The 1908 Tunguska event and electromagnetic phenomena

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Dedicated to the blessed memory of my grandmother (Tuzlukova Anna Ivanovna) and my mother (Ol'khovatova Olga Leonidovna)

Abstract. This paper is a continuation of a series of works, devoted to various aspects of the 1908 Tunguska event. In this paper its author would like to draw attention to the arguments about the manifestations of electromagnetic phenomena in the 1908 Tunguska event. A review is provided of some data supporting the idea about the manifestation of electromagnetic phenomena. Although there is no direct instrumental registration of electrical discharges in the epicenter area in 1908, there are many indirect arguments in favor of their presence. The latter is in agreement with the geophysical interpretation.

1. Introduction

This paper is a continuation of a series of works in English, devoted to various aspects of the 1908 Tunguska event [Ol'khovatov, 2003; 2020a; 2020b; 2021; 2022; 2023a; 2023b; 2025a; 2025b; 2025c; 2025d; 2025e]. The works can help researchers to verify the consistency of the various Tunguska interpretations with actual data. A large number of hypotheses about its causes have already been put forward. However, so far none of them has received convincing evidence.

The Committee on Meteorites of the USSR Academy of Sciences (KMET) stopped research the area of the Tunguska event in the early 1960s. Later amateurs most of whom united under the name Kompleksnaya Samodeyatel’naya Ekspeditsiya (KSE) continued research. Since the late 1980s foreign scientists take part too.

Please pay attention that so called the epicenter of the Tunguska forestfall (the forestfall is named “Kulikovskii”) is assigned to 60°53' N, 101°54' E, and in this paper is called the epicenter. In this paper its author (the author of this paper i.e. A.O.) for brevity will be named as “the Author”. The surname Vasil'ev can also be translated as Vasilyev in some references. The Author already pointed (in English) to probable manifestations of electromagnetic phenomena in [Ol'khovatov, 2023b] and in some others.

2. Arguments for the Electromagnetic Phenomena

In his publication called “Instructions for observing lightning”, L. Kulik wrote as the first phrase [Kulik, 1933] (translated by A.O.):

> “Of exceptional interest is a continuous uniform and monotonous burn, in some cases similar to a lightning burn, which I observed in the center of a radial windfall at the site of the Tunguska meteorite 30 VI 1908, forced me to make an attempt to collect observations of burns caused by lightning to various objects.”

During the Kulik last expedition in 1939 a young painter Nikolai Fedorov sketched (on the Kulik's instructions) the traces left in the taiga by the event. Fedorov sketched, for example, the characteristic ribbon-shaped burns on the stand-up trees in the central region of the forest-fall. Strips of charred wood, according to Kulik, were traces of lightning strikes that accompanied the fall of the Tunguska meteorite [Zhuravlev and Zigel, 1998]. Unfortunately, the original sketches were lost, but Fedorov restored in 1987 from memory the drawing [Zhuravlev and Zigel, 1998] shown in Fig.1.

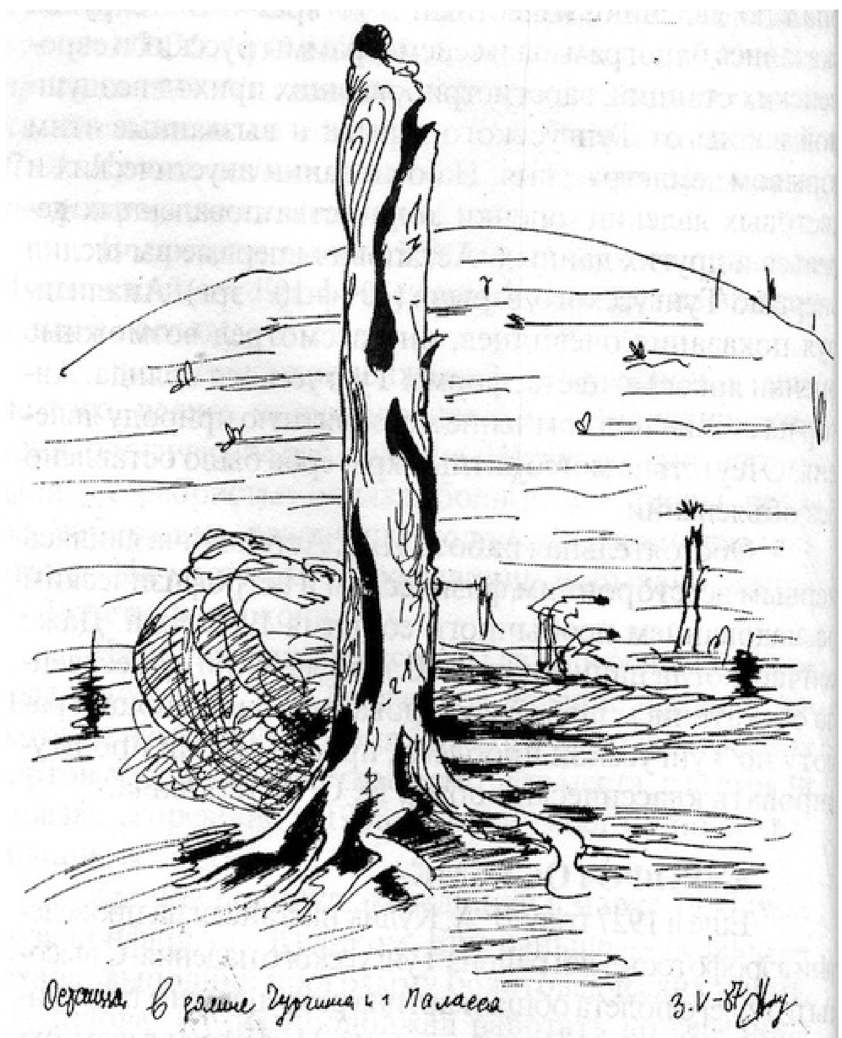


Fig.1

In 1960 some research of the survived trees near the epicenter was done. Usually the trees had some injuries. Here is from [Zenkin et al., 1963] (translated by A.O.):

"Schematically, the following types of damage can be identified:

1. Straight vertical cracks that extend from the base of the tree to a height

of 2-3 meters. The depth of the crack sometimes reaches the radius of the trunk. The bark near the crack is often burned.
Among the injuries located at a height of less than 1 m, there are several starting at a height of 20-30 cm and having a length of 30-50 cm.
The direction of these injuries is approximately perpendicular to the direction of the injuries described above (groups 29, 27, 28, 30, and 8).
2. Curved crevices starting from the base of the tree or higher and having a length of 2 to 7 m.
3. Straight crevices 10-30 cm long in the upper part of the trunk.
The azimuths of damage to old trees averaged by groups are plotted on the appendix. A review of it shows that although It is not possible to note strict damage orientation, most of them still face towards the Northern and Southern Swamps."

