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Physical Aspects of the Meteorite-Shower of Knahina on the Basis of a Map Constructed by Prof. J. SZABÓ

László BENDEFY
Budapest

ABSTRACT: The author reexamined the circumstances of the meteorite-shower of Kňahiňa (1866). He established that after the meteoric explosions the balance of the meteoric bodies becomes disarranged. In such cases the meteoric body's masse didn't to fill the wholly area of the enveloping ellipse, but only the area of the direction line. In case of the Kňahiňa in the western third part of the ellipse area, no fragment of an essential size has been recovered.

On the 9-th June, 1866, about 05 p.m., "a fire ball appeared high in the sky" to the inhabitants of the village of Kňahiňa, County Ung (SZABÓ 1867). Though "on the azure background of the sky no cloud was visible with the exceptions of some Altocumuli, the fire-ball was emitting, in spite of the full brilliancy of the summer Sun, a very strong light which has been seen by several thousands of labourers who were tilling the earth on this Saturday afternoon." (SZABÓ 1868.)

These are the introducing words to the description of the shower of meteorites at Kňahiňa, given by József SZABÓ the celebrated one-time Professor of Geology in the University of Budapest, and secretary of the Comission for Mathematics and Sciences of the Hungarian Academy of Sciences. After this preambule, SZABÓ states the following:

According to the evidence given by eye-witnesses, the fire-ball appeared in the western sky and continued its path in an easterly direction. Among the data collected by the Academy of Sciences, the westernmost locality at which the fire-ball has been observed, was there town of Liptószentmiklós. Starting from this point, there is available a continuous set of observations throught the counties Szepes, Sáros and Zemplén to the northwestern corner of the county Ung. In every case ther is a statement in these documents concerning the direction at which the phenomenon was sighted in the various villages. In addition, it appears from these documents, which are those of the villages, where all of the observers had seen the phenomenon to appear at the zenithal point. Plotting these localities on a map, we are obtaining a line having the length of 28 Austrian miles (i.e. 112 200 fathoms of Vienna, that is 212,3 kilometres), directed from the West to the East.

On the northwestern end of this line, i.e. above Liptószentmiklós, was the highest observed position of the fire-ball (Fig. 1.), while at the southeastern end, at Kňahiňa, it hit the earth in an explosed state (Fig. 2.).

"Observers at the two ends of the line in question are giving evidence on very different phenomena; those at the western end of the path experienced only optical events; acoustical ones (a detonation) were lacking. However, at the Kňahiňa end of the path observers experienced a mighty detonation; and then when searching for its origin in the atmosphere, they experienced the spectacle of a black cloud. From above (accompanied by a sharp siffling tune) stone fragments of smaller or greater sizes were falling to the earth; from these emanated in turn a dust-cloud of grey colour, which has been carried, by the locally prevailing northerly wind, along the valley of the Ung river toward the South in the direction of Ungvár. Thus, the later mentioned observers experienced, no sight of a fireball, but only of its extinguished and exploded remains..."

"Observers at the intermediary section of the line in question experienced both phenomena. At first they have seen a firy ball which initially has been smaller and then increased in size: finally, they heard a detonation and the light (of the fire-ball) has gone out. People at the eastern end of the line heard a stronger detonation than those located at the middle section. And the whole chain of events described here took place within some few seconds", in the words of SZABÓ.

Of course, the phenomenon has been observed not only people along the path-line Liptószentmiklós - Knahina but also by a great number of people living within a wide band of territory on both sides of the path. On the northern side, the observations were impeded by the presence of the Carpathian Mountains, and, as a consequence, the fire-ball was seen by nobody in Galicia. On the side of the Hungarian Lowlands however, the data are spreading over a wide territory. We are citing, as an interesting feature, that though at Tokaj (as a consequence of orographical screening) nobody has remarked the event, on the other hand, at Rakamaz, located on the other side of the mountain, several people observed both the fire-ball and the detonation. At Erdőbénye, again the fire-ball was seen to appear on the western sky and to desappear as a dark spot in the East, and even a faint acoustical effect (in the form of a muffled noise) has been observed.

SZABÓ, receving the first news on the phenomenon from the town Eperjes, where "people have seen the fire-ball in its full glory and heard its explosion", travelled at once to Eperjes. According to news received, the meteorite fall in a neighbouring village and killed some cows. This proved, of course to be incorrect and SZABÓ took a cart for visiting the whole territory of the counties Sáros and Zemplén. However, hearing rumours that the fire-ball must have fallen in Galicia, he ended his journey and sought other methods for the collection of scientific data on the phenomenen, solving this problem very successfully.

