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Research Institute on Anomalous Phenomena (RIAP) is an independent scientific research body, established in 1992 by the Kharkiv-based aerospace company *Vertical* and aimed at scientific studies in the fields of non-traditional energy sources, the problem of anomalous atmospheric phenomena and the SETI (Search for Extraterrestrial Intelligence) question.

We study:
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We consider:
any theories.
We accept:
normal proofs,
exact references.

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A Note From the Staff of RIAP

We wish to express our sincere apology to the readers of *RIAP Bulletin* for the long delay in publishing and distributing this RB issue. The Institute has been passing through a difficult period; indeed, its continued existence has been threatened. Furthermore, although many obstacles have been overcome, we cannot as yet say that the struggle is finished. However, happily enough, *RIAP Bulletin* is once again afloat, with a fighting chance at remaining in syndication. Additionally, we can finally hope to reach an important goal, established at the Bulletin's inception, but formerly unrealized: to issue a complete set of *four* issues of RB this year, without any serial issues. We would like to thank you, our subscribers and readers, for your patience, understanding, and constant support during this difficult time. It is important to realize that is nearly as difficult to engage in serious anomalistics investigations in post-Soviet countries as it was in the former Soviet Union, although the causes of such difficulty, then and now, differ considerably. Nevertheless, we will certainly continue to do our best, studying anomalous phenomena and sharing our findings with you. The central purpose of the *RIAP Bulletin* – of disseminating reliable information and well-founded hypotheses about the nature of anomalous phenomena – remains our unwavering commitment to you, our subscribers and readers.

Vladimir Rubtsov, Alexander Beletsky, Valentin Andreev, Svetlana Sobolevskaya, Pyotr Kutniuk, Nikolay Nesterenko, Yuriy Shanin.

EDITORIAL

The Tunguska Event: Still Highly Enigmatic...

Both this and the next RB issues, published simultaneously, are given over to that seemingly insoluble problem – the riddle of the Great Tunguska explosion of 1908. Less than two years remain before the first centennial of the event, and it appears that the problem will meet its 100th birthday as enigmatic and perplexing as it has remained throughout the past century. This does not mean, however, that *no* progress has been made in the investigation of the mysteries posed by the "Tunguska meteorite" (as this strange and complex phenomenon was named many years ago, when a meteoritic nature of the extraterrestrial body was considered self-evident).

Russian Tunguska investigators (including those involved in IITE – the Interdisciplinary Independent Tunguska Expedition; see RB, 1994, Vol. 1, No. 3-4; 2000, Vol. 6, No. 1) have finally found a tentative niche in the new, post-communist socio-economic order. Of course, large expeditions to the site, comprising up to 100 participants during the decades 1960–1980, are now in the past. At the same time, the National Nature Reserve *Tungusskiy* is established and functional, the Tunguska explosion area is not standing empty (even tourists from abroad visit the region, mainly in summer), and scholarly conferences on the Tunguska problem are organized by serious scientific institutions. Yet, the general situation in the community of Tunguska researchers is far from stable. First, this community remains inhomogeneous: the "traditionalists" support "classical" (strictly meteoritic or cometary) hypotheses on the nature of the Tunguska space object , while the "alternativists" are willing to consider an entire range of hypotheses, including "unconventional" or "non-classical" ones.

Essentially, these two factions are speaking rather different languages. The former prefer abstract "disciplinary" models of the phenomenon (i.e., purely mechanical, or cosmochemical models, taking into consideration only a small part of the potential evidence collected in the course of various field investigations); the latter attempt to develop complex *interdisciplinary* models, taking cognizance of the complex character of the Tunguska event and giving due consideration to *all* potential evidence. Since the prevailing epistemological (and social) values in science favor a "disciplinary" approach, it is this approach that is broadly approved by most conventional academicians who are not, as a rule, aware of the complete nature and range of data obtained by Tunguska researchers during a century of investigations. Neither are such traditionalists well-informed regarding the true complexity of the phenomenon revealed in the mass of data that has been acquired.

The IITE has had its share of internal problems as well. After the untimely death of the long-standing IITE Scientific Director, Dr. Nikolay Vasilyev (see: RB, 2001, Vol. 7, No. 1), a conflict inside the organization arose that resulted in rift between the two "factions" – one oriented towards a closer cooperation with "normal science" (which could in the near future lead to a radical change in the course of the IITE research), and the other, which, while not denying the need to attract "mainstream science" to the Tunguska problem, still insisted that the first priority should be to develop the "alternative" models of the phenomenon. In addition to this potent problem, the journal, *Tunguska Herald* (whose 15 issues, containing a lot of truly interesting ideas, data, and discussions, have been published by the IITE between 1996 and 2003), is no longer published – which of course, does not facilitate the development of further Tunguska studies.

To this author's mind, the conflict is mainly the result of a misunderstanding. "Alternative" conceptions in this field of research are not necessarily strictly "unscientific" ones. If some representatives of mainstream science still cannot bring themselves to entertain certain alternative ideas, this is the result of their own unique biases. In fact, it is the ongoing vacillation of the "conventional astronomer," back and forth between the cometary and meteoritic models of the Tunguska space body (TSB), that is in sharp contrast with the usual methodological standards of science. The steady development of the "starship conception" has been more consistent with the traditional scientific methods. Granted, the latter hypothesis did encounter a deadlock of sorts: a great deal of "anomalous" (from the cometary-meteoritic point of view) data has been collected, but a sound theoretical model of an "alien starship" is, of course, presently lacking. It is therefore impossible to compare these anomalous data with such a model, thereby lending support to the starship hypothesis. As Dr. Victor Zhuravlev notes in his interview (published in the section "RB Questions and Answers" of this RB issue), the only way out of this deadlock seems to be through instituting an intensive search for material remnants of the TSB.

Of course, the IITE is a dynamic organization that has endured other crises, and this gives hope that the current crisis will also be successfully resolved. The approaching 100th anniversary of the Tunguska event will hopefully serve as an opportunity for increased mutual understanding. Organizational committees have already begun to plan anniversary conferences in Moscow, Novosibirsk, Tomsk, and Krasnoyarsk. The "main" conference, in Krasnoyarsk, will be held over a three day period in June 2008, after which participants will be given the opportunity to fly to Vanavara, and from there to the Tunguska explosion site. Foreign participants and – possibly – tourists are expected to attend this event, and field work is also planned for those days. In addition to this, a "non-meteorite conference" is planned in Moscow, where researchers will be able to present and discuss those ideas about the Tunguska event that are currently rejected by mainstream science. Several collections of articles on the Tunguska problem will likely be published, some even before the conferences convene.

The 95th anniversary of the Tunguska event was also marked by a large conference in Moscow, organized jointly by the International Astronomical Society, the Institute of Mechanics, the Sternberg State Astronomical Institute of Moscow State University, and the IITE. Abstracts of papers presented at this conference were published in separate sections, one being devoted to discussions of primarily (but not exclusively) "traditional" models and hypotheses, and the other to "non-traditional" ones. The "traditionalists" generally held to the position that the Tunguska problem is at last finally solved (certainly not the first time this claim has been made in the last century); the "alternativists" maintain that such declarations are premature and propose other interpretations of the event. Only time will tell which faction proves to be correct – nevertheless, such a balanced and respectful approach to the presentation of widely differing conceptions should be commended. This may well even serve as a *model* for future publications on this subject.

Anniversaries are important, but still more important is the ongoing research into the event. Despite many years of active Tunguska investigations, much remains to be done in both the field and the laboratory. The paper authored by the late Drs. Nikolay Vasilyev and Gennadiy Andreev, concerning the problem of radioactivity at the Tunguska explosion site, is an example of a crucially important program that was implemented at the very beginning of multidisciplinary Tunguska investigation (as far back as 1958), but has never been completed. While some may point out that conceptions founded on the meteoritic hypothesis do not require such investigations, at all, it is a fact that IITE was formed in the late 1950s as a research body devoted to *fully objective* research work. This being the case, scientific objectivity not only *allows* for investigations such as those proposed by Vasilyev and Andreev; in fact, it *demands* that such investigations proceed.

Incidentally, an “alternative” approach to the Tunguska problem does not necessarily mean a “starship hypothesis.” As is suggested in the paper by Dr. Zurab Silagadze, published in this and the next RB issues, the variety of minor bodies in the Solar system may turn out to be considerably richer than is supposed nowadays. It should be noted that specialists in meteoritics are often unaware of recent findings in particle physics, and may therefore have no knowledge of exotic hypothetical constructs such as “mirror matter,” predicted to exist in certain mathematical models. While it is at present uncertain whether the idea of “mirror bodies” might explain the Tunguska event, I nevertheless maintain that the paper presented by Dr. Silagadze is of great importance. Therein a serious scientist refuses to reject, out of hand, such seemingly anomalous phenomena, but treats them with serious consideration. It is well to keep in mind that nature is always “right,” whereas our theories and preconceptions often are not.

This is not to say that starship models are not worthy of attention. As is detailed in the paper, “Analysis of the Map of Ash Content at the Area of Tree Leveling of 1908,” Dr. Zhuravlev has found new evidence for a non-uniform structure of the TSB. It appears to have consisted of two different parts: an “explosive” and a “shell,” resembling in this way an artificial construction, and not a natural body from the space. Dr. Zhuravlev, being one of the founding fathers of the IITE, has made a great contribution to transforming the initial, rather vague starship idea by Alexander Kazantsev and Alexey Zolotov into a verifiable hypothesis with a specific research strategy. In particular, he studied in depth the geomagnetic effect of the Tunguska explosion (see: RB, 1998, Vol. 4, No. 1-2). Now, another magnetic anomaly associated with this event has attracted attention of the Tunguska research community – namely, the so-called “Weber effect.” In the paper by Boris Bidiukov (published in RB, Vol. 10, No. 2) the existing information about this effect, however scarce, is analyzed in detail. Again, the quasi-regular oscillations of a magnetic needle, recorded by Professor L. Weber in Kiel, Germany, from June 27 till June 30, 1908, can hardly be related to a stony asteroid or a comet approaching the Earth.