Such details as "the bark near the crack is often burned" hint on the damage by electrical discharges.

It is important to add that sometimes no visual damage was noticed on trees near the epicenter. For example, the Wulfing grove with dimensions 500m X 700 m is at distance about 3 km from the epicenter. Here is what I.K. Doroshin wrote about the Wulfing grove [Doroshin, 2005] (translated by A.O.):

"...at least one grove consisting of larch, spruce and cedar (near the Wulfing mountain). In such places, the trees either did not lose their crowns at all, or the loss was minimal. There are either no traces of the 1908 fire here at all (a grove near the Wulfing mountain), or there are traces of a grass-roots fire of varying intensity;... ".

Also here are several points from [Plekhanov, 2009]:

"d) On the whole territory of the fire, including the centre, there are some areas where the surviving trees do not reveal any traces of the 1908 fire. <...>

f) Every zone of the fire area 1908 including the centre contains standing and felled trees burned to the core along with the trees still having small branches. <...>

h) Peat bogs have areas where the surface layer, dated to 1908 according to the outgrowth of the moss, covers a 5–10 cm thick layer of ash (L.A. Kulik also claimed that there are peat bog spots with the layer of ash up to 30 cm thick).

i) There are also peat bog spots with a 5–10 cm thick layer of ash next to the areas with no signs of the fire."

So one of the peculiarities of the Tunguska event near the epicenter is the spotty nature of the manifestations when areas with a high degree of damage are adjacent to almost intact ones. This fact is in agreement with manifestations of electric discharges. This allows explanation on the phenomenological level of the following phenomenon related with disrupted tracheids of trees near the epicenter of Tunguska. Here is from [Vaganov, et al., 2004]:

> “Given the observations of disrupted tracheids, we can make some preliminary estimates of the forces acting on these trees at the time of the Tunguska event. <…> Experiments and theoretical calculations of the tensile strength and elasticity of tracheids under tension (Mark, 1976) showed that the normal failure stress … of cells that have only middle lamellae and primary walls reaches 58.8 MPa in air dry conditions (Table 10-2 on p. 249) and is significantly less (i.e., probably 9.8-19.6 MPa, p. 33) for wet conditions. This last value, probably most relevant to the condition of tracheids on June 30, 1908, is between 20 and 30 times greater than that needed to fell the trees (Zolotov, 1961, 1967; Zotkin and Tsikulin, 1966). It is clearly difficult to explain the disruption of tracheids in surviving, standing trees near the epicenter from the point of view of an isotropic blast wave front. <…>
>
> Tracheid transformation could have been caused by other factors. For example, live trees were found close to the explosion epicenter that had vertical or twisted stem cracks of varying depths differently oriented relative to the epicenter (Zenkin et al., 1963). These may be scars produced by lightning strikes associated with the Tunguska event.”

Interestingly, trees like the one in Figure 1 have partially persisted many years later. Here is from [Anfinogenov, and Budaeva, 1998] translated by A.O.:

> “In the epicentral zone (the eastern marginal part of the Southern Swamp), continuous groves of small-sized (skinny) larches (about 150 years old) that survived the disaster are observed with peculiar spiral lesions of the trunks in 1908 (lightning, electric discharge — ?).”

In the second half of 1990s groups of teenagers led by a prominent Tunguska researcher - Vitalii Romeiko examined damaged trees near the epicenter. In total 545 trees were examined [Rastorgueva et al., 2000]. Among them some were like on Fig.2 (taken from [Rastorgueva et al., 2000], and unfortunately the original printing is of low quality).

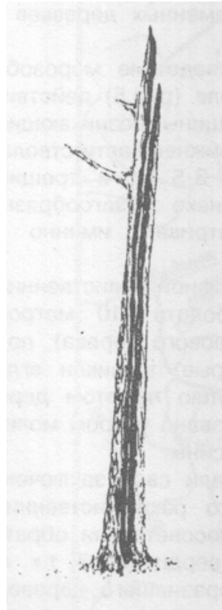


Fig.2

The authors of [Rastorgueva et al., 2000] think that at least a part of the damage was caused by electric discharges.

At the end of 1950s articles appeared about influences of atomic explosions at high altitude on geomagnetic disturbances. A researcher at the Institute of Terrestrial Magnetism in Irkutsk Kim Ivanov in the summer of 1959 read the June issue of the magazine "Znanie-Sila", in which the article by F. Zigel "Unsolved mystery" was published about Tunguska. The arguments given in the article in favor of the idea of the similarity of the Tunguska explosion with a nuclear explosion, seemed interesting to Ivanov, and worthy of attention. So Ivanov searched an archive for the 1908 magnetogram. And the magnetogram (discovered in the Irkutsk archive) showed the geomagnetic disturbance. Ivanov, well aware of the significance of his discovery, immediately sent a scientific report titled "Geomagnetic Phenomena Observed at the Irkutsk Magnetic Observatory Following the Explosion of the Tunguska Meteorite" to "Astronomicheskii Zhurnal". However, the journal's editors did not recognize the importance of this new discovery [Zhuravlev and Zigel, 1998]. Ivanov's article was eventually included in the "Meteoritika" annual and was published in print for the first time in 1961. The local disturbance of the Earth’s magnetic field began 5.9-6.6 mins after the Tunguska explosion (based on seismograms), and continued for more than 4 h, the maximum alteration of magnetic field H component reaching up to 70 gamma [Vasilyev, 1998]. Since then, many different mechanisms have been proposed to explain this phenomenon, but none of them has been widely accepted.

Anyway, this discovery stimulated the search for possible magnetic anomalies near the epicenter.