Returning to the Hungarian capital, he requested, through the intercession of the Hungarian Academy of Sciences, an order to be emitted by the Regency Council for finding out and questioning all the people in the counties Zemplén, Ung, Abauj-Torna, Szepes and Sáros who were witnesses of the phenomenon. The witnesses deposited their testimonies with the local authorities. The protocols were sent to the secretary of the Academy of Sciences, the great poet János ARANY, who transmitted to SZABÓ (VENDL, 1960).

In the search for the exploded fragments of the fire-ball and in the careful mapping of the spots where they were retrieved SZABÓ was strongly aided by György DUMA, teacher at the Gymnasium at Ungvár. Their correspondence has been described by A. VENDL (VENDL 1960) and is mentioned by E. VADÁSZ as well (VADÁSZ 1967).

From the testimonies of witnesses it appeared, that on June 9-th 1866. about 05 p.m. Kňahiňa has been hit by an actual shower of meteorites. More than thousand stone fragments were falling from outer space. Their total weight reached almost one-half of a ton. However, when DUMA finally succeeded on June 29-th, to obtain "on a very serious request the permission from the head of his school for investigating this famous phenomenon", only 31 samples could be secured. The diligent and successful work of DUMA has been rewarded by the Academy of Sciences with a sum of 150 Guldens. Later the efforts to obtaining further specimens were rather unsuccessful ones, as only a few number of them could be secured from the village inhabitants. The success of this collection "was strongly impeded by the activities of the owners of some antiquity shops extablished in the neighbouring towns who were offering six to ten times higher prices for a piece of meteoric matter as compared to the prices determined by the Hungarian National Museum. The shopkeepers sold the greater part of the specimens collected by them on the markets of foreign countries (VENDL 1960).

From protocols taken officially at the site, it appeared that people in the vicinity of the spot where the bolide was hitting the ground "felt distinctly the tremor of the earth and the vibration of house walls and windows (e.g. at Nagy-Berezna) was stronger than that observed at the time of a lightning stroke" (SZABÓ 1968).

In hitting the ground, the two biggest fragments penetrated deeply into the soil: the one, transported to Vienna, having a weight of 294 kgs, penetrated to a deth of 11 feet (3, 5 metres) and after penetration they filled up the hole themselves. However, even the smaller fragments were penetrating to such depths that they could bye secured only upon fastidious searching. According to Szabó about 1200 fragments were certainly collected, however the total number of fragments has been estimated to be about 1700 (TOKODY - M. D. VENDL 1951).

It should be mentioned that the meteoric fragment of 294 kgs (Fig. 3) is constituting not only the biggest specimen in the collection of the Natural History Museum at Vienna, but at the time (1866) it was also the biggest among all the meteorites in the museums of the world and even now it is occupying the third place (Fig. 4.) among stony meteorites. The fragment of 41, 26 kgs, purchased by the Hungarian Natural History Museum from certain people in Ungvár for 750 Guldens and exhibited in the great hall of the Museum, was at the time the fourth biggest one among all the meteorites in the museums of the worlds, and hundred years later, about 1963 it was the sixth one (Fig. 4).

During a further trip, SZABÓ visited the sites where the greater fragments hitted the ground and verified in the clayey soil the penetration channels. Their slopes, controlled with a compass, proved to be of a "true West-toEast direction, in complete agreement to the path direction of the firy meteor". The exploding "bomb from the sky" arriving under a higher slope angle, scattered "the soft, thick lawn in an elliptical (pattern) in a manner that the remains of the grass were found in an eastern direction from the hole at a distance of 20 to 40 steps (that is 15 to 30 metres) and even at a distance of 120 steps (90 metres) while, on the western side of the hole, no such remains were founds".

Fragments of medium size penetrated only half-way into the loomy soil. The clay attached to them is "a safe indicator of the leading side of the meteorite in the course of its path through the atmosphere". Smaller fragments were lying simply on the groung surface. A great number of micrometeorites of the size of a dust particle has also been found (SZABÓ 1868),

The centre of the stone-shower was located within the administrative area of the village Kňahiňa. However some fragmentes, such as the biggest one with a weight of 294 kgs, was found on the administrative area of Uj-Sztusica in the county Ung, and the area of the village Zboj, county Zemplén.

From the spatial distribution of the fallen, or, respectively, scatered fragments some very interesting conclusions may be drawn. Some observations are already mentioned in the publication of Szabó, however, the mapped data collected by SZABÓ concerning the hitting sites of the fragments after the explosion of the meteoric body are of a still higher interest.