Thus, we may conclude that Alexander Kazantsev’s conjecture about the overground character of the Tunguska explosion and non-mundane nature of the Tunguska space body *did* stand the test of time. Its author passed away in September of 2002 not having seen his hypothesis entirely vindicated. However, when *all* the evidence collected at the Tunguska explosion site is examined and compared from an interdisciplinary perspective, this “fantastic hypothesis” looks much more rational than certain abstract hypothetical schemes, which remain internally consistent only due to the employment of a “Procrustean” methodology. We should be deeply grateful to the Tunguska researchers of various generations – beginning with Leonid Kulik and his colleagues – for their selfless efforts in investigating this anomaly. The paper “Questioning Witnesses in 1926 about the Tunguska Catastrophe,” by Innokentiy Suslov (RB, Vol. 10, No. 2), is a testimonial to these early efforts, well worthy of presentation to the RB readership.

Let’s celebrate the work of past Tunguska researchers – and let’s wish success to their successors!

— Vladimir V. Rubtsov

THE PROBLEM OF THE TUNGUSKA METEORITE

Tunguska Genetic Anomaly and Electrophonic Meteors – Part 1

Zurab K. Silagadze

1. Introduction

The Tunguska region has been surrounded by an aura of mystery and adventure over the last 98 years. Many different theories have been proposed to explain what happened so many years ago in a remote corner of *Siberia*, which means the "Sleeping Land" in Tatar (Gallant 2002). However, none of these explain all the facts. This is not surprising – the systematic research into the Tunguska explosion began only after a significant delay, and the facts which have since been revealed are indeed perplexing (Vasilyev 1998, Bronshten 2000a, Zolotov 1969, Zhuravlev & Zigel 1998, Ol'khovatov 2003).* More surprising is that this ostensibly scientific problem has raised so much interest and excitement outside the scientific community. It seems that the psychological roots of an emotional approach to the problem of the Tunguska meteorite are not always well recognized and appreciated. We are therefore inclined to give some thought to this side of the Tunguska problem before we engage in a more conventional scientific discussion.

The truth is that both public and scientific interest in the Tunguska catastrophe were inspired by Alexander Kazantsev's (1946) fantastic suggestion that the explosion of a nuclear powered alien spacecraft was the cause of the Tunguska event (Plekhanov 2000, Baxter & Atkins 1977). It should also be noted that, quite unlike the "man on the street," the scientific community is rather "reluctant" when the subject of alien spacecraft, and UFOs in general, comes up. Because of this reluctance, the scientific community thus turns a blind eye to an important phenomenon: the birth and rise of the modern-day UFO myth, as well as its apparent impact on the popular culture. This is a highly problematic phenomenon, crying out for scientific explanation. To the best of this author's knowledge, the famous Swiss psychologist Carl Jung (1959) was the first scholar to realize scientific importance behind seemingly absurd accounts of unidentified flying objects.

According to Jung, these accounts are a projection of the inner psychic state of modern man onto the heavens, and represent his longing for wholeness and unity in this divided, hostile, and often confusing technological society in which he finds himself. Viewing the UFO phenomenon in this respect, it appears that it may have been a harbinger of increasing social and psychological pressures in society, of archetypal changes. It may reflect the end of one historical era and the beginning of a new one (Fraim 1998).

In this respect the "mythic impact" of the Tunguska explosion on the native Evenk people, representatives of a different culture, is of great interest. Therefore it is not surprising that Floyd Favel, one of Canada's most acclaimed playwrights and theater directors, wrote a play, *The Sleeping Land*, based on the profound spiritual impact that the Tunguska event had upon the Evenk people (Gordon & Monkman 1997). It is a fine story. It begins by showcasing the clash "between two Tunguska Evenk clans. Over the years, their feud escalates, both clans using their powerful shamans to curse to the other with evil spirits, misfortune, and disease. The hostility between them grew until one shaman called upon the Agdy to destroy the hated enemy forever. These fearsome iron birds fly above the earth in huge clouds, flapping their terrible wings, causing thunder, and lightning flashes from their fiery eyes. On that sunny morning in June 1908, the sky became black as a never ending legion of the fearsome birds swooped low over the unfortunate Shanyagir clan. Their devastating blasts of fire blew the Shanyagir's tents up into the air, over the tree tops. The clan's belongings were destroyed, two hundred and fifty of their reindeer vanished without a trace, the ancient forest was flattened in every direction, and those who still could, fled in panic. To this day, the Evenk believe that only the Agdy can live in the area where explosion took place. Only a few will risk visiting. And none will live there." (Gordon & Monkman 1997)

Although there are cultural differences, this Evenk myth resembles the Biblical story of Sodom and Gomorrah, where according to a divine mandate, fire rained from heaven, destroying these two cities. One may suppose that this ancient myth chronicles a genuine

* For the complete list of references, see Part 2 of this paper, published in the next RB issue. – *Ed.*

cosmic event (Clube & Napier 1982). In the Koran, the holy book of Islam, one finds a similar story (Wynn & Shoemaker 1998) about an idolatrous king named Aad who scoffed at a prophet of God. As punishment for his impiety, the city of Ubar and all its inhabitants were destroyed by a dark cloud brought on the wings of a great wind. This story has an unexpected and remarkable continuation. In 1932 an eccentric British explorer named John Philby (Monroe 1998), obsessed with finding Ubar, made an arduous trek into the Empty Quarter of southern Saudi Arabia, one of the most inaccessible and formidable deserts of our planet (Wynn & Shoemaker 1997). He did find something interesting in the place he dubbed "Wabar" – in retrospect, his misspelling of "Ubar" was fortunate, because he had found not the lost city of the Koran, but the location of a fierce meteorite impact (Wynn & Shoemaker 1997, 1998).

The real city of Ubar was allegedly found much later, and its ultimate fate proved to be similarly dramatic (Clapp 1999). Radar images from the *Landsat* and *SPOT* satellites, which uncovered old caravan routes, played the crucial role in this discovery (El-Baz 1997). Evidence indicates that Ubar's destruction was not from a cosmic source; instead it fell into a sinkhole created by the collapse of an underground cavern of limestone. However, the Wabar meteorite most certainly could have destroyed Ubar, or any other ancient city – the force of its impact was approximately 12 kilotons, comparable to the atomic bomb dropped on Hiroshima during WWII (Wynn & Shoemaker 1998). By comparison, the Tunguska explosion was thousand times more powerful, capable of annihilating any modern city. With this in mind, we reach conclusion that the unconscious fears of modern man about hazards from outer space are not completely groundless, although in this case, it is not aliens but minor members of the solar system – comets and asteroids – which are the source of apprehension. It is clear that to reliably estimate the dangers of a cosmic impact would aid in the understanding of the Tunguska space body (TSB). Therefore, we now embark on a more conventional scientific track, as promised above.

There are two main hypotheses regarding the nature of the TSB: that it was a comet (Shapley 1930, Fesenkov 1966, Zotkin 1969, Kresak 1978) or an asteroid (Kulik 1940, Fesenkov 1949, Sekanina 1983, Chyba et al. 1993). Unfortunately for science, the proponents of these two hypotheses have largely ignored each other for a long time (Farinella et al. 2001), assuming that the question has been settled once and for all by one hypothesis or the other. This calls to mind Planck's principle (Hull et al. 1978), which states that "a new scientific truth does not triumph because its supporters enlighten its opponents, but because its opponents eventually die, and a new generation grows up that is familiar with it." There is still no consensus among scientists which of the two prevailing hypotheses is the correct one. Some recent research supports an asteroidal origin of the TSB (Foschini 1999, Farinella et al. 2001), while Bronshten (2000b) advocates the cometary hypothesis, citing that despite an extensive and scrupulous search, no fragments of the alleged meteoritic body were found. He argues that neither fireball radiation nor air friction would completely eliminate the fragments from a stony asteroid.

However, there are phenomena in the Tunguska region which are hard to reconcile with either of the prevailing hypotheses (Vasilyev 2000, Ol'khovatov 2003). We will now discuss the ecological and genetic impacts of the Tunguska event, which is one such phenomenon.

2. Biological consequences of the Tunguska event

Ecological consequences of the Tunguska event have been comprehensively discussed by Nikolay Vasilyev (1999, 2000). They constitute another problematic aspect of this intricate phenomenon. There were two main types of effects observed. The first effect includes accelerated growth of young trees which sprouted after the explosion, as well as trees that survived the catastrophe, over a vast area. Also curious was the quick recovery of the taiga after the explosion. The second type of effect concerns the genetic impact of the Tunguska event.

Participants in Kulik's first expeditions made some observations about forest recovery in the region. In various years the impressions were different (Vasilyev 1999): in 1929–1930 the growth of the taiga seemed depressed in this area, while in 1953 no signs of growth deceleration were observed in the taiga, when compared with neighboring regions. The first systematic study of growth of the trees in the region was performed during the 1958 expedition (Vasilyev 1999). Anomalously large tree ring widths up to 9 millimeters were found in young specimens which had germinated after the catastrophe, while the average width of the growth rings before the catastrophe was only 0.2–1.0 mm. Not only the young trees were affected, however –

the accelerated growth was observed in trees which had survived the catastrophe.