In an interview with "Smena" magazine (1962, N19), F. Zigel mentioned that

A. Zolotov had discovered the residual magnetism of samples of some rocks in the vicinity of the epicenter. According to F. Zigel (with reference to Zolotov), the Tunguska explosion "magnetized" fragments of some rocks that make up the hills surrounding the Southern Swamp.

Thus, it is likely that Zolotov was the first to discover the effect. The Author was unable to find these findings in Zolotov's publications. This may be due to the fact that Zolotov was a proponent of a nuclear explosion in Tunguska in the air, and therefore the discovered effect was not of great interest to him, as it did not help to prove the existence of the nuclear explosion.

In 1969-1976, KSE, together with a number of other organizations, conducted a paleomagnetic survey of the area, as a result of which 897 samples were selected and analyzed from a total area of about 15 thousand square kilometers. The objects of the study were oriented samples of loose sedimentary rocks (soils). The samples were taken from the surface layer in the form of a cube with a side length of 2-4 cm and faces parallel to the modern magnetic meridian, i.e., the north-south direction. Result was presented in [Boyarkina et al., 1980] where it was written that in the Tunguska event area up to 20 km or more from the epicenter, there is a deviation in the declination of the residual magnetization vector of loose rocks (soils).

However the situation is not so evident. Here is from [Vasil'ev, 2004} translated by A.O.:

"Later, however, it was found that during the transportation and storage of samples in the laboratory, under the influence of local electromagnetic fields, their re-magnetization occurs, distorting their original characteristics. As a result, A.P. Boyarkina questioned the correctness of the previously made conclusions, and the study of this issue was temporarily suspended. It was resumed by KSE in 1991-1992, with the participation of E.N. Lind, who used a more advanced method for sampling and studying samples (Lind E.N., 1998). As a result, it was shown that in some areas, the there are violations of the position of the vector of residual magnetization, however, the presence of a "chaos zone" and a sharp shift deviations of the vector to the west from the direction of the modern magnetic field have not been confirmed.

It is too early to dot the i's and cross the t's in this story: the area covered by paleomagnetic survey at the first stage of work is much more extensive, and the number of samples studied is an order of magnitude larger than E.N. Lind had at his disposal. In addition, the vector structure of the paleomagnetic characteristics of the soils of the region is uneven: there is a clear shift of the vector of residual magnetization to the west from the current direction of the magnetic field in the area adjacent to Mount Chirvinskii and to the southwest of Mount Farrington, as well as gross violations of its orientation in the area of highlands north of Lake

Cheko and near Churgim waterfall. The data of E.N. Lind do not contradict the results of A.P. Boyarkina and S.D. Sidoras in the part concerning content in the soil of ferromagnetic.

In general, thus, the question remains unresolved, and the need is obvious for further study of it."

E.N. Lind proposed the search for remagnetized soils which is based on the fragments of igneous rocks of the trappean formation, which are widespread in the study area. According to E.N. Lind, when using the proposed method, any trappean formations are suitable, including primary outcrops, eluvial deposits, and even alluvial (river) deposits.

The paleomagnetic research was resumed many years later. Here is from [Gladysheva and Popov, 2016]:

"The rock samples for our study were collected by the staff of the Tunguska State Nature Reserve in the vicinity of the Tunguska catastrophe epicenter and at a distance of >40 km from the epicenter. Samples of bedrocks were collected on the tops of mountains or hills. During the sampling each sample was oriented in the horizontal plane so that Xc component was directed to the magnetic north, Yc—to magnetic east, and Zc—down. The GPS coordinates of each sampling site were recorded.

<...>

It was expected that the paleomagnetic values measured for the samples from the epicenter are essentially different from those of background samples. Ideally, this would allow one to reveal traces of the catastrophe's impact on bedrocks in the epicenter. However, these expectations were not met: the directions of the first and second components in ten samples measured in a geographic coordinate system (Fig. 7) are concentrated in one field; only the second component in samples from Mt. Farrington has almost the opposite direction."

In the Conclusion section the article states:

"Studies have shown that bedrocks from the top of Mt. Stoikovich have a natural remanent magnetization that is considerably higher than that in rocks from Mt. Farrington and the upper reaches of the Churgim creek canyon."

Other researchers also started to research the paleomagnetism in the area. Here is from [Kletetschka et al., 2019]: "Paleomagnetic data revealed presence of plasma during the Tunguska Event near rock surfaces". In the later article [Kletetschka et al., 2025] its authors presented even more arguments about the plasma, but in the opinion of the Author, their proposed mechanism of the plasma generation does not conform with the known Tunguska facts [Ol'khovatov, 2025b].

In [Takáč et al., 2025] (an open access article) magnetic field was researched near the epicenter using UAV, which flew above the ground. Here is a fragment of an abstract from [Takáč et al., 2025]:

> "The Tunguska event of 1908 remains the most significant atmospheric explosion in recorded history, yet its geophysical effects, particularly its impact on Earth's magnetic field, remain uncertain. This study presents the first detailed magnetometer survey of the Tunguska epicenter, aiming to map regional magnetic anomalies and assess potential impact-induced magnetization. The survey used unmanned aerial vehicle and covered approximately 30 square kilometers, revealing a complex pattern of magnetic anomalies that correlate with known geological structures. Notably, some anomalies exhibit spatial alignment with the presumed trajectory of the airburst (~300° azimuth), suggesting potential influence from the event. This spatial correlation raises the possibility that transient electromagnetic effects from the airburst, such as ionization-induced remagnetization or shock-induced changes in magnetic mineralogy, could have contributed to the observed anomaly distribution. However, due to the limitations of our data set, we cannot definitively attribute any observed anomalies to impact-related remagnetization."

It is worth to add a couple of quotes from the article regarding the "spatial alignment with the presumed trajectory of the airburst (~300° azimuth), suggesting potential influence from the event". Here it is:

> "Boundaries of the geological units show a band of the highest magnetic intensities (b2, c3, d4, and e5) running parallel to the proposed 300° azimuth of the impact. However, this pattern is offset from the epicenter and consists of isolated anomalies with varying polarities that correspond to geological variations, as seen in the geological map, suggesting a coincidence between lithology and the impact direction.
> <...>
> In the RTP TMI map, both dominant positive and negative anomalies form a belt that runs parallel to the expected impact trajectory. However, this belt is offset southwest of the epicenter and follows the distribution of geological units, as seen in the geological map. The TDR map further delineates portions of this belt, reinforcing its structural association rather than a direct impact signature.
>
> A second noteworthy pattern is a belt of smaller, localized magnetic anomalies trending at approximately 330° azimuth through the epicenter.