Copies of this map are now of a high rarity. Its title is: "Map of the Meteorite Shower that Occurred on June 9-th, 1866 at 05 p.m. in the Area of the Village Kňahiňa, County Ung, prepared by SZABÓ, 1869 - Rohn and Grund Printers, Pest, 1869".

Size data: outer size 51 x 69 cm, inner size 45 x 56 cm.

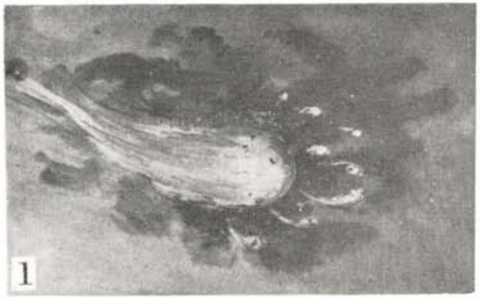
Scale: 1:28.800; corresponding to 12 = 400 fathoms of Vienna. This was the scale of the II. military survey (the so-called Francistic Survey); this survey of the country was terminated in 1869. This is the explanation of the circumstance that SZABÓ waited some three years for the publication of this map; it was only in 1869 that he came in the possession of a reliable projection.

The base of the map is a black-on-white lithography originating from the II. military survey, indicating orographical conditions by a fine striping, on which a superprint was made in discrete brown, green, and respectively, red colours. The hilly areas were represented by a very clear grey-brown colour, while the meadows, grass-lands, and straw-yards were printed in a vivid spinach-green colour.

The most valuable feature of the map consists in the indication of the sites where the various meteorites were found. By analysing these data, we can reach the following conclusions.

Fig. 1. Aspect of the "firy meteor" of Knahina as seen by eye-witnesses. Fig. 2. View of the hills in the vicinity of Kňahiňa, at the time of the explosion of the meteor. (From the exhibits of the Mineralogical Department of the Hungarian Natural History Museum.)

1. kép. A knyahinyai "tűzmeteor", amilyennek a szemtanúk látták. 2. kép: A Knyahinya-környéki dombok a meteor szétrobbanása perceiben. (Festmények a budapesti Természettudományi Múzeum Ásványtára kiállításán.)



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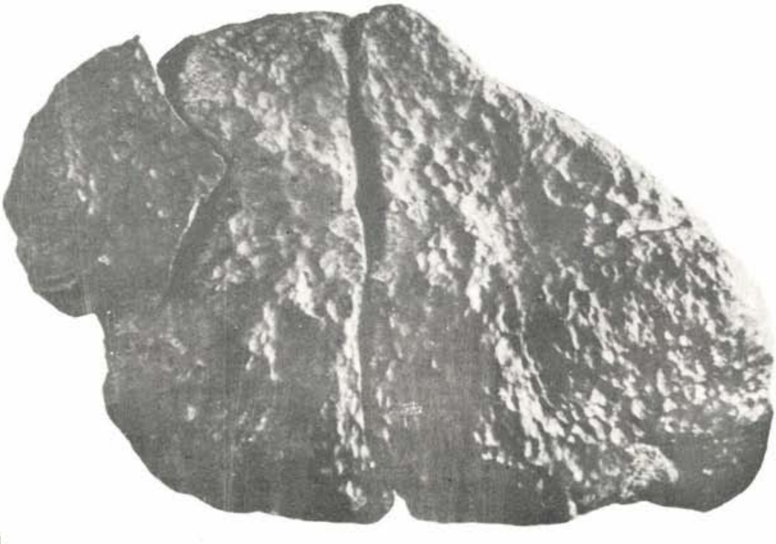

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On the map, red points and spots are symbolizing the sites where the exploded meteoric fragments were hitting the ground. From the meteorites the number of which was originally of aproximatively 1700, the map is containing only the spots of incidence of those 53 meteorites, which DUMA has ascertained, and, in addition, the spot of the largest meteorite which has been transferred to Vienna. Geodetical work was done by an engineer, as emissary of the Catastral Bureau of Ung county.