Stimulated by these first findings, a large scale study of forest recovery in the Tunguska area was performed in a series of expeditions after 1960. In the 1968 expedition, morphometric data for more than six thousand pine specimens were collected. This large sample clearly establishes the reality of the accelerated growth (Vasilyev 1999). A more recent study by Longo & Serra (1995) confirms this spectacular phenomenon and indicates that the growth has weakened only recently for trees older than 150 years.

The cause of the anomalous growth remains uncertain. The most simple and most prosaic explanation, suggested in the sixties (Vasilyev 1999), assumes that the explosion led to an overall improvement in environmental conditions, the result of ash fertilization and decreased competition for light and minerals as a function of the increased distance between trees. Longo & Serra (1995) found an interesting correlation between the anomalous tree growth and the dimensions of the growth rings before the catastrophe. The growth acceleration was more prominent for trees that grew more slowly before the catastrophe. However, concluding that this finding favors the simplistic hypothesis, described above, should be considered premature in light of Vasilyev's (1999, 2000) analysis, which was conducted in more detail and from a broader perspective.

According to Vasilyev (1999), the influence of the Tunguska event on the final tree dimensions is simply a manifestation of Wilder's Law of initial values (Wilder 1953), which states that the higher the initial level of some physiological function, the smaller the response of a living organism to function-raising agents and the greater the response to function-depressing agents, regardless of the nature of the stimuli. Naturally, the change of the environmental conditions doubtless played a significant role in the recovery of the taiga, but there are some features of the accelerated growth phenomenon which are hard to explain solely on the grounds of this consideration alone.

There are areas in which the accelerated growth is observed to have produced different shapes for both the young, post-catastrophe trees and the old "survivors" (Vasilyev 1999). For the young trees the effect is maximal within the epicentral area. But the region where the accelerated growth is observed differs significantly both from the area where the forest was blown down, and from the area affected by fire. This interesting detail hints that a change in the environmental conditions is not the leading cause of the accelerated growth in this case. Instead, one can suppose that the primary factor was the proximity of the ancient volcano and the resulting enrichment of the soil with nutrient-rich volcanic material (Vasilyev 1999). An interesting fact is that the location of the Tunguska epicenter coincides almost precisely with the vent of a Triassic volcano. Therefore, if the accelerated growth of the young trees in the Tunguska area is indeed related to the soil enrichment with rare earths and other elements of volcanic origin, it is not surprising that the effect is maximal in the epicenter area, where the volcanic vent is also situated. What is surprising was found by observing later generation trees. It turned out that the younger the trees, the more pronounced the accelerated growth effect towards the projected TSB trajectory (Vasilyev & Batishcheva 1979, Vasilyev 1999). Therefore there is an additional factor, directly related to the possibility of mutagenic effects associated with the TSB.

For the old, "survivor" trees, the effect of the accelerated growth is of a patchy character. One can find such trees in the area where the forest fell, as well as outside it. Again, this effect is more prominent in regions in the vicinity of the TSB trajectory. Besides this, the areas where the effect is observed have oval contours, paralleling the direction of the TSB trajectory (Emelyanov et al. 1979, Vasilyev 1999). It is also interesting that there are regions, such as the area between the Kimchu and Moleshko rivers, with considerable forest fall but lacking any signs of the accelerated growth among "survivor" trees (Vasilyev 1999). Moreover, the effect of the accelerated growth does not reach its maximum within the area of investigation. Instead, maximum is extrapolated to be far from the epicenter, some 20–25 km away (Emelyanov et al. 1979, Vasilyev 1999). One gets the impression that the flight of the TSB was accompanied by some unknown agent which caused remote ecological effects, and perhaps even genetic ones.

Genetic consequences of the Tunguska event are the most controversial aspect of the Tunguska explosion under serious discussion. In the 1960s, some experiments were performed in Novosibirsk to study the genetic effects of ionizing radiation on pine trees. Among various changes observed, the most prominent effect was an increased occurrence of clusters of three needles, on pines which normally possessed on clusters of two needles. Excited by this finding, G. F. Plekhanov organized special expeditions to study young pines in the catastrophe area. It turned out that the frequency of 3-needle-cluster trees actually was higher in the epicentral area, having its maximum near Mount Chirvinskii – the point where the TSB trajectory “pierces” the Earth’s surface and where the effect of accelerated growth also reaches its maximum for post-catastrophe trees (Vasilyev 1999). However, it is rather common that 3-needle cluster pines should occur with high frequency in areas undergoing major recovery after forest fires, when pines exhibit a rapid increase in growth. It is therefore unfortunate that this interesting phenomenon cannot be definitively associated with the primary factors of the Tunguska explosion and may, instead, be a secondary effect.

In the 1970s, V. A. Dragavtsev developed a special algorithm to separate genotypic variations from phenotypic ones. The linear increments of Tunguska pines were processed with this algorithm. It was found that the genotypic dispersion has sharply increased in the Tunguska trees. The effect is pronounced, has a patchy character, and concentrates toward the epicenter area, as well as towards the projection of the TSB trajectory (Vasilyev 1998, 1999, 2000). At its maximum the genotypic dispersion shows about a 12-fold increase (Vasilyev 2000). One of the maximums coincides again with Mount Chirvinskii, another with the projection of the calculated center of the light flash onto the earth surface (Vasilyev 1999).

No indications of an increased level of mutagenesis were found in the area in a later study of pine isozyme systems polymorphism utilizing eletrophoresis. Unfortunately only 11 trees from various locations were studied and the results could not be averaged because of the small size of the sample. Therefore, although this result does not strengthen Dragavtsev’s findings, it does not provide a basis of rejecting them, either (Vasilyev 1999).

Some population-genetic studies were performed in the catastrophe area by using a variety of pea plant, *Vicia cracca*. All of the phenogenetic characteristics studied were found to be considerably higher in the epicentral area than at the reference point near the settlement of Vanavara (about 70 km from the epicenter). Two special points showing a maximal effect are clearly seen in the resulting data. Remarkably, one of them again centers on Mount Chirvinskii. The other point, Churgim canyon, is located only 1–1.5 km from the projection upon the earth’s surface of the center of the light flash which accompanied the Tunguska explosion (Vasilyev 1999).

The same researchers studied fluctuating asymmetry of birch leaves in a wide region. It is believed that fluctuating asymmetry arises as a result of stress the organism experiences during its development and is a good measure of its ability to compensate for the stress. It was found that the asymmetry is significantly increased not only in the epicentral area, but also in remote regions not affected by the Tunguska explosion (Vasilyev 1999). This is not surprising because the climatic conditions are severe in the Siberian taiga and recent studies indicate that fluctuating asymmetry in leaves of birch seems to be a reliable indicator of ambient climatic stress (Hagen & Ims 2003). Interestingly, within the epicentral area, the highest asymmetry is observed in the vicinity of the previously noted Mount Chirvinski (Vasilyev 1999).

In 1969, morphometric peculiarities of the ant species *Formica fusca* were studied in the epicentral area by inspecting 47 anthills. No noticeable differences were found at several locations, but ants from the vicinity of Mount Chirvinskii and the Churgim canyon were significantly different (Vasilyev 1999). Unfortunately, no control studies were performed outside the epicentral area. Related studies were carried out in the years 1974–1975 utilizing the ant species *Formica exsecta*. No peculiarities were found in the ants residing in the central and peripheral parts of the catastrophe area (Vasilyev 1999).

A very interesting genetic mutation, possibly related to the Tunguska event, was discovered by Y. G. Rychkov (2000). Rhesus negative persons among the Mongoloid inhabitants of Siberia are exceptionally rare. During 1959 field studies, Rychkov discovered an Evenk woman lacking the *Rh-D* antigen. Genetic examinations of her family led to the conclusion that this very rare mutation of the *Rh-D* gene happened in 1912. This mutation may have affected the women’s parents, who in 1908 lived at a distance of some 100 km from the epicenter and were eyewitnesses of the Tunguska explosion. The woman remembered her parents’ impressions of the event: a very bright flash, a clap of thunder, a droning sound, and a burning wind (Rychkov 2000).

All these facts indicate that the Tunguska event left some very peculiar ecological and genetic anomalies. It is rather hard, though, to distinguish between the primary and secondary factors which led to the observed anomalies. The latter ones could have had a complex origin. However, the recurrent factor of the TSB trajectory, along with certain factors related to it in the above reports, nevertheless suggest that the flight and explosion of the

TSB were accompanied by an unknown agent that precipitated ecological and biological effects. A recurring feature of the conventional Tunguska theories is their inability to explain the nature of this agent. We think that this unknown agent might be electromagnetic radiation. Interestingly, powerful electromagnetic radiation is suspected to accompany "electrophonic meteors" – a very interesting class of enigmatic meteoritic events.

3. Electrophonic meteors and the Tunguska bolide

The history of research into electrophonic meteors presents another good example of Planck's principle in action. In 1719 the eminent astronomer Edmund Halley collected eyewitness accounts of a huge fireball seen over much of England. He was perplexed by the fact that many reports declared the bolide emitted a hissing sound, as if it was very near to the observers. Being aware that sounds cannot be quickly transmitted over great distances, Halley dismissed the effect as purely psychological, as "the effect of pure fantasy." His conclusion and Halley's authority hindered any progress in the field for two and a half centuries (Keay 1997).