This belt is visible in both the AS and VD maps, suggesting shallow magnetized sources with varying polarities. The absence of this feature in the UP map supports a near-surface origin, consistent with the alternation of geological boundaries shown in Figure 10. However, due to the limitations of UAV-based magnetometry, which lacks direct constraints on remanent magnetization direction, the possible influence of transient remagnetization remains unresolved."

So the "300°- alignment" has offset from the epicenter, and words "suggesting a coincidence between lithology and the impact direction" are remarkable.

The Author already wrote many times in previous papers that a deep-penetrating Berezovsko-Vanavarskii tectonic fault is passing through the area. The Kulikovskii paleovolcano can be seen on a fragment of the "Kosmogeologicheskaya karta SSSR" by Ministry of Geology of the USSR, published in 1982 [Kozlovskii, 1982], which is shown on Fig.3.

Fig.3

The paleovolcano is approximately in the middle of the picture. The Berezovsko-Vanavarskii tectonic fault crossing the paleovolcano approximately along WNW- ESE line. Remarkably what is written in the book [Yeromenko, 1990] (translated by A.O.):

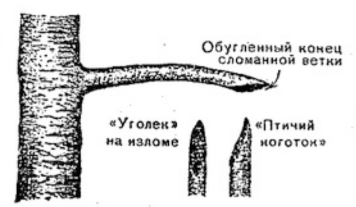
"The Berezovsko-Vanavarskii fault (BC, fig. 15, 16) within the Siberian platform was traced from the mouth of the Bakhta river to the settlements of Poligus and Mutorai and further along the route of the Tunguska meteorite in the upper reaches of the Vanavara river."

These facts allow us to look in a different way at the results which are presented in [Takáč et al., 2025].

One researcher tried to re-create in a lab one specific type of tree's damage near the epicenter - so called a "bird's claw". At first a few words about the bird's claw. Here is what E. Krinov (he participated in the Kulik's expedition to Tunguska in the late 1920s) wrote [Krinov, 1966]:

> "The most characteristic feature of this scorching was that the end of every snapped-off branch from the dead trees held a charred cinder. The fracture itself always ran obliquely downwards and the broken-off end of the branch with the cinder was peculiarly reminiscent, as Kulik described it, of "a bird's claw" (Fig. 166). At the top of the tree thick and slender branches are often seen side by side, having cinders on their broken ends. This suggests that the scorching occurred from the momentary effect of high temperature and not from an ordinary forest fire. Indeed, if the scorching had occurred from the flames of an ordinary fire, the slender twigs would have been completely burned by heat sufficient to char the end of a thick twig."

Here is on Fig.4 the Krinov's sketch of the "bird's claw" burn [Krinov, 1949]:



Фиг. 40. Характер излома и ожога ветвей («птичий коготок») в районе падения Тунгусского метеорита, по наблюдениям автора.

Fig.4

Here is the Nesvetajlo opinion [Nesvetajlo, 1998] about the bird's claw:

> "Despite 80 years that have passed since the 1908 catastrophe year, the dead standing trees unlike those that were felled by the explosion, have preserved very well and one can reconstruct whether the branches were dead or living at the moment of the impact by analyzing the peculiarities of the annual tree rings. Application of this simple technique has proved that the charcoal occurs only at the ends of those branches, that had already been dead by 1908. All test lots proved that there was no trace of thermal damage at the ends of the branches that were living in 1908, which fact imposes certain restrictions on the size of the thermal impulse, that caused tree damage. Distribution character of charcoals at different heights in the

test lots permits to the assertion, that these damages were generated by an upward thermal flow, directed from the surface of the ground; ..."

Nesvetajlo wrote that "these damages were generated by an upward thermal flow, directed from the surface of the ground" because he discovered the bird's claw only on dry branches with their ends pointing downwards. According to Nesvetajlo, the needles of the fallen trees and the broken crowns ignited from the primary ignition sources on the ground, creating a powerful but short-lived upward heat flow that ignited the ends of the broken branches.

However in the opinion of the Author there is a reason to take the Nesvetajlo explanation with caution. Here is why. When it comes to the bird's claw at altitude 15-20 m, it would be reasonable to expect (due to the strong fire below according to the Nesvetajlo's explanation) the appearance of the bird's claw (at least in a weaker degree) also on some lower live branches. However, according to Nesvetajlo, there is no such case detected.

Moreover, in [Nesvetajlo, 1986] some data is presented on individual trees. According to the data, dry branches/limbs with severe bird's claw burn can be at high altitudes, and (on the same tree) dry branches/limbs with moderate bird's claw burn or even no-burn at the low altitudes.

Possibly due to this fact and maybe due to some others there are researchers who consider other possible mechanisms of the bird's claw damage. At least one of them even conducted experiments in his lab. Here is from [Galantsev, 2001], translated by A.O. (T.M. is the Tunguska meteorite):

"Consideration of the last stage of these processes, the gas discharge of atmospheric electricity by T.M., as one of the sources of fire in the zone of catastrophic forest collapse, along with a polyspectrum of the radiant nature of burns and fire (Zenkin, 1964, Tsymbal, 1988, Vorob'ev, 1976), are relevant in the light of the contradictions of the occurrence of burns (Kulik, 1939, Plekhanov, 1998). <…>
To solve the problem of charge kinetics in this article, i.e. the definitions criterion threshold currents of the positive corona for the transition to the streamer mode at atmospheric pressure at the heights of the tips of coniferous trees, experiments were carried out on the "thundercloud – coniferous tree" model, described by the flowchart (Fig.2).
<…>
Under experimental conditions - at Ph =760 mm Hg, T=21.5 °C, atmospheric humidity 65%, convective flow of CO_2 at a flow rate of 15 l/min – coniferous tips and branches with seasonal properties were used on 04/15/98. <…>
The difference in the ignition time after the streamer discharge (see Table) is due, to a greater extent, to the seasonal properties of electrical

conductivity and resin of the tree, as well as the position (direction) of the tip of the branch relative to the current of the electric field in the "thundercloud - coniferous tree" model. So, the ignition of coniferous branches of all tree species with a slope to the horizon of less than 60° - 65° forms a "bird's claw" type burn through the mechanism of bending a branch to the top of a tree under the influence of electrostatic forces specified in the model. The laboratory burn of a coniferous branch with a streamer electric discharge has the form of a "coal on a break" – charring of the end with a completely intact lateral surface of a coniferous branch, below the concave plane of charring."