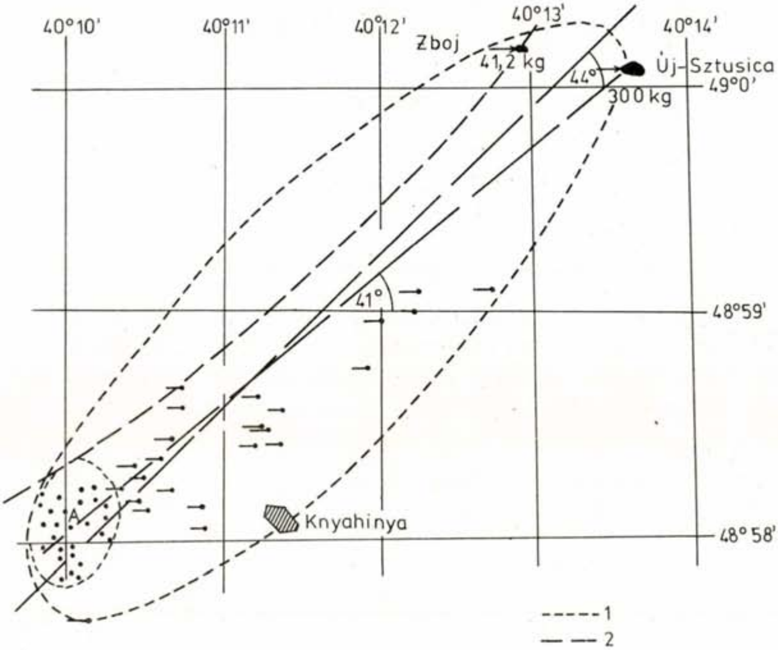

Fig. 5. The meteorites collected at the site hitted the ground within the area of an ellipse (BENDEFY 1973).

5. kép: A helyszinen összegyűjtött meteoritok egy ellipszisen belül értek földet (BENDEFY 1973).

The shattered smaller or larger meteorites were found on the area of an elongated ellipse the main axis of which is possessing a NE - SW direction (Fig. 5.). SZABÓ sta-

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Fig. 3. The biggest meteorite of Knahina; property of the Natural History Museum at Vienna. Length: 77 cm, height: 46 cm, weight: 293,5 kgs. Fig. 4. Second biggest fragment of the meteorite of Knahina, collection of minerals in the Hungarian Naturas History Museum. Length: 46 cm, heigth: 30 cm, thikness: 24,5 cm, weigth 41.26 kgs.

3. kép: A knyahinyai legnagyobb meteorit; a bécsi Természetrajzi Múzeum tulajdona. Hossza: 77 cm, magassága: 46 cm, súlya: 293,5 kg. 4. kép: A knyahinyai meteorit második legnagyobb darabja; a budapesti Természettudományi Múzeum tulajdona. Hossza: 46 cm, magassága: 30 cm, vastagsága: 24-5 cm, súlya: 41,26 kg.

tes, that the direction of this axis is "essentially different from the orientation of the path of the fire-ball which was from W to E (SZABÓ 1868).

The length of the main axis of the extensive enveloping ellipse is of 6050 metres. In the SW corner of the enveloping ellipse, a muchsmaller other ellipse may be constructed; in the centre of this (designed by A on Fig. 5) occured the explosion of the first major detached fragment. Accordingly, on this smaller ellipse, having a main axis of 1000 metres and a width of 610 metres, were found, more than half of all the fragments collected by DUMA, namely 27 of them.

The main axis of the enveloping ellipse is inclined to the W-E direction by 44 degrees, while that of the smaller ellipse has an inclination of 85 degrees. The center of the smaller ellipse (designed by A) could be regarded as the approximative central core of the explosion. However, the largest fragment having a weight of 294 kgs, was flying still further to a distance of 590 metres and reached the ground only on the administrative area of Uj-Stusica. (Fig. 6).

Earlier literature investigated - other data being lacking (not uniquely in the case of the meteorite of Knahina, but also in all other cases) only the following questions: how much meteorites hit the ground and on how great an area, as well as the size and shape of the enveloping ellipse. In the present case (thanks to the ceraful data publication by SZABÓ) these investigations may be somwhat extended.

According to the ideas of SZABÓ, the main axis of the elliptical area containing the meteorites is including an angle with the path direction W-E. Connecting the hitting site of the most lately fragment of 294 kgs to the explosion centre A by a straight line, this line is inclined by 41 degrees, while the main axis is inclined by 44 degrees to the W-E direction. We are now asking the question: from a physical point of view, what is the meaning in the present case of the size and shape of the enveloping ellipse, as well as of the discrepancy existing between the direction of the main axis and that of the path of the meteoric body?

The size and shape of the smaller ellipse connected to the explosion are characteristic data for the strength of the explosion and for the amount of matter which has explosed. The shape of the enveloping ellipse is without any significance: however the length of its main axis, as well as the distance of the most lately fallen fragment from the explosion centre are both valuable data for the reconstruction of the whole process.