At present, eyewitness accounts reporting unusual sounds in association with meteoritic events are quite numerous (Vinkovic et al. 2002, Keay 1994a), and the reality of the effect is practically beyond question. Electrophonic sounds can be divided into two classes according to their duration. Some 10 % of the observed events have a short duration, about one second, belonging to a class of "burster" events. They produce sharp sounds which are reported as "clicks" and "pops." Other electrophonic events are of longer duration, and are described as "rushing" or "crackling" sounds (Keay 1992a, Kaznev 1994). Interestingly, similar "clicks" have been reported to be heard by soldiers during nuclear explosions and it is assumed that these sounds are caused by an intense burst of very low frequency (VLF) electromagnetic radiation, which peaks at 12 kHz (Johler & Monganstern 1965, Keay 1997).

The mechanism by which VLF radiation can be generated by a meteoroid was proposed by Keay (1980). It is suggested that the geomagnetic field becomes trapped and "twisted" in the turbulent wake of a meteoroid. Afterwards, the plasma cools and the energy of the "strained" field is released as VLF electromagnetic radiation. This theory was further elaborated by Bronshten (1983), who showed that VLF energy on the order of 1 megawatt can easily be generated by sufficiently energetic bolides.

Extremely low frequency (ELF) and VLF electromagnetic fields can be generated by other mechanisms as well. For example, explosive disruption of a large meteoroid will generate an electromagnetic pulse similar to that produced during nuclear explosions. An electrostatic mechanism which may perturb the geomagnetic field, in the case of bolides with steep trajectories, was considered by Ivanov and Medvedev (1965). Beech and Foschini developed a space charge model for electrophonic bursters (Beech & Foschini 1999, 2001). They suggest that during the catastrophic breakup of a meteoroid, a shock wave propagates in the plasma around the meteoroid and leads to a significant space-charge, resulting from the differing mobility of ions and electrons. In this case no significant VLF signal is generated; instead we have a brief disruption in the geoelectric field.

Some manner of transducer is required to transform the VLF energy into an audible form, and this is what makes the electrophonic meteor observations such a rare and capricious phenomenon (Keay 1997). In a group of observers within close proximity of one another, one or two may hear the sounds and the others may not. In a series of experiments, Keay and Ostwald demonstrated (1991, 1997) that for audible frequency electric fields various common objects may serve as transducers. For example, volunteers were able to detect as low as 160 volts peak-to-peak variations of the electric field at 4 kHz frequency, with their hair or eyeglass frames acting as the transducer.

Therefore, at last we have an elegant and scientifically sound explanation of these mysterious sounds which have baffled scholars for centuries. But any theory needs an experimental confirmation. Unfortunately, instrumentally recorded electrophonic meteor data are very scarce due to the extreme rarity of the phenomenon: by an optimistic estimate, a person who spends every night outdoors might expect to hear an electrophonic sound once in a lifetime (Keay & Ceplecha 1994b, Keay 1997).

In 1993 Beech, Brown and Jones (1995) detected 1–10 kHz broad band VLF transient concomitant to a fireball from the Perseid meteor shower. However, no electrophonic sounds were reported. Even before this, a meteoritic VLF signal was detected by Japanese observers (Keay 1992b). Garaj et al. (1999), as well as Price and Blum (1998) reported detection of ELF/VLF radiation in association with the Leonid meteor shower. A very interesting observation was made during reentry of the Russian communication satellite Molniya 1-67 (Verveer et al. 2000). An observer reported an electrophonic sound near the terminus of the trajectory of the satellite. The satellite had produced a large orange fireball when reentering the atmosphere. At the same time several geophysical stations in Australia detected a distinct ELF (about 1 Hz) magnetic pulse. Unfortunately, no instrumentation was available to detect electromagnetic radiation above 10 Hz to confirm Keay–Bronshten's theory. Interestingly, ELF electromagnetic transients may affect the human brain directly and therefore may require lower energy levels to produce electrophonic effects (Verveer et al. 2000). These sparse experimental data are clearly insufficient to draw definite conclusions about the physics of the radio emissions from meteors (Andreic & Vinkovic 1999). On the other hand, the existing theoretical models are also too simplified to be able to give a detailed description of the phenomenon (Bronshten 1991).

A remarkable breakthrough in the research of electrophonic meteors came with the first instrumental detection of electrophonic sounds during the 1998 Leonid meteor shower (Zgrablic et al. 2002). Ironically, Leonid meteors are not well-suited for production of the VLF radiation via the Keay–Bronshten mechanism which demands the Reynolds number in the meteor plasma flow exceed 10^6. In the case of the Leonids, which are mostly dust grains, this leads to unreasonably large initial size $D_0 > 3$ m and mass of some 3000 kg (Zgrablic et al. 2002). Nevertheless, two clear electrophonic signals were instrumentally recorded in this experiment. The first one originated from a meteor at an altitude of about 110 km, the second from another at an altitude of 85–115 km. In both cases the sounds preceded the meteors' light maximum. These features are also hard to explain in other models suggested for electrophonic bursters. No ELF/VLF signal was detected in these two events – but the receiver apparatus was insensitive to frequencies below 500 Hz, while the frequency range of the observed electrophonic sounds was 37–44 Hz. If one assumes that these sounds originated from the transduction of the ELF/VLF transient, the observed sound intensities will imply unreasonably high ELF/VLF radiation power, which cannot be explained by any theoretical mechanism resulting from the meteor alone (Zgrablic et al. 2002). Therefore, this remarkable observation shows that the existing theories are at least incomplete and the electrophonic meteor mystery remains largely unresolved.

Zgrablic et al. (2002) suggested that the Leonids acquire large enough space charge to trigger a yet unidentified geophysical phenomenon upon entering the E-layer of ionosphere at ~110 km altitude. It is assumed that such a phenomenon will in turn generate a powerful EM radiation burst. Note that this possibility was advocated by Ol'khovatov (1993) much earlier.

Keay–Bronshten's mechanism is expected to operate quite well for slow and bright bolides (brighter than the full Moon) which penetrate deep into the terrestrial atmosphere. The Tunguska meteorite was definitely of this type. Therefore we cannot exclude that its flight was accompanied by a powerful ELF/VLF radiation. Are there any eyewitness accounts which support the electrophonic nature of the Tunguska bolide?

As far back as 1949, Krinov noted with curiosity that many independent observers of the event described sounds that preceded the appearance of the bolide. He notes that similar phenomena have often been reported by those witnessing electrophonic meteors. However there was a significant difference between the two cases: in the case of the Tunguska bolide, the sounds were loud and strong, more like powerful strikes than feeble electrophonic cracks and rustles. Krinov notes further that this difference might be a consequence of the enormous size of the Tunguska meteorite. However, he finds it most likely that all these reports were purely psychological in nature – that the observers had an unconscious tendency to transpose the succession of light and sound effects, or temporally unify them, ignoring the actual time lag between these effects.

Here is one such witness account (Krinov 1949) from K. A. Kokorin, resident of the village of Kezhma:

"...At about 8 or 9 o'clock in the morning, not later, the sky was completely clear, without any clouds. I entered the bathhouse (in the yard) and just succeeded in taking my shirt out when suddenly heard sounds resembling a cannonade. At once I run out to the yard, which had an open perspective towards the south-west and west. The sounds still continued at that time, and I saw in the south-west direction, at an altitude about the half between the zenith and the horizon, a flying red sphere with rainbow stripes at its sides and behind it. The sphere was flying for about 3-4 seconds and then disappeared in the north-east direction. The sounds were heard all the time the sphere flew, but they ceased at once as the sphere disappeared behind the forest."

Krinov's reaction to this report is very characteristic of the history of the electrophonic sounds research. He considers it utterly impossible for the sounds to precede the bolide flight and concludes that Kokorin has simply forgot the right succession of the event's stages, as the inquiry took place in 1930, that is 22 years after the occurrence. Of course, in this particular case Krinov might be right, but the fact that similar assertions can be found in many other witness accounts forces us to consider just the opposite.

Y. S. Kudrin, who was child of nine years at that time, gives the following description of the sounds heard (Vasilyev et al. 1981): "The sound was like a thunder, it ceased after the bolide flew by. The sound was not very strong, just like an ordinary thunder. The sound was moving together with the object towards the north. The sound was heard before the object became visible and it stopped as the object disappeared."

I. K. Stupin was also a boy of 8-10 years old in 1908 and also remembers that the appearance of the sound preceded the appearance of the object. According to him the sound was muffled and of low tone. He did not notice any air wave or vibration of the ground (Vasilyev et al. 1981).

The eyewitness report from V. I. Yarygin is also of interest in this respect (Konenkin 1967): "In 1908 I lived in the village of Olontsovo, some 35 km from the town of Kirensk upstream the Lena river. At that day we were riding to a field. At first we heard a loud roar, so that our horses stopped. We saw a blackness on the sky, behind this blackness there were blazing tails and a fog of black color. The sun vanished and darkness came down. From this blackness a flame of fire darted from south to north."

One can easily find witness reports where the sounds resemble very close electrophonic ones. For example, E. K. Gimmer describes the sounds from the meteorite as "sizzling," like red-hot iron put into water (Vasilyev et al. 1981). S. D. Permyakov remembers that there was no roar when the bolide flew above him, instead he heard some noise and boom (Konenkin 1967).