Unfortunately, the shape of the branch's bending is not completely clear from the text. Let's look what Galantsev wrote in 2008 [Galantsev, 2008], translated by A.O.:

"Effects of classical thunderstorms on the crowns of all trees in Central Siberia (between the rivers Khushmo and Kimchu) before the explosion, and especially 19 years of their effects on the established, weakened post-disaster forest, before the first description of thermal burn damage to the forest by Kulik in 1927, and complicated the classification picture according to these signs. According to Tables 1-3, the latest work on forest fires from linear lightning in the territory of the Krasnoyarsk region, ribbon-shaped burns, burns of the ends of the tops of coniferous trees, fire ignitions, layers covering the ground (with the exception of the "bird's claw" burn) are signs inherent in lightning discharges of classical thunderstorms (Korshunov, 2002), (Ivanov, 2006). <…>

During experiments using the proposed thundercloud–tree model, it was discovered that unlike high-voltage arc discharges (linear lightning), so-called "silent discharges", then corona discharges ("lights St. Elmo's") and "barrier" (turning into arc discharges) do not leave traces of thermal burns on living branches of coniferous trees (including the "bird's claw" burn). <…>

The use of a powerful inverter-type high-voltage source in the "thundercloud-tree" model (by creating on the tips of drying coniferous samples without needles electric tension more than 10^5 V/m) allowed artificially to form burns of the "bird's claw" type on the ends of experimental branches and even the ignition of branches."

So in 2008 Galantsev abandoned the idea about the induced electrostatic fields by the Tunguska spacebody, and appealed to terrestrial thunderstorms. He planned new experiments, but he tragically left our world at the end of 2008…

The topic of lightnings and thunderstorms related to the Tunguska event has already been considered in [Ol'khovatov, 2023b].

If we assume that the Galantsev's experiments correctly describe the creation of the bird's claw, then this implies the presence of strong near-ground-level electric fields at the time of the Tunguska event. In some cases, their energy was sufficient only to cause minor burns on vegetation, while in others, it led to its ignition.

Also it can't be ruled out that in some rare places the electric current density can achieve level enough to melt the sand. Here is from account collected in 1969 [Vasil'ev et al., 1981] translated by A.O.:

> "Yakochon Andrei Petrovich, Evenk, 80 years old. At the time of the disaster, he was living with his parents in Vanavara. He heard an unusual thunder, long, giving the impression of a flight. Later, the old people told him that the thunder was slow, as if something was flying. This flying body and thunder were heading north. No one knows how far it has flown. It was said that there was an extraordinary fire at the crash site; the earth and sand were burning (they were melted {oplavleny – which in Russian often means 'superficially melted' – A.O.}). <…>"

G.A. Sal'nikova wrote [Sal'nikova, 2000], translated by A.O.:

> "To this observation, we can add the birch root found by E.K. Dmitriev in 1989 in a crater on the Small Northern Island of the Southern Swamp. The root was fused by lightning or another intense heat source, resulting in a collection of "pseudo-tektites" - black glasses with a distinctive sheen and hardness. The ash content of the "pseudo-tektites" after annealing at 800°C was 10%, which is higher than that of charcoal and is approximately equal to the ash content of coke."

Something similar could take place in association with earthquakes. Here is from [Enomoto and Zheng, 1998] regarding the Kobe earthquake of 1995:

> "A fisherman at Tonouchi on Awaji Island (Figure 1a), stated that he saw several electric streaks of bluish-white color spread out for about a second from a localized area near the Nojima fault...
>
> <...>
>
> We found unusual features in the fault in the Hirabayashi district where it crossed an unpaved road.
>
> <...>
>
> The unusual features were: 1) vegetation roots exposed on the wall of the fault were extraordinarily charred as shown by arrow A in Figure 1b; 2) sharp and blackened veins marked the weathered granite fault wall as shown by arrow B in Figure 1b; and 3) the clayey fault gouge under the part

where the charred roots were found was highly lithified and showed a lamellar structure.

<…>

Furthermore, chemical analyses by an induction coupling plasma (ICP) method showed that the contents of metal elements such as Fe, Ti, Al, Mn etc. in the charred roots was about 10 times as large as that of the non-charred roots of the same vegetation."

Phenomena looking similar to lightnings and ball-lightnings are known also in association with earthquakes. Here is from [Ikeya, 2004]:

" Many people observed strange lightning at the time of the Zenkoji Earthquake in 1847. In addition to a pillar of fire (or fire rod) and a trumpet of fire extending upward from the source of light, luminous variously shaped, moving objects like fireballs (ball lightning) were reported. On the ground dried grasses were burned in the flames. <…>

For several days after the quake balloons of bright light came out of the sea over the Gulf of Izmit and the northeastern Marmara Sea and sounds of explosions were heard from the gulf area (Barka, 1999). Fire balls (presumably ball lightning) were observed several times during a period of two or three months before the earthquake, according to a fisherman (Ulusoy and Ikeya, 2002). Some fishermen described a co-seismic undersea explosion and light ascending out of the water into the sky. Fishing nets were found burned."

But such "underwater" case is not alone. Here is, for example, from [Corliss, 1977]:

"The following notes, made on board H. M. S. Volage, while at anchor in Callao Roads, during the severe earthquake which occurred in March, 1828, are of considerable interest. <…>

March 30, 1828. The morning clear, and a light breeze from the southward. At 7h. 28m. a black thin cloud passed over the ship, with very heavy distant thunder. At the same moment we felt the shock of a severe earthquake. <…> The ship was moored with two chain-cables, and on weighing the anchors a few days after, we found 56 links of the best bower cable much injured; the iron had the appearance of being melted, and nearly one-sixth of the link was destroyed. This piece was 30 fathoms from the anchor, and 20 fathoms from the ship. The bottom was soft mud, in which the cable was buried. During the earthquake the water alongside was full of little bubbles; the breaking of them sounded like red-hot iron put into water."