At first, it should be elucidated, in which way the conclusion was reached that the fragment of 294 kgs was that which has fallen latest among all the meteorites. Now, SZABÓ has observed and carefully verified, that not only the fragment of the weight of 294 kgs possessed a penetration channel in the soil which had (like the path of the original meteoric body having a weight of about 500 kgs) an orientation of W-E, but also the further big meteorites penetrated equally in a W-E direction into their channels. This is also supported by the position of the remains of lawn relatively to the sites of penetration. The penetrating meteorites continued their path below the lawn cover to a distance of 15 to 90 metres, all of them in W-E direction. On the W side of the spot of penetration, no one single remain of grass has been found (SZABÓ 1868). In the case of smaller meteorites, which had not penetrated into the ground, burned grass was found consequently

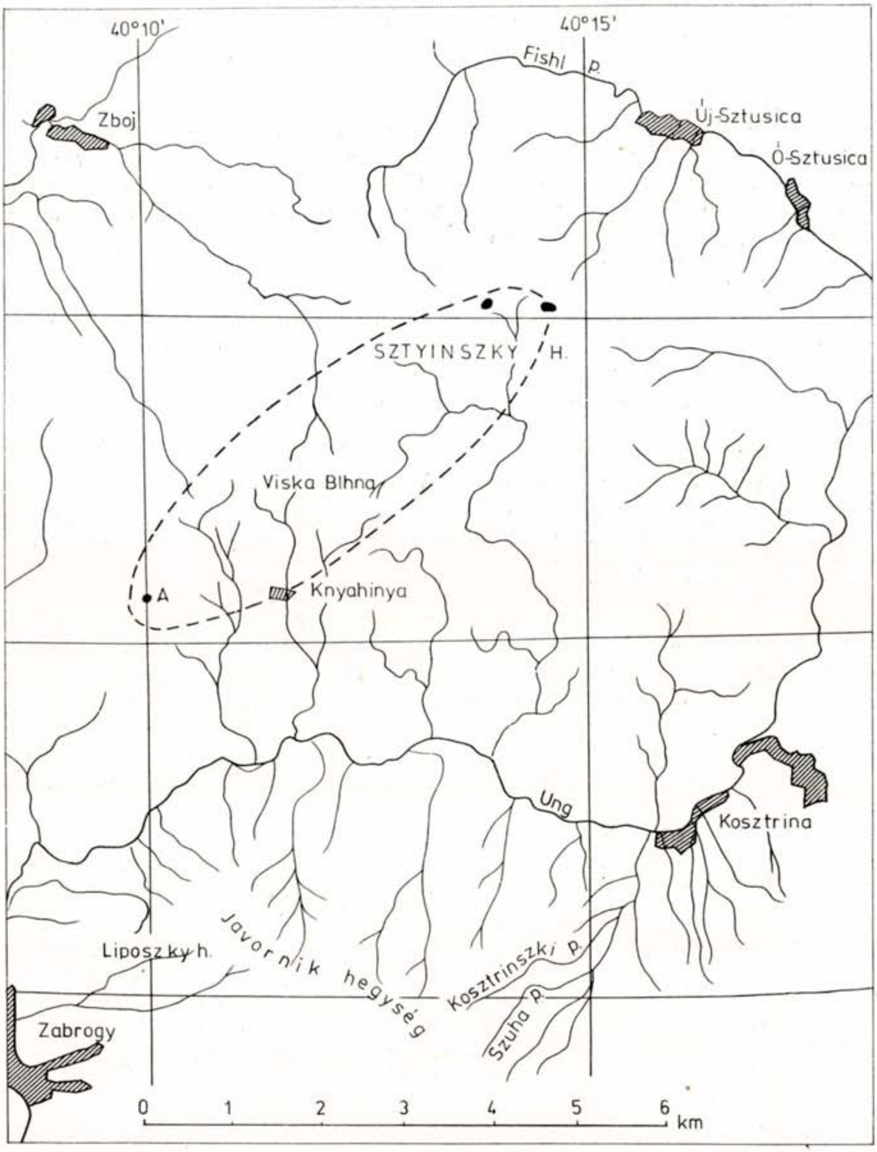

Fig. 6. Location of the meteorite field of Kňahiňa within its geographical surroundings. (On the basis of the map by J. SZABÓ constructed by BENDEFY, 1973.)

6. kép: A knyahinyai meteoritmező helyzete a földrajzi környezetben. (SZABÓ J. térképe alapján szerkesztette: BENDEFY L. 1973.)

on their eastern sides, which is an evidence of the fact, that, when they reached the earth in an incandescent state, they slided on the surface of the loomy ground for some decimetres (SZABÓ 1868).