Note that the electrophonic nature of the Tunguska bolide was argued earlier by Khazanovitch (2001), who gives other examples of eyewitness accounts to support this suggestion. Even earlier Vasilyev (1992) discussed the curious situation that thunderlike sounds were heard not only during and after the observed flight of the bolide but also *before* it. He dismissed the idea that this peculiarity was merely the product of subjective error on the part of the witnesses, as it had been reported by too many independent observers, some of them located several tens of kilometers from the projection of the bolide path. He came to the conclusion that the only reasonable explanation involved some kind of energetic electromagnetic phenomenon induced by the bolide.

It is interesting that a terrific roar of presumably electrophonic nature was reported by eyewitnesses as a Tunguska-like bolide passed over British Guyana in 1935 (Steel 1996). Other evidence suggestive of electromagnetic disturbances produced by bolides indirectly supports a possibility that a similar phenomenon cannot be ruled out in the Tunguska event either. The most recent one is related to the Vitim meteorite which fell in Siberia on September 25, 2002. The witness report from G. K. Kaurtsev, a Mama airport employee, clearly indicates that a strong alternating electromagnetic field was induced by the bolide during its flight, which led to induction phenomena and to the appearance of St. Elmo's fires (Yazev et al. 2003):

"At night there was no electricity, the settlement was disconnected from the power source. I woke up and saw a flash in the street. The previously unlit incandescent lamps of the chandelier lighted dimly, to a half their normal intensity. After 15 to 20 seconds an underground boom came. Next morning I went to the controller's office of the airport. Security guards Semenova Vera Ivanovna and Berezan Lydia Nikolaevna have told the following story. They were on the beat and saw that 'bulbs were burning' on the wooden poles of the fence surrounding the airport's meteorological station. They were scared very much. Fires glowed during 1–2 seconds on the perimeter of the protection fence. The height of the wooden poles is approximately 1.5 meters."

Note that the Mama settlement was located at a distance of several tens of kilometers from the bolide's flight path. Additionally, the scale of the Vitim event is incomparable with the scale of the Tunguska explosion: the latter was more energetic by at least three orders of magnitude. Therefore it seems very plausible that the flight of the Tunguska bolide might have been accompanied by very strong alternating electromagnetic fields. The central question is whether these fields could lead to the observed ecological and genetic consequences.

(To be continued in the next RB issue)

Analysis of the Map of Ash Content at the Area of Tree Leveling of 1908

Victor K. Zhuravlev

1. An Analog of the Ash Field

The peat layer that originated from the moss that had grown in 1908 in the area of the Tunguska catastrophe has been investigated over many years under the guidance of Dr. Nikolay V. Vasilyev and Dr. Yuriy A. Lvov. These studies made it possible to compose a map of the territorial distribution of peat cores that showed the layer corresponding to the year 1908 had been enriched with a mineral fraction (see Fig. 1, taken from Ref. 1). The authors of that paper noted that the discovered structure of the peat cores that showed the distribution of ash content was remarkably complicated and therefore required a thorough examination. However, even though that map of the ash content was published as far back as 1976, there has been no published research in the scientific literature to interpret it. In 1994, in the book [2] by V. K. Zhuravlev and F. Y. Zigel, we put forward a qualitative interpretation – which did not however attract any interest in the community of Tunguska researchers. So here we are going to elaborate this model further, using some quantitative estimations of the factual material we possess.

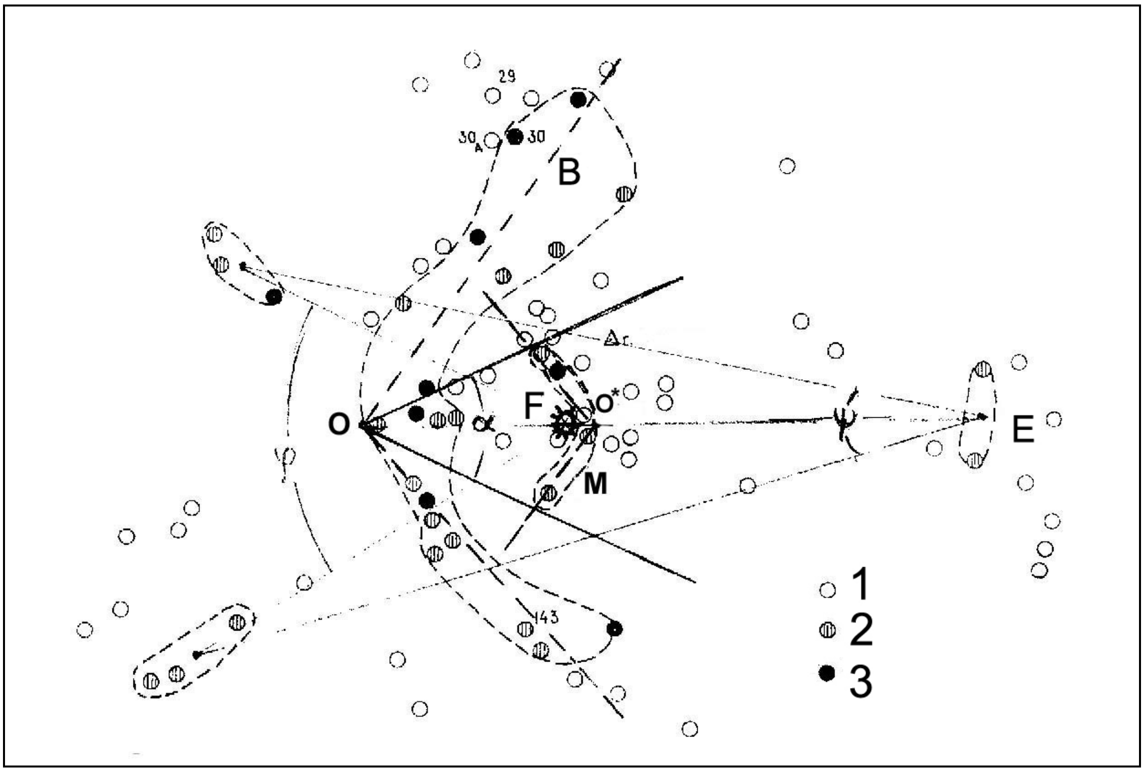

Fig. 1. A schematic map of the territorial distribution of peat samples, in which was selected the layer of 1908 (works of 1969-1970). The zones containing the samples with the peaks of the ash content in this layer are ringed with dotted lines.

Nomenclature: B – the greater arc-like zone; M – the smaller arc-like zone; E – the small zone in the east; F – the "epifast" (epicenter of the Tunguska explosion, calculated by Wilhelm Fast); OO* – the length selected as the scheme scale (the distance between the fronts of the arcs).

Angles: α – the sighting angle of the ends of the arc M from the point O (cf. Table 1); β – the angle, corresponding to the arc B (cf. Table 1); μ – the angle, corresponding to the arc M. The angle ψ sights on the symmetrical zones in the west from the center of the zone E; the angle φ sights on the symmetrical zones in the west from the "epifast" F.

1 (empty circles) – samples without peaks of the ash content; 2 (crosshatched circles) – samples with small peaks of the ash content; 3 (black circles) – samples with high peaks of the ash content.

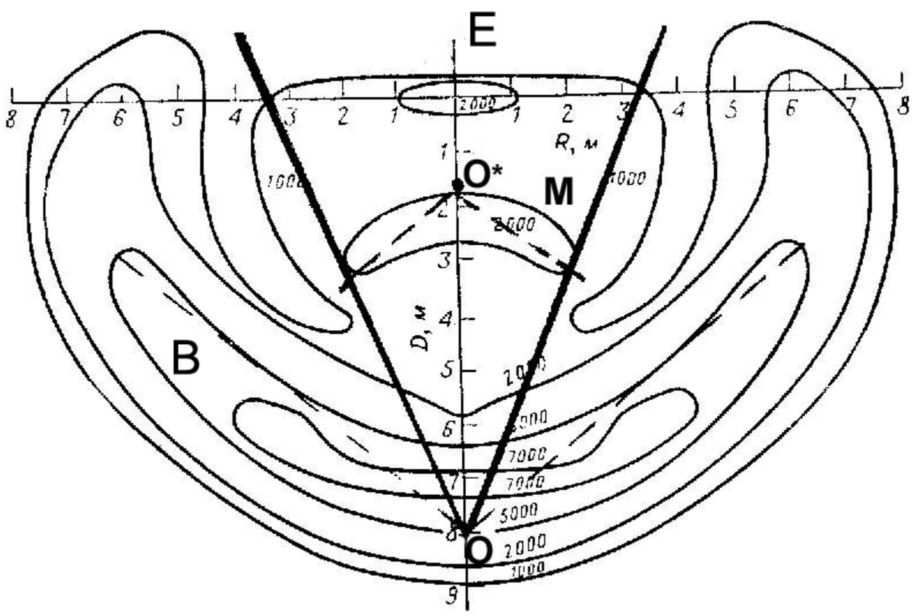

Fig. 2. Scheme of the lines of equal pressures (isobars), obtained from computer simulation of the contact explosion [3; 4]. The line segments on the scheme are the same as on Fig. 1.

Nomenclature is also the same. Coordinate axes: R – the horizontal axis; D – the vertical axis.

One should pay serious attention to the unexpected and hard-to-explain (at least at first sight) similarity between the schematic map of the ash content and the field of the blast wave that springs up when a contact ground explosion occurs. American scientists have published the schemes of isobars of the explosion of a 2 MT nuclear charge at several centimeters under the surface of a volcanic rock (tuff). A computer calculated two-dimensional schemes of the isobars in the framework of a hydrodynamic model for different moments after the initiation of the charge [3; 4]. One of these schemes is represented in Fig. 2. It shows the field of the isobars in the rock as it looks in a 0.1 millisecond after the initiation of the charge.