Of some interest is also ‘’on-water” case from an abstract of [Enomoto, et al., 2019]:

> “In this paper, we investigate the mysterious tsunami fires that occurred at Aonae Harbor on Okushiri Island during the 1993 Hokkaido Nansei-Oki earthquake. Specifically, five fishing boats moored separately from each other in the harbor suddenly caught fire and burned nearly simultaneously with the arrival of the first tsunami wave. However, the ignition mechanism of those fires has, until now, remained largely unknown. At the time the earthquake occurred, an NHK (Japan Broadcasting Corporation, Tokyo, Japan) crew that was on the island to report on its scenic natural attractions just happened to capture video footage of those tsunami-related fires. Using that NHK video footage in combination with eyewitness accounts, this study investigates the spatio-temporal process leading to those tsunami-related fires. For example, one witness said, "There was whitish bubbling in the offshore area and I saw five burning fishing boats moored on the seawall being blown about by the strong winds. The burning boats were swept ashore with the tsunami and ignited the gasoline of a car that was rolling in the waves. The fire eventually spread to the center of the Aonae District." The NHK video footage confirmed flames arising from the five fishing boats almost simultaneously and the shimmering white color of the tsunami waters striking the seawall, which were consistent with the eyewitness testimony. Based on these spatio-temporal data, we propose the following hypothetical model for the origin of tsunami fires. Combustible methane gas released from the seabed by the earthquake rose toward the surface, where it became diffused into the seawater and took the form of whitish bubbles. The tsunami strike on the Aonae Harbor seawall resulted in the generation of large electrical potential differences within the seawater mist, which quickly developed sufficient electrical energy to ignite the methane electrostatically. The burning methane bubbles accumulated on the boat decks, which then burned violently.”

It is quite possible that some gas outbursts also took place in the Tunguska event.

With the 1828 underwater chains melting the situation looks more complicated. Maybe the earthquake-related electric current melted the chains? The electric current also could transform water into gas (water vapor, hydrogen plus oxygen), the hydrogen plus oxygen can burn violently adding to the melting. Could something similat take place in Tunguska? Indeed the Tunguska event took place during an upsurge of tectonic activity on the regional level [Ol’khovatov, 2003, 2022]. So an increase in endogenic degassing is possible.

Here is from [Alekseev, et al., 2010] about the paleovolcano:

> “During the expedition, hydrogen flows were measured on the routes to the Farington and Stoikovich mountains and around the Suslov crater. In some areas, the hydrogen flows related to degassing of breakage structures of the paleovolcano are anomalously high. This fact also confirms a possible endogenous origin of the geochemical anomalies (elevated concentration of microelements in the 1908 moss layers). Anomalous hydrogen flows suppress plant growth as identified in satellite photographs.”

Authors of [Skublov, et al., 2011] also wrote about discovery of 2 hydrogen degassing anomalies. In favourite circumstances the electrical discharges could ignite hydrogen (and some other degassing gases) in the air. Moreover increased hydrogen degassing can result in increased water vapour content in the upper atmosphere. The Author in [Ol'khovatov, 2025e] proposed that the hydrogen degassing could make input in the atmospheric optical anomalies reported at the time in question [Vasilyev, 1998; Ol'khovatov, 2025a].

Anyway, let's return to the electromagnetic manifestations. The next interesting fact is not strictly an "argument", it is sooner a question.

Researchers marked a peculiarity of the dead trees. The words by Nesvetajlo: "Despite 80 years that have passed since the 1908 catastrophe year, the dead standing trees unlike those that were felled by the explosion, have preserved very well..." were already presented early in this paper. Here is from [Doroshin, 2005] translated by A.O.:

> "There are two well-known comments about the good preservation of wood trunks - one from a denunciation by Temnikov (1929), who believed that the reason for the good preservation was the release of preservatives by the tree under the influence of fire, the second from the collective response of the participants of the Meteorite Expedition to this denunciation: "...assume that Temnikov opposes the ground/earth fire to the burning by a hurricane of incandescent gases, then we can say that, firstly, the general appearance of the central area of the radial windfall exposed to the burn does not correspond to the usual type of forest (taiga) fires, and secondly, we do not know another case when (after a forest fire that almost completely killed the taiga) the dry forest would have remained on the roots for 22 years with such a high degree of safe, not blue, with amber-yellow wood, so that from this forest you can take, as in a living forest, material (now dry, of course) for buildings, crafts and magnificent firewood".
>
> Temnikov also gives a corresponding argument in favor of his interpretation - the lower part of the (dry) deadwood was more or less

preserved, while the tops rotted and fell off. There is no direct answer from Kulik to this argument, but it is clear from the general meaning of the answer that he considered the argument to be erroneous.

The author had a chance to work with specialists in forestry and fire research in the epicenter area. They extremely vigorously denied the possibility of preserving the bark on the larch pillars for more than 80 years after the fire ("This cannot be!"), and only a special check that these larches died in 1908 convinced them of this. At the same time, experts concluded that the fire led to the conservation of wood and bark.

The mechanism of wood conservation is still not completely clear, but no detailed research has been done on this topic."

Could the electric discharges "preserve" the wood? Food for thought...

Another question concerns an accelerated growth of trees [Vasilyev, 1998]. Could the electric fields be responsible (at least partly) for the growth?

It is known that electric discharges in the air can produce some level of radiation, like X-rays, and in some cases even production of antimatter was registered ([Gibney, 2024] and references in there). Discussion of probable physical mechanisms is beyond the scope of this paper. It is remarkable that there are some hints on such production in Tunguska. The hints are associated with thermoluminescence research in Tunguska. Here is from [Vasil'ev, et al., 1976] translated by A.O.:

"It is known that the thermoluminescence of materials increases as a result of irradiation with hard ionizing radiation, high-temperature exposure, on the contrary, it extinguishes it. In 1966, the Tunguska meteorite impact area was surveyed in order to study the thermoluminescence of traps. It is known that the thermoluminescence of traps in the center of the area is slightly increased compared to the periphery. In the east there is an area of reduced thermoluminescence. The configuration of the eastern boundary is shown in Fig. 1. It can be seen that in the eastern part there are two symmetrical protrusions of increased thermoluminescence values.