On the basis on these features, we are reaching the following conclusions. The part which separated itself of the original meteoric body of about 500 kgs, was scattered into numerous smaller fragments, and a numberless lot of micrometeorites from the size of a pie to the size of a dust partiole has been formed. From the fragments exploded in this process even the largest ones had only a weight of 0, 5 to 1, 5-2, 0 kgs. They were flying along ballistic curves into every direction (Fig. 5).

At the moment of the explosion and loss of mass which occured on the western side of the meteoric body a force was produced which caused a deviation from its W-E path into a path N 49°-229°, that is, in a northeasterly one. This force can be characterized by a North-South component which is theoretically equal to 0, 87 per cents of the W-E component.

From notes taken by SZABÓ, we are knowing that the meteorites which flaw after the first explosion in a north-easterly direction and were detached subsequently, reached (all the fragments of them) in sliding in a W-E direction, or penetrating in the ground in the same direction, their final positions.

Before discussing the question, why all the soil channels are possessing a W-E orientation, it should be mentioned that DUMA has made the following observation: within the enveloping ellipse, the meteorites which were fallen in the neighbourhood of the eastern boundary are in every case bigger than those which were fallen behind of them. This is quite obvious, as meteorites possessing a greater weight are flying (after their separation) with a higher initial energy. DUMA was able only to collect the bigger ones and to dosign their site for geodetical surveying. The smallest ones were micrometeorites, of the size of a coarse quartz-sand particle.

On the map of SZABÓ it can be noted that in the western third part of the ellipse area, no fragment of an essential size has been recovered. Accordingly, the positive area of the meteoric shower has a sausage-like shape. The area on Fig. 5. was covered by more than a thousand meteorites of various sizes.

It follows from all that has been said above, that the meteorite of the weight of 294 kgs, which was fallen at the easternmost end of the area, covered the largest distance and it was the last to fall. The extra length of this path, as compared to the explosion centre A, was:

$$n_1 = 5,9 \cos 41^{o} = 4,45 \text{ km}.$$

On the questions how and why some fragments are separated from a larger meteoric body, and why meteorites are generally explosing, we are answering as follows. Meteor showers are travelling since many million years across cosmic space. They are exhibiting temperatures corresponding to cosmic space. For a meteoric body of the mess and size corresponding to that of Kňahiňa before its explosion (of a masse of 500 of 550 kgs) a temperature between -50 and -180 degrees centigrade) may be surmised (that of the Moon being -180 degrees centigrade). When, however, this cold meteor is penetrating into the terrestrial atmosphere and frictional heating is experienced, its surface may be heated even to 1200 or 2000 degrees centigrade. The red-hot and later incandescent white outer shell of the meteoric body is gradually separating from the inner core which remains in an invariably cold state. Lather the deformed incandescent shell is unable to counterbalance the stress by elastic forces, it suffers fissures it breaks down, and its fragments are flying away. The separation of the fragments of the shell from the main mass of the body is taking place under violent jerkes and the presence of this force, as well as the loss of mass are disturbing the existing state of equilibrium and the meteoric masses are tending toward another state of equilibrium. However, this process is repeating itself almost at every moment, and thus the meteor is experiencing an accelerating and irregular fluctuating motion, conserving, however, as a consequence of its inertia, its path along a straight line.

Concerning the time which elapsed from the first explosion until the hitting of the ground by the last fragment, we computed probable duration of 4, 5 to 5, 0 sec. SZABÓ is stating correctly, that "this whole sequence of events (i.e. from the appearance of the phenomenon at Liptószentmiklós until the hitting of the ground by the last fragment of 295 kgs) occured within a few seconds."

A probable value for the translation velocity of the meteor in its path can be determined on the basis of the assumption that its altitude at the time of its appearance should have been (according to earlier experience) about 200 kilometres and the projection of its path had a length of 212, 3 kilometres. The real path has, however, a length of 292 kilometres and this path was covered in 4, 5 to 5, 0 sec. Thus, its velocity was 65 km/sec, a velocity which has decreased only in the near-the-ground atmospheric layers, that is, within the last few kilometres of the path (RÓKA 1963).

The fragment weighing 294 kgs of the Knahina meteor penetrated, in spite of its enormous velocity, only to a depth of 3, 5 metres into the soil. This may be explained by the fact that soil is exerting against every penetrating body a very high resistance. In the course of my studies in the field of vulcanology (as early as in 1932) some experts of the Institute of Military Engineering were kind enough to consider for me the following situation: if, from an active volcano, a basaltic bomb of the weght of 1000 kgs and of the shape of a citron, with a sharp regular end, would be projected to a very great height, say, to the 1000 metre level, its falling back into a loose Pannonian sand soil would be causing no larger penetration than one of 3 or 4 metres.