An explosion at the boundary between rock and air generates in the 3D space of the rock a more or less hemispherical blast wave with a fairly complicated structure. Roughly speaking, its outward isobars form a hemisphere, whereas inward ones form a hyperboloid. In 1×10^{-4} of a second after the explosion the field of the surplus pressure perturbs the rock down to a depth of 9 meters. Judging from the results of this modeling experiment, the reflecting blast wave is formed in the rock at the depth of several meters and not at the boundary between rock and air. In Fig. 2 one can see that at the moment $T = 1.0 \times 10^{-4}$ s at the depth of four meters a "reverse" hyperboloid M is formed. It outlines a zone, inside which the pressure is comparable with that in the areas of the direct blast wave, but lesser in geometrical dimensions. Just in 1 millisecond the front of the greater hyperboloid B reaches the depth of about 20 m, the pressure at its border having diminished from 5000 to 500 kilobars. At this moment the pressure at the depth of 10 meters falls down to 100 kilobars. The reflected blast wave, generated in the form of the smaller hyperboloid M, goes out into the atmosphere, turning into an air shock wave. It follows the "primary" air shock wave that is spreading from the upper part of the charge. (The air shock waves are not shown in the schemes of isobars.)

We can suppose that the fields of the increased content of ash in the peat, as shown in Fig. 1, are the traces of the isobars of the blast wave that affected the Earth surface at the moment of the Tunguska explosion. On the terrain the greater arc B turns out to be in the same zone where is located the isodynamic line with minimal dispersion – which on the map composed by Wilhelm Fast [5, p. 52] corresponds to the maximal magnitude of the horizontal component of the shock wave. No model of the Tunguska phenomenon predicted that blast waves could be "recorded" in the moss "cushion." Such an "unusual" supposition is however fraught with some non-trivial consequences which will be considered below.

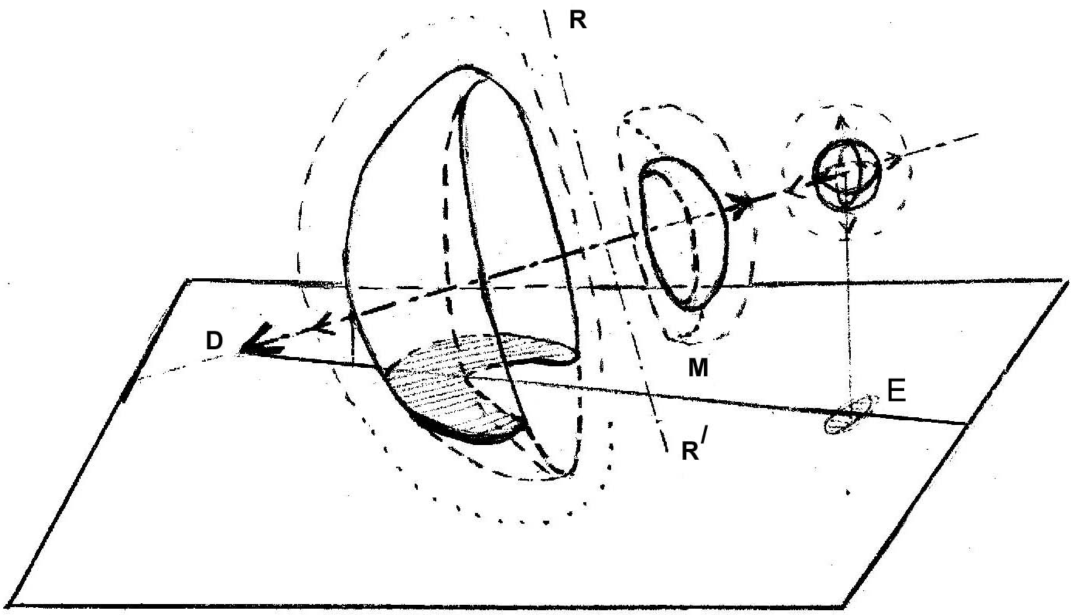

Fig. 3. Model of formation of the system of blast waves from an overground explosion of a hollow object and generation of its imprints on the earth surface. Nomenclature is the same as in Figs. 1 and 2. The axes DD' and RR' are equivalent to the axes R and D in Fig. 2.

There can be two possible physical mechanisms for the "recording" of the blast wave by the moss cover of the marsh. The authors of the work [1] produced a map of the territorial distribution of areas with increased concentration of the mineral fraction found from the ashing of the peat layer corresponding to the year 1908. A regular and symmetrical distribution of the dust of the exploded body is possible if at the moment the shock wave made contact with the ground surface the shock wave pressure front did not yet lose contact with the 3D "piston" of the explosion products. The probable size of the Tunguska space body (TSB) is usually estimated from the dimensions of the central part of the area of leveled trees as being of the order of 10^2 meters. As is known from the theory of chemical explosion, the shock wave is separated from the explosion products that "prop it up" at a distance of 8 to 15 radii of the charge [6]. Estimations of the altitude of the explosion over the epicenter of the Tunguska devastation (the location of which has been calculated by Fast [5, p. 57]) vary in the literature between 5 and 11 kilometers. Therefore, for this explanation to be considered as plausible the space density of the energy of the Tunguska explosion must have exceeded that of a chemical one by a factor of 10, or even 10^2. Such estimations have been published (see, for example, Ref. 7) and therefore this variant cannot be ruled out *a priory*.

Another possible explanation of the "natural recording mechanism" is based on the supposition that the "catastrophic" moss layer has been crumpled and compressed by the shock wave of the Tunguska explosion. In this case its increased ash content is due to the greater peat density in this layer, not to the added mineral substance.

2. Comparison between the empirical and standard ash fields.

Let's consider the fields of isobars obtained in the modeling experiments [3; 4] as a standard for analyzing the scheme of the field of ash content in the Tunguska explosion area. Then it becomes possible to draw a simple geometrical construction to help in studying this problem quantitatively. The result of this construction may be seen in Fig. 3.

Now let's compare the "greater arc" B (the field containing samples with increased ash content) in Fig. 1 with the field B outlined in Fig. 2 by the isobar of 5000 kilobars. Both schemes also contain the "reverse" smaller arcs M. In Fig. 2 the center of the explosion is surrounded by the isobar 2000 kilobars, looking as an elliptical-like contour E. A smaller field correlating with this isobar can be found in Fig. 1 as well. True, in Fig. 1 we can also see two almost symmetrical small spots located in the westerly direction from the epicenter F, whose location has been calculated by Fast [5, p. 57]. On the "standard" scheme (Fig. 2) such areas are lacking. Neither are there any special features in Fig. 2 that could have correlated with the point F.

Table 1.
Characteristic angles of the fields of a contact explosion and those of the fields of the ash content in the area of the Tunguska catastrophe

Angles	Angle designations	Values for the contact explosion, in degrees	Values for the fields of the ash content, in degrees
Angle of sight of the arc M from the point O	α	47	50
The angular measure of the arc B	β	102	103-110
The angular measure of the arc M	μ	106	105
Angle of sight of the local zones in the west from the center of the zone E	ψ	-	28-30
Angle of sight of the local zones in the west from the “epifast”	φ	-	57-60

Let’s designate in Fig. 2 the major axis of the ellipse E as e, whereas the distance between the fronts of the greater arc B and the smaller arc M (OO*) as h. Paying closer attention to Fig. 3, we can make sure that the fields in Figs. 1 and 2 are not only visually similar; their geometrical parameters do also coincide. The only exception is the distance S between the point O and the center of the ellipse E: this distance in the scheme of the ash content is twice that in the etalon scheme. Table 1 permits to compare angular characteristics of the scheme under examination with the standard one; Table 2 permits to compare their linear characteristics.

Having made certain that the angles and relative distances in both schemes are very similar, let’s pay attention to the absolute values of characteristic distances in them. The distances in Fig. 1 are expressed in kilometers, but in meters in Fig. 2.

A noteworthy fact here is that there are in the area of the Tunguska explosion of 1908 no traces of a near-ground contact explosion: no peculiarities in the structure of the leveled forest in the zone E or at the places that fixed the “imprints” of the shock waves – to say nothing about a crater (which seems to have been inevitable for such a powerful explosion). Therefore the shock wave recorded in the moss cover and the shock wave that leveled the taiga *are not identical*. At the same time, the location of the “epifast” in the structure of Fig. 1 is far from accidental.

All these seemingly contradictory peculiarities of the structure under consideration may be logically explained in the following hypothesis.

The structure that manifested itself as the scheme of the ash content of peat has been generated by a hollow source of the shock wave locating at the moment of the explosion at an altitude of about 10 km from the earth’s surface. The explosion occurred inside a spheroidal shell of several meters thick. The boundary between the void and the shell be-

Table 2.
Relative distances on the scheme of isobars of a contact explosion and those on the scheme of the fields of the ash content in the area of the Tunguska explosion
(Note: The major axis of the ellipse E is designated as *e*; the distance OO* as *h*.)

Characteristic distances	Designations (dimensionless units)	Values for the contact explosion	Values for the fields of the ash content
Span of the arc B	b/e	5,5	5
Span of the arc M	m/e	1,9	1,4
Span of the arc B	b/h	1,95	2,3
Span of the arc M	m/h	0,68	0,65
Ratios of spans of the arcs B and M	b/m	2,9	3,3-3,6
Distance from the front of the arc B to the center E.	S/h	1,25	2,6

haves like the boundary between the air and the rock. In this case, there is generated a system of shock waves of the same type as was described in the works [3; 4]. The solid source of the explosion, whose diameter was, according to the model of Fig. 2, in the order of several meters, therefore disappears.