In 1963 — 1968 in the same area, work was carried out to study the mutational background of pine trees. The basis for these studies was information that pine radiation mutants have a characteristic feature of somatic mutation as a three-needle bundle. It was discovered, that the frequency of occurrence of trees with the increased number in bundles decreases with distance from the epicenter, reaching at 20 km background values. The shape of the area where this effect is observed is also shown in Fig. 1. It shows that, as in the previous case, the eastern boundary of the contour has a two-petalled shape, similar to the similar boundary of the areas of thermoluminescence and intense burn. It should be pointed out that the biological mechanism of the appearance of the three-needle pine bundles is not completely clear."

Fig.1 from [Vasil'ev, et al., 1976] is reproduced here on Fig.5 with a little adaptation. 1 — the boundaries of the burn area; 2 — the boundaries of the zone of high "mutation" of pines; 3 — the boundaries of increased thermoluminescence of traps; the red square – the Kulik huts. The line with the arrow on the left is not marked (possibly one of the proposed trajectories of the alleged Tunguska spacebody).

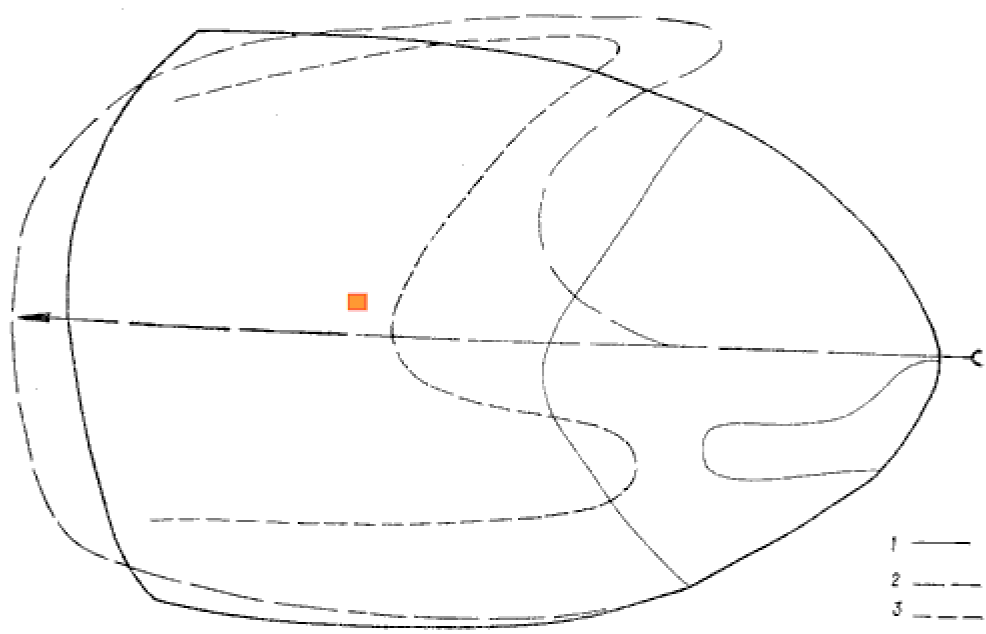


Fig.5

Authors of [L'vov and Vasil'ev, 1976] wrote about this peculiarity (translated by A.O.):

"Comparing the propagation areas of the branch burn effect, the mutation effect and the thermoluminescence effect, we find similarities in the shape and the size of the area of their distribution, up to the presence of an area with an extremely weak manifestation of these effects. It suggests a physical similarity of the mechanisms of their origin (the release of radiant energy) in contrast to the group of effects (the forest-fall, distribution of "telegraphic" forest, etc.), in which the main or significant role was played by the air wave."

Since 1976 and until recently, KSE has been conducting research on the thermoluminescence of minerals in the soils of the area. A large number of samples allowed obtaining a more detailed picture of the thermoluminescence field. In the zone from 5 to 15 km around the epicenter, there is a predominance of samples with high thermoluminescence values, and in the zone directly adjacent to the epicenter, samples with low thermoluminescence values.

Additional research showed that (unaccounted-for) fluctuations in the mineral composition of the concentrate did not significantly affect the results of the analysis.

Now let's give the floor to the leading researcher of thermoluminescence – here are several fragments from [Bidyukov, 2008], translated by A.O. (TL is thermoluminescence, ETL is natural thermoluminescence):

> “The above considerations show that the patterns of effects that develop according to two methods (concentrate and traps) complement each other rather than contradict each other (pp. 97-107). <…>
>
> Summarizing the above, we will briefly list those provisions of the article that seem to us the most significant.
>
> 1. According to the totality of the measurements carried out in the Tunguska disaster area, two effects were reliably recorded: the local thermoluminescence field of both traps and soils has deviations from the natural background:
>
> - towards lower levels, when the values of the TL parameters are close to zero (range 0-7 units compared with background values at the level of 80-100 units);
>
> - towards higher levels, when the values of TL parameters exceed the background average by 1.5-2 times; given the nature of sample preparation in the field, these values must be increased by the same amount.
>
> 2. The level of background values is estimated, which allows to navigate when selecting abnormally low and abnormally high values of the TL field.
>
> 3. Fluctuations in the natural field of radioactivity in Tunguska do not affect deviations in the variation of the TL field.
>
> 4. The "spotting" effect, when samples located at a distance of ten meters from each other can give significantly different values of TL parameters, does not allow to fully navigate by the absolute values of measurements and requires the use of statistical processing methods when constructing a TL field throughout the Disaster area. <…>
>
> 5. The study of the vertical gradient of the TL field of the Disaster area showed that the effect of strengthening the TL of the upper layers of the John's Stone section (experiments by M. V. Korovkin's group) with a decrease in TL values with depth was definitely detected. In soil sections, this effect was recorded only for near-surface layers in several samples of the epicentral zone. In soil sections taken at a depth of up to a layer of

permafrost or solid pebbles (depths of 50-70 cm), coincidences with the theoretical model of vertical gradient ETL (monotonous increase in levels with depth) are not observed. Approximately equal levels in all 6-8 layers are detected, which does not allow establishing any pattern.