Thus, the biggest meteorite of Kňahiňa is not only that one which penetrated to the largest depth among all the known meteorites, but even the meteorites and volcanic bombs possessing much greater weight respectively masses are unable to penetrate to greater depths.

However, it should be noted, that this big fragment fell not vertically but it arrived from the W and digged for himself a channel of about 90 metres in length with a slope angle of $2^{o}14'$ and came finally to rest in the depth of 11 feet, that is of 3, 5 metres.

The enormous velocity, with which the meteors are penetrating into the atmosphere, is quite rapidly reduced by air resistance. In the vicinity of the terrestrial surface, meteorites are arriving at most with a velocity of several hundreds of m/sec. Their final velocities are, accordingly, not higher than those of artillery projectiles, and they are almost not penetrating into the soil. The smaller fragments are (as mentioned above) at most sliding on the earth's surface and are damaging the grasscover only. Even the famous meteorite of Hoba farm, possessing a weight of 60 metric tons, penetrated only to a depth of 1,5 metres into the soil. However, the depth of penetration of a meteorite is not depending only on its weight, that is, its mass, and not even only on the altitude from whichit is falling down, and on the incidence angle as it is strongly dependental so, on the nature of the soil. From a hard rock surface, it could be perhaps elastically repelled, andin a peaty, marshy soil it can be submerged without any vestige.

We found also a relation among the radii of spherical meteorites falling with a final velocity of 60 km/s and their velocities of incidence. A table containing the corresponding results has been published on p. 59 of a book by DETRE (1939).

In the present case, we know that the mass of the meteor, when it was still flying as an intact fire-ball through the atmosphere, was of about 500 kgs, which corresponds to the following radius of the sphere:

$$r = 76,19 \text{ cm}$$

thus the diameter of the original meteor appearing above Kňahiňa was about 152 centimetres. To this diameter corresponds a velocity of 750 cm/s. However, this value has been somewhat reduced at the time when the last meteorite actually hit the ground. Namely, at this moment, the mass of the meteorite which penetrated the ground was only 294 kgs, corresponding to an effective radius of

$$r = 64 \text{ cm}$$

that is, the virtual velocity of the reduced meteorite, which still possessed a diameter of 127,6 cm and a mass of 294 kgs, was about 720 m/s. This means that in the time of less than a second this big meteorite penetrated into its 90 m long channel in the soil and reached there a depth of 3, **5** metres below a wood-clearing covered by bushes.

Such short a time is not sufficient for a body, having the velocity of an artillery projectile, for changing its direction. This circumstance is yielding also an explanation for the extremely interesting observations made by SZABÓ.

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A shower of meteorites depassing that of Knahina was observed only once in this country. This occurred on February 3-d, 1882 in the afternoon. This time, the number of counted stone fragments in the village Mócs in Transylvania surpassed 3000; their total weight was about 300 kgs. While the meteorites of Kňahiňa explosed near-the-ground, and certainly within the terrestrial atmosphere, those of Mócs arrived as separate fragments, that is, they are members of a real meteoric shower. This circumstance is sharply expressed in the spatial distribution of the fragments.

The most glorious and most large meteoric shower ever observed on Earth has been described by Alexander HUMBOLDT who witnessed this unforgettable phenomenon, having duration of several hours, together with his friend BONPLAND, the botanist, on the neight of November 11, 1799 at Cumana in Venezuela, where many thousands of meteorites showered down during four hours (HUMBOLDT - BONPLAND 1807).

BENDEFY László: A knyahinyai meteorkő-hullás fizikai vonatkozásai SZABÓ József professzor térképe alapján

1866. június 9-én 17 óra tájt az Ung-megyei Knyahinya lakóinak egy "tűzmeteor" tűnt fel (1. ábra), amely a "nyári nap teljes fénye mellett is erősen világított, s mint ilyet, a szombati napon szabadban dolgozók ezrei látták" (SZABÓ 1967, 1968). A szemtanúk egybehangzó vallomása szerint a tűzgolyó nyugaton, Liptószentmiklós (Lip. Sv. Miku - las) fölött tűnt fel és Knyahinya határában szétrobbanva csapódott a földbe (2. ábra.) Eközben 213,3 km utat tett meg.