Having found itself in the air, the system of the shock waves is expanding, maintaining its shape and characteristic ratios of dimensions. At a certain moment it meets with the ground, leaving its traces in the biosphere (see Fig. 3).

Dynamical pressure is determined as the space density of kinetic energy E:

$$E = 0{,}5dV^2 ,$$

where d is the density of the medium, V is the velocity of particles.

3. Some quantitative estimations

The data obtained may be used as the basis for a computer simulation and physical test simulation of the field of the ash content, discovered in the area of the Tunguska explosion. The figures shown in Tables 1 and 2 suggest some interesting conclusions that are evident from the proposed model.

For example, the fact that the ratio S/h on the map of the ash content is twice as great as the same ratio on the scheme of isobars may be due to the motion of the source of the shock wave over the Tunguska area (the American authors considered their source of the explosion as motionless). This supposition makes possible to compute the velocity of the TSB in the last seconds before its explosion. When calculated, a correction for a shift of the coordinate system, fixed in the leading shock wave, proves to be equal to about 15 km. (The distance between the point O – the leading edge of the shock wave, recorded by the field of the ash content – and the center of the zone E is some 30 km.) Typically, a shock wave of a megaton high-altitude explosion takes to reach the earth surface 10 to 100 seconds. Whence it follows that the velocity of the shift of the coordinate system, fixed in the leading shock wave, should have been 1.5 to 0.15 km/s.

Now let's find the minimal thickness of the front wall of the shell of the charge, which in the time interval between zero and $T=10^{-4}$ (that is, during the time of forming the structure represented in Fig. 2) could be regarded as a boundless medium having the density of a solid body. The velocity of detonation D for usual explosives is about 10^4 m/s, for superpowerful explosives about 10^5 m/s. Therefore, the sought-for thickness $L=DT$ would be 1 to 10 meters.

Two smaller zones of peat contaminated with a mineral fraction that were found by the authors of the work [1] in the western direction from the "epifast" are located symmetrically both in relation to the TSB trajectory and to the axis of symmetry of the greater and smaller arcs in Fig. 1. From the center of the zone E they are seen at an angle $\psi \approx 30°$. From the "epifast" this angle increases exactly by a factor of two – up to $\varphi = 60°$. It is intriguing that the angle 30° coincides with the value obtained by D. V. Dyomin from completely different data, when trying to determine the regular "beam" structure of the Tunguska fallen forest area, "masked" by the dispersion of the directions of the leveled trees in the outer zone of this area [8].

Even though any unambiguous interpretation of these regularities and coincidences would be premature, it seems evident that various data about the Tunguska catastrophe, recorded in the environment, clearly demonstrate a very orderly pattern of processes that formed the Tunguska phenomenon.

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RB Questions and Answers: Dr. Victor K. Zhuravlev

From the Editor: Dr. Victor Zhuravlev was born in Western Siberia in 1933. He finished at Tomsk State University, after which he worked at Tomsk Polytechnic Institute, as well as at research institutes of the Siberian Branch of the Russian Academy of Sciences in Novosibirsk. He has a Ph.D. in physical chemistry, being author and co-author of several inventions in the field of non-traditional methods of photography. He became one of the founding fathers of the IITE – the Interdisciplinary Independent Tunguska Expedition – an informal scientific research body that arose in the late 1950's in Tomsk and Novosibirsk, and is still working. Starting at 1959, Dr. Zhuravlev participated in many expeditions to the region of the Tuguska meteorite fall, as well as in scientific investigations of this region. Also, he is a co-author of two very important books – *The Tunguska Miracle* (written together with the "father of Soviet ufology" Dr. Felix Zigel) and *The Tunguska Phenomenon of 1908 as a Kind of Cosmic Connections Between the Sun and the Earth* (written together with Dr. Alexey Dmitriev).

1. Dr. Zhuravlev, first of all I would like to express my sincere gratitude for your kind consent to answer our questions! Your answers will certainly be of much interest to RB readers. But still, how one should name the problem that we are now discussing: the problem of the Tunguska meteorite, the problem of the Tunguska catastrophe, or the problem of the Tunguska explosion? How should it be correctly designated?

Well, the "fall of the Tunguska meteorite" is a term that formed purely accidentally, so to say. This event was initially erroneously classified as a usual meteorite fall. Inasmuch as this term has been broadly used in scientific literature, both by specialists and popular writers, it should probably be preserved as a generally comprehensible one. Just compare: astronomers still name dark regions on the Moon "mares" ("seas") – even though there is no water basins on this heavenly body – and none understands this word literally. Equally, one should take into account that the "fall of the Tunguska meteorite" is rather a metaphorical expression.

Even if some astronomers are still discussing at scientific conferences whether the Tunguska space body (TSB) was an iron, or a stone, or an ice meteorite, there is not the slightest chance (at least, in my opinion) to find there the remains of a usual meteorite. Such a natural body would never have left after its explosion those traces that have been found in this area.

Apparently, the most precise term would be the "*Tunguska phenomenon*" – which is also in use in the scientific literature. The terms "Tunguska explosion" and "Tunguska catastrophe" can also be used – but they do not cover the whole set of consequences of the invasion of the Tunguska "bolide" into the terrestrial atmosphere.

2. Who – which organizations and which persons – studied this problem during the last 100 years? Who of them made the most essential contribution to its solution?

As a matter of fact, the first investigators of the Tunguska phenomenon were those European and Russian astronomers, who observed the optical anomalies in the atmosphere immediately before and after June 30, 1908, and then published their descriptions of these anomalies in scholarly periodicals. Those were L. Apostolov, F. Archenhold, W. Denning, V. Fesenkov, A. Polkanov, F. de Roi, R. Suring, M. Wolf. They knew nothing, however, about the flight and explosion of the gigantic Tunguska bolide and therefore could not associate their observations with it. Director of the Irkutsk observatory in Siberia, Dr. A. V. Voznesensky, began to receive letters of the witnesses of the flight of this gigantic "bolide" as soon as early July 1908. Yet, the European and Siberian "signals" were united into a whole picture only after Dr. Leonid Kulik began his search for the place of the Tunguska meteorite fall, that is, after 1921.

But for the perseverance and truly heroic organizing efforts of Dr. Kulik, the Tunguska catastrophe could have simply escaped the attention of world science. It was Kulik and his collaborators who discovered, 20 years after the event, the epicenter of the Tunguska explosion – the huge area of forest leveled strictly radially. Also, they talked with witnesses of this event, took aerial photographs of the leveled forest, and attempted to find the remains of what they believed to have been an immense iron meteorite.

The second most important factor that played the crucial part in the history of this unique scientific problem was the "short story-hypothesis" (this is the literal translation of its subtitle) "The Explosion," authored by the Soviet engineer and SF writer Alexander Kazantsev and published in 1946 in the Moscow journal *Vokrug Sveta* ("Around the World"). Its author conjectured that the alleged Tunguska meteorite was in fact not a natural space body, but an extraterrestrial spaceship equipped with a nuclear engine that exploded for some reason or other when the spaceship entered the terrestrial atmosphere. Naturally enough, this hypothesis was considered as pseudo-scientific by professional astronomers, but many a young scientist all over the Soviet Union took it to heart. Half- (but only half-) jokingly they said: “We must find a nozzle from this spacecraft!” It was however rather difficult to find ways for verification of this “fantastic hypothesis” until the IITE has been formed. But after that, the situation has abruptly changed.

A very important result of the IITE Tunguska investigations was prediction and subsequent discovery in the archives of the Irkutsk observatory perhaps the most strange trace of the Tunguska explosion – the so-called geomagnetic effect, that is abrupt disturbances of the terrestrial geomagnetic field that occurred a few minutes after the explosion and persisted for about four hours. The magnetograms from the Irkutsk observatory put the researchers at a true paradox: there was no magnetic disturbance from the flight of the gigantic bolide, but after its explosion there arose a regional geomagnetic storm *that was very similar to geomagnetic disturbances following high-altitude thermonuclear explosions in the atmosphere*.

Now, one should say that the crucial parts in the history of Tunguska studies were played: in the first half of the 20th century by Leonid Kulik’s expeditions, and in the second half of the same century by the Interdisciplinary Independent Tunguska Expedition, organized by Gennadiy Plekhanov and Nikolay Vasilyev. Competition and collaboration between the IITE and official academic institutions saved from disappearance traces of a unique space phenomenon, demonstrated its highly complicated character, and opened way for creating truly scientific models of this phenomenon.

3. Which hypotheses about the nature of the Tunguska space body and Tunguska explosion have been convincingly refuted? And what is your own opinion – which hypotheses still can be discussed?

Well, there exists one popular myth that is maintained by mass media and even by some scholars… According to this myth, the Tunguska problem is so enigmatic that trying to find a correct explanation, scientists had to propose about a hundred hypotheses about the nature of the TSB. Authors of this myth simply do not know the ABC of scientific methodology. In fact, *hypothesis* and *explanation* are far from being synonyms. A hypothesis is just a starting point, from which a research program is developed, and this program leads either to the correct solution of a scientific problem or to the refutation of the initial hypothesis and – sometimes – to replacing it with another hypothesis.