6. Samples with reduced TL values are concentrated in the area of particularly severe burning of tree branches. The TL "annealing" zone thus allows its identification with the zone of primary ignition of the moss litter and the occurrence of a catastrophic fire, i.e. the "annealing" zone TL locates the zone of maximum thermal loads of radiation from the Tunguska explosion. The heat flow is estimated at no more than 7 cal/cm^2. <…>

9. Irradiation in the UV range does not lead to a significant increase in thermoluminescence levels. The processes of erasing the previously stored light sum of TL are associated with this range. The restoration of annealed samples by UV radiation gives the lowest possible base level of TL in the sample. Thus, there is no reason to associate the effect of abnormally high TL values in Tunguska with the effect of UV radiation.

10. The claims about the stimulating (or erasing) effect of the shock wave of the Tunguska explosion on the TL field are also completely unfounded. The levels of overpressure in the wave front are many orders of magnitude less than those necessary to obtain the effect of changing the TL parameters in the crystal.

11. There is no alternative to the action of radiation fluxes in the explosion zone in the range of X-ray, gamma radiation, or neutron and proton radiation.

12. Considerations for explaining the identified anomalies due to the genesis of the minerals themselves are not supported still by any research. Proof of participation in the formation of the TL field in this area of the paleovolcano also requires the formulation and implementation of a special research program. Before receiving any results in this pledge, any statements on this topic should be regarded as unfounded.

The ghost of a nuclear explosion (according to A. P. Kazantsev), the idea of which is based on analogies with terrestrial man-made models and their full-scale implementation, for a long time closed/interfered vision of the researchers of the Tunguska Event. Now it is necessary to build a different model, free from the "birthmarks" of the basic one."

Also it is remarkable that all 3 effects (the burn, thermoluminescence anomalies, and mutations) demonstrate the spotted nature.

Regarding thermoluminescence peculiarities, there is a special case regarding so called "John's stone" [Haack et al., 2016]. Here is from [Korovkin et al., 1997], translated by A.O. (RL is x-ray luminescence, TL is thermoluminescence):

"The TL restored by gamma irradiation of quartz samples taken from the near-surface layer has a high intensity of luminescence, indicating the presence of previous radiation exposure.

A regular decrease in TL with the depth of sampling is observed (Fig. 1). The assumption that thermal annealing of near-surface samples affects the enhancement of TL luminescence in the temperature range up to 100 C is not supported by the results of RL measurements (Fig. 2), as the luminescence spectra of samples subjected to thermal annealing should exhibit an additional luminescence band in the ultraviolet region of 300-400 nm. The difference in TL and RL properties between irradiated and calcined/heated samples is due to the specific nature of radiation and thermodiffusion reactions in quartz.

Based on the experiments conducted, it can be assumed that the Tunguska explosion was accompanied by radiation exposure."

So the Tunguska event was very complex phenomenon. Research of the Tunguska event requires participation of experts in various fields of science.

3. Discussion

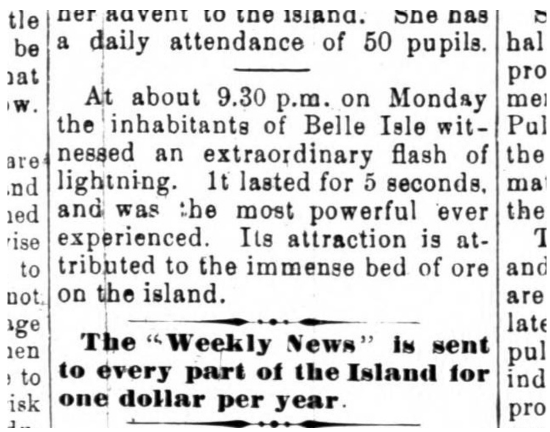
In the opinion of the Author the data points to action of electromagnetic processes according to the geophysical interpretation of the Tunguska event as it was briefly discussed in [Ol'khovatov, 2023b] where also eyewitness accounts are presented in favor of action of electromagnetic processes. In the Author's opinion the 1993 Jerzmanowice event in Poland can be called mini-Tunguska [Ol'khovatov, 2025d].

The Bell island (an island near Nova Scotia, Canada) event in 1978 possibly also could be called as mini-Tunguska, but unfortunately, this event is poorly presented in the scientific literature. This event was heard over distance of 100 km. Residents of the island reported a loud explosion (or possibly three closely spaced explosions) and one resident reported seeing a bright flash followed by the appearance of a luminous ball. This ball faded after a few seconds. There was damage to nearby electrical equipment [Stevenson, 2016]. Here is from [Stevenson, 2016]:

"Using data from the Vela gamma ray satellites, which were used to monitor nuclear tests, John Warren and Robert Freyman from the Los Alamos National Laboratory (then called the Los Alamos Scientific Laboratory) detected a superbolt over the island at about the time the reports of the explosion or explosions came in."

Interestingly that the Author read in web-page

(https://www.productofnewfoundland.ca/articles/the-bell-island-boom) about an unusual lightning over the island in 1896. The Author discovered scanned archive of The Daily News newspaper (https://dai.mun.ca/digital/dailynews) and here it is from Nov. 11, 1896 issue on Fig. 6.



her advent to the island. She has a daily attendance of 50 pupils.

At about 9.30 p.m. on Monday the inhabitants of Belle Isle witnessed an extraordinary flash of lightning. It lasted for 5 seconds, and was the most powerful ever experienced. Its attraction is attributed to the immense bed of ore on the island.

The "Weekly News" is sent to every part of the Island for one dollar per year.

Fig.6

This explanation which seems rather reasonable even nowadays demonstrates level of local journalism in Canada in 1896.

There may be a question: what if to switch from mini-Tunguskas to super-Tunguskas? Food for thought...

Anyway researching mini-Tunguskas could help better understand the Tunguska event, and probably even super-Tunguskas. So, for example, comprehensive research of the Bell island event would be very desirable.

4. Conclusion

Thus, although there is no direct instrumental evidence of electrical discharges in the epicenter area in 1908, there are many indirect arguments in favor of their presence. The latter is in agreement with the geophysical interpretation.

The general conclusion is that the Tunguska event was a very complex phenomenon. Research of the Tunguska event requires the participation of experts in various fields.

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