relatively large amount of an organic matter began to accumulate in the depressions. The obtained ages ranging from 600 to 700 yr BP, seem to agree with

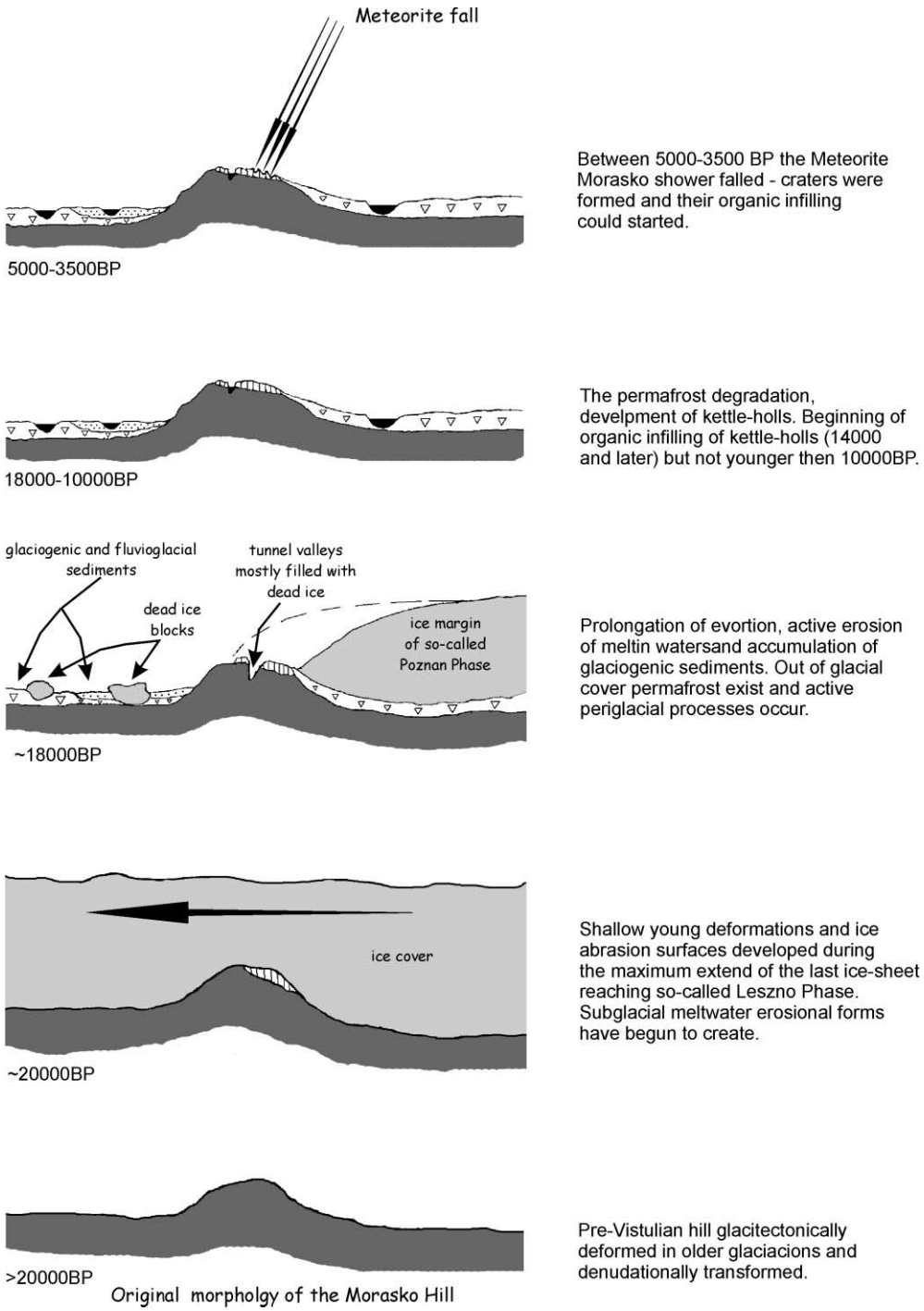

Fig 2. The impact craters in the context of the origin of Moraska Góra.

paleoclimatological data, suggesting that climate of the period of A.D. 1200–1400 was humid and favorable for the accumulation of organic sediments.

The results of the palynological tests and the radiocarbon datings differ to a significant degree. Yet, as a whole they seem to disprove an idea that the discussed depresions were produced by melting ice. The accumulation of the organic matter did not start earlier than 5000–5600 yr BP, i.e., several thousand years after the degradation of the permafrost in this area, which occurred at latest app. 10,000 yr BP (Kozarski, 1963).

The interpretation of the origin of the internal structure and the geomorphological features of Moraska Góra, as well as age of several very regular oval depressions existing on the north-east slope of the hill is summarized in the Fig. 2.

4. Conclusion

The recent studies and the interpretation of their results suggest that six depressions from north-east slope of Moraska Góra in the reserve "Meteoryt Morasko" were produced by the impact. This is supported by the shape and concentration of the hollows, the age of the oldest organic sediments inside them, and—most importantly—by the presence of meteorites, micrometeoroids and shock-pressure structures in the quartz grains. The craters were produced by the impact in disturbed Quaternary and Tertiary loose rocks. The results obtained so far are promising, however need more substantiating evidences.

The Morasko Hill with its craters is one of the few places in the Earth where impact craters are accompanied by identifiable meteorites (Hodge 1994).

Acknowledgements

The financial support of the Polish State Committee for Scientific Research (KBN) under project No. 6 PO4E 055 10 is gratefully acknowledged.

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