In the beginning of the 20th century Leonid Kulik based his research strategy in the Tunguska problem on the iron meteorite hypothesis. However, no fragments of such an iron meteorite have been found at the site of the explosion and therefore this hypothesis has been rejected. It was replaced by the cometary hypothesis, authored by F. Whipple, I. S. Astapovich, and V. G. Fesenkov. This hypothesis has formed the framework for “official” theoretical and empirical studies of the Tunguska problem during the whole second half of the 20th century. It is considered as preferable by the majority of professional astronomers even in the 21st century. What is more (and worse), they are inclined to regard this idea as an obvious fact, rather than as an unconfirmed (and rather speculative) conjecture. Of course, one can understand such an approach to the Tunguska problem on the part of the astronomers. After all, they know well that there are in the Solar system *only two kinds* of minor natural objects: asteroids (whose fragments we call “meteorites”) and comets. Sometimes orbits of these small heavenly bodies intersect the orbital path of the Earth and they collide with our planet. If the Tunguska space object could not be an iron or stony meteorite (and it could not – otherwise its fragments would definitely have been already found) what do you think it could be? Right, a comet.

This is why the cometary hypothesis of the TSB origin is considered by the astronomical community as a self-evident basis for scientific studies of the Tunguska problem and not as just another supposition that must have been checked. However strange, this research strategy is regarded by many professional physicists and astronomers as truly scientific.

The scholarly community would not consider Kazantsev’s idea about the explosion of a spaceship over the Southern Swamp as worthy of attention simply because there was (as now) no available science about extraterrestrial spaceships (“alien-spaceship-logy,” so to say). Such an idea could be expressed in a science-fiction (or fantasy) novel, or as a result of a poetical insight, or as a simple guess based on common sense, but not on the base of the scientific picture of the world.

Nevertheless, deep investigations at the Tunguska explosion area led to discovery of the facts that could be neither predicted, nor explained from the viewpoint of the cometary (or asteroidal) model of this phenomenon. On the other hand, these facts in themselves could not be regarded as the convincing scientific proof of the alien spaceship hypothesis – again, just because science does not have at its disposal any well-founded theoretical model of extraterrestrial machinery. Supporters of Kazantsev's idea (Drs. Plekhanov, Vasilyev, Zolotov, Mekhedov, et al.) paid their attention, first of all, to the nature of the Tunguska *explosion*. Basing on the anomalous (as regards the cometary model) traces and parameters of the Tunguska blast, they tried to find out if this explosion had been accompanied by nuclear reactions. As for the nature of the *object itself*, this question was shelved and could, as they believed, wait until the nuclear explosion hypothesis has been finally proved. Many facts do seem to corroborate this hypothesis. At the same time, there are some traces that are not in full accordance with the nuclear model of the Tunguska event. This is why in 1983 A. N. Dmitriev and myself conjectured that the TSB was in fact a "plasmoid" ejected from the sun – a sort of the spindle-like "magnetic bottle" containing a considerable amount of plasma and surrounded by an external magnetosphere.

A lot of flimsy suppositions have been propounded in newspapers, popular journals and on TV. Every now and then, we can hear from the TV screen or read in newspapers that the enigma of the Tunguska meteorite has at last been solved: it was either a "microscopic black hole," or an "electrodynamic meteorite," or "gigantic ball lightning," or an earthquake, or God-knows-what-else. For serious specialists in this problem, who spent many years studying the real traces of the Tunguska explosion in minutest details, all this is sheer nonsense.

The main defect of these quasi-hypotheses is the lack of any verifiable predictions and therefore their complete uselessness for researchers. As it seems to me, there are only four serious models of the Tunguska "meteorite": a comet, a stony asteroid, a solar "plasmoid," and an extraterrestrial spaceship. At present the former two of these hypotheses cannot be considered as totally refuted, but they meet with very serious difficulties when trying to explain the collected empirical material.

4. There exists a widespread opinion in the Western mass media, according to which "science believes" that the Tunguska meteorite was either just a meteorite or a small comet (for the general public the difference between these versions is negligible), whereas the spaceship idea is a nonsense shared by pseudo-scientists and simple nuts. Is such a dichotomy correct, to your mind?

I have already said that the competition between the meteorite and the starship conceptions played a very important part in the history of the Tunguska studies. Kazantsev's idea about the explosion of an extraterrestrial spaceship over the taiga has freed the problem of this very complicated phenomenon from the narrow limits of purely "natural" explanations. We should remember, however, that this idea was put forward as far back as 1946. During the last 60 years it has considerably evolved – particularly due to essential changes in the current scientific picture of the world.

In the first half of the 20th century interplanetary voyages were thought of as, first, an affair of very distant future and, second, as something like the epoch of the Great Geographical Discoveries. Shipwrecking – now in the space, not in the ocean – looked therefore very probable. Besides, Alexander Kazantsev believed this spaceship could have arrived from Mars or from Venus – since in those years even some astronomers thought that life could exist on these planets.

In the early 1960s first terrestrial space probes started for planets of the Solar system. Alas, no civilization has been found on Mars or Venus. But some 15 years earlier there arose the UFO phenomenon. Strange objects have appeared in the atmosphere of our planet, being perceived by the general public mainly as extraterrestrial machinery. Stories about UFO landings and contacts with some individuals proliferated in Western mass media, even if being ridiculed by science and political authorities everywhere and especially in the former Soviet Union. However, attempts of the official science to convince the public that UFOs are just a new mass psychosis and mythology of the 20th century have failed. The books by Aimé Michel, Jacques Vallée, J. Allen Hynek, and other serious students of this phenomenon opened the way for a rational approach to the UFO problem. Under these conditions, the hypothesis by Kazantsev's about the "spaceshipwreck" of a "rocket from Mars" should have evolved as well. Dr. Felix Zigel examined the reports of some eyewitnesses of the TSB flight, according to which the shape of the Tunguska bolide was cylindrical and identified it with a rare variety of UFOs – the so-called "cloud cigars." Such "cigars" were observed only in the air and seem never to have landed on the Earth surface. There are, however, reports about smaller objects – balls or "saucers" – separating from these "mother ships." The "cloud cigars" appear, as a rule, at high altitude over the earth surface. The pilots who observed these cigar-shaped UFOs believe that their dimensions were from 100 to 800 meters in length. One should recall that, according to the estimation of Dr. Zolotov (made from the parameters of the central zone of the leveled forest), the Tunguska space body was a cylinder some 600 meters in length and 50 to 70 meters in diameter.

However, the scenario of the Tunguska phenomenon had nothing in common with the "typical UFO," even when a cigar-shaped UFO is concerned. Very startling results were published in 1988 by a group of Russian geophysicists – Drs. K. Y. Kondratiev, G. A. Nikolskiy, and E. O. Schultz. They have thoroughly studied actinometric spectra, recorded at the Mount Wilson Observatory in California in 1908 and come to the conclusion that the Tunguska explosion *has stopped the ozone crisis that was then approaching in the Northern hemisphere of our planet and could have led to a sharp decrease of the average annual temperature and to serious problem for the terrestrial biosphere*. This conclusion may be considered as a hint: the Tunguska phenomenon was in fact not an accident, but a goal-directed influence, initiated by a cosmic super civilization that keeps an eye on our planet and its inhabitants. Thus, Kazantsev's hypothesis was modernized in the late 1980s – now the Great Explosion of 1908 could be considered not as a catastrophe, but as an experiment or even a controlling action of an extraterrestrial intelligence.

5. What could become, in your opinion, the final proof of Kazantsev's hypothesis? How would it be possible to convincingly demonstrate that the Tunguska space body was in fact an extraterrestrial spaceship?

It is my sheer conviction that the only final proof of this hypothesis may be the discovering of material remnants of the supposed Tunguska starship. When studying the indirect traces and consequences of the catastrophe, even using the most up-to-date scientific equipment and methodology, it is, unfortunately, impossible to finally choose between the "natural" and "artificial" models of the phenomenon. One cannot rule out, however, that further progress of the scientific methodology can make such a choice at least conceivable.

As far back as the 1950s, the famous Russian specialist in theory of explosion Dr. M. A. Sadovskiy, while getting acquainted with results of the first post-war academic expedition to Podkamennaya Tunguska, expressed his opinion that the pattern of forest leveling demonstrated: *the blast source had a very complicated shape*. This conclusion was effectively corroborated by Wilhelm Fast's maps of forest leveling, as well as by the catalog of tree burns. The combination of the "butterfly-like" shape of the area with the general radial pattern of forest falling suggests that *the Tunguska body consisted of two different parts: an "explosive" and a non-uniform "shell," resembling thereby an artificial construction*.

In the 1970s, after the TNT equivalent of the Tunguska explosion was estimated by experienced specialists as reaching 30 to 50 megatons, the hope to discover large fragments of the TSB practically vanished. There is no chance to find any remnants of a nuclear bomb after it has exploded. Certain researchers did however attempt to look for such fragments, in spite of this obvious consideration, and all such attempts have failed. If, however, the TSB was not just a "nuclear bomb from the space" (and this is hardly so) and the blast features were complicated enough, there is still some hope to find in the future somewhere in the Southern Swamp material remnants of this enigmatic body.

6. How soon will the Tunguska problem be solved and what solution it will be?

I think that under favorable conditions we can hope to find the final solution of this problem during the next 10 to 12 years (by the 110th anniversary of the phenomenon itself). There may be two alternative variants of this solution:

(1) It will have been proved that the TSB was the core of a comet. In this case the contemporary models of comets' structure, as well as models of their interaction with atmospheres of planets will be exposed to serious modifications. This will definitely be a very essential scientific achievement in itself.

(2) It will have been ascertained that the Tunguska phenomenon was in one way or another generated by an extraterrestrial civilization. It goes without saying that the potential importance of such a discovery for humanity would be enormous.

I must confess that the latter variant seems to me more probable than the former one.

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