Azok, akik a meteort útvonalának Ny-i felén kísérhették figyelemmel, csak a tűzgolyót látták, de semmiféle hangtüneményt nem észleltek. Azok viszont, akik Knyahinya közelében láthatták, egy fekete felhőt észleltek és néhány másodpercen belül a meteor szétrobbanása és becsapódása pillanatában hatalmas dörrenést hallottak. Egyesek, akik a meteor útvonalának éppen a közepetáján tartózkodtak, mind a kétfajta jelenséget észlelték. SZABÓ professzor szerint "a leírt tünemények egész láncolata mindössze néhány másodperc műve volt."

Utólagos megállapítás szerint a knyahinyai kőmeteorit kb. 1700 kisebb-nagyobb darabra robbant szét. Az összegyűjthető darabok száma kb. 1200 volt. Ezek közül 53-nak a becsapódási helye volt pontosan meghatározható. E megjelölt helyeket az ungvári Kataszteri Felügyelőség mérnöke mérte be és rögzítette a kataszteri térképen. Ennek alapján SZABÓ egy 1:28.800-as méretarányú topográfiai térképen az említett 53 meteorit becsapódási helyét piros pontokkal tűntette fel. A térkép címe: "Knyahinya Ungmegyei falu határában 1866 junius 9. d.u. 5 órakor történt Meteorkő-esésnek Térképe Szabó Józseftől 1869. - Nyomta: Rohn és Grund, Pest. 1869."

E térkép, valamint SZABÓ feljegyzései és közlései (Szabó 1967, 1968) alapján az alábbi megállapításokra jutottam:

A szótszóródott kisebb-nagyobb meteoritokat egy ÉK-DNy-i főtengelyű, hosszúra nyúlt ellipszis alakú térségen belül találták (5. ábra). Az ellipszis tengelye lényegesen eltér a tüzes meteor Ny-K-i irányától (6. ábra). Az ellipszis főtengelye 6050 m hosszú, legnagyobb szélessége pedig 1840 m volt. Az első robbanás az ellipszis DNy-i részében következett be. Itt egy 1000 m hosszu főtengelyű és 610 m maximális szélességű kisebb ellipszisen belül DUMA György, ungvári gimnáziumi tanár 27 ökölnyi vagy annál valamivel kisebb meteoritot gyűjtött össze.

Legtávolabbra a két legsúlyosabb darab repült. Egyik 294 kg-os volt, ez a bécsi Naturhistorisches Museumba került (3. ábra); a másik 41,26 kg-os darab (4. ábra) ma a budapesti Természettudományi Múzeum Ásványtárának tulajdona.

SZABÓ megfigyelte, hogy valamennyi nagyobbacska meteorit úgy fúródott a talajba, hogy a meteor eredeti útvonalának megfelelő befúródási csatornája iránytűvel bemérhetően Ny-K-i csapású volt. Magukat a meteoritokat is úgy találták meg, hogy a gyér fűvel borított talaj É 90°-270° irányban fel volt túrva és a becsapódáskor szerteröpített talajrészek is ilyen irányban helyezkedtek el.

A legsúlyosabb darabot a becsapódási helyétől 90 méter távolságban 3,5 m mélységben találták meg. Csatornájának lejtőszöge 2° 14' volt. A 41,26 kg-os meteorit is tekintélyes utat tett meg a talajban, és méternyi mélységben állapodott meg. A kisebb darabok behatolási távolsága 12-25 m körüli volt.

SZABÓ becslése szerint a knyahinyai meteor teljes súlya 500 kg körüli lehetett. Mint ilyen, a kőmeteorok között világviszonylatban a legnagyobbak közé tartozik. Megfigyeléseiből és feljegyzéseiből az az érdekes és fontos fizikai következtetés vonható le, hogy amikor egy ilyen nagytömegű meteor szétrobban és egyes darabjai szétrepülnek, a héjdarabok elválása a meteor főtömegétől heves lökéssel történik, s ez az erőhatás, valamint a leváló rész okozta tömeghiány az addigi egyensúlyi állapotot megzavarja. Mivel ez a folyamat szinte pillanatonként megismétlődik, a meteor gyorsuló jellegű, szabálytalan imbolygó mozgásba jön, de egyenesvonalu pályáját tehetetlenségénél fogva megtartja.

Ugyanezen ok miatt a szétrobbanó és a talajba fúródó meteoritok nem töltik ki a burkoló ellipszis egész területét, hanem csakis a haladás irányába eső ívhez tartozó teret. Esetünkben ezért az ellipszis Ny-i felében meteoritokat egyáltalában nem találtak.

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László BENDEFY
H-1122 Budapest
Maros u. 36.