On radiocarbon near the epicenter of the 1908 Tunguska event

Andrei Ol'khovatov

https://orcid.org/0000-0002-6043-9205

Independent researcher
(Retired physicist)

Russia, Moscow
email: olkhov@mail.ru

This is a non-peer-reviewed preprint submitted to EarthArXiv.

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. A large number of hypotheses about its causes have already been put forward. However, so far none of them has received convincing evidence. Since the late 1950s, a large number of studies have been carried out in the area of the Tunguska event, including those related to radiocarbon measurements. Some radiocarbon measurements have produced results that are problematic to explain within the asteroidal and the cometary interpretations of the Tunguska event. This paper shows how these results can be explained using 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; 2025f; 2025g]. 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. As it is written on the title web-page of the web-site created by KSE (see below about KSE) tunguska.tsc.ru/ru/ (translated by A.O.):

> "About a thousand researchers have devoted years of their lives to the Tunguska phenomenon. However, there is still no well-founded scientific understanding of what happened over the Siberian taiga on June 30, 1908."

This is probably why new hypotheses appear almost every year, not only in the mass-media, but also in scientific literature. At the same time, any hypothesis should not contradict the known facts about the event. Unfortunately, the authors of new hypotheses, as well as the authors of popular science articles, often use data, many of which turned out to be not entirely accurate, or even incorrect. The author of this paper hopes that it will help both the authors of various hypotheses and their readers to evaluate the validity of the proposed hypotheses.

Let's start with brief info about research of the Tunguska event. 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 (consisting mainly of scientists, engineers and students) most of whom united under the name Kompleksnaya Samodeyatel'naya Ekspeditsiya (KSE) continued research (KSE started research in 1959). 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”.

This paper is based on a review and analysis of some works related to radiocarbon measurements. The Author presents his point of view on the causes of the peculiarities of radiocarbon measurements.

2. Peculiarities with radiocarbon near the epicenter

In [Nesvetailo and Kovalyukh, 1983] 2 trees from the epicentral area were sampled. In the opinion of the authors [Nesvetailo and Kovalyukh, 1983] their data fits well into the model of temporal changes in the rate of radiocarbon formation depending on the level of solar activity. In [Longo et al., 1994] one tree was investigated, and the result was in accordance with expected ^{14}C variations with the solar activity. In [Yonenobu and Takenaka, 1998] one tree was investigated, and the result indicated no significant differences between the sampled ^{14}C and the variations observed in their control trees.

In 1970s KSE conducted rather large research on radiocarbon in trees near the epicenter. Seven trees were sampled. In [Firsov et al., 1984] 5 out of 7 trees showed an increase ^{14}C isotope which does not go beyond normal fluctuations associated with solar cycles. But two trees showed anomalous results which will be discussed below in this paper.

Probably the most peculiar features of the radiocarbon measurement results were revealed in the peat. These results are described in the article [Rasmussen, et al. 1999] and the subsequent discussion in the journal. Here are several fragments from the article [Rasmussen, et al. 1999]:

> "...the slight but distinct ^{14}C anomaly seen in Fig. 2a. We interpret the anomaly to be due to an excess of nonradioactive C caused by a sudden influx of cosmic material. <...>
>
> The depth interval from 43 to 63 cm, in which we find the radiocarbon depletion, is comparable to the depth of the 1908 layers found in previous studies (e.g., Kolesnikov *et al*., 1996). There are no signs of fire in the cores at or near the depleted layer. <...>
>
> These deposition rates yield a C/Ir ratio of $12 \pm 3 \times 10^8$, which is exceptionally high. Comparing it to various meteorite groups (see Table 3) shows that the Tunguska impactor had a C/Ir ratio of at least a factor 10^4 higher than the meteorites:... <...>
>
> As part of the normal radiocarbon dating procedure, we have also measured the $\delta^{13}C$ of the samples in core #1 and core #4. Distinct anomalies are found in both cores coinciding with the ^{14}C and Ir anomalies (see Fig. 3a,b). Using the determined excess ^{14}C and the calculated cosmic C deposition rate, we can estimate the $\delta^{13}C$ of the impactor material. For core #4, this yields $\delta^{13}C = +55 \pm 10$ ‰ VPDB for the impactor material. <...> The same study of Kolesnikov *et al*. (1996) failed, however, to detect a pronounced ^{14}C anomaly. <...>
>
> Our findings are, however, in good agreement with the lack of excess Ir depositions found in both Greenland (Rasmussen *et al*., 1995) and Antarctic ice fields (Rocchia *et al*., 1990). From the present results, we are forced to conclude that the Tunguska impactor was indeed very depleted in Ir, but high in C."

The authors estimated a net deposition of 136 000 ± 20 000 tons of cosmic C.

In 2001 a comment on the article was published [Jull et al., 2001]. Here are several fragments from [Jull et al., 2001]:

> "However, the assumed "typical $\delta^{13}C$" for the impactor appears high and is based on the assumption of Rasmussen *et al.* (1999) that the ^{14}C depression is due to an extraterrestrial component. Using this assumption of an average $1.73 \pm 0.24\%$ addition of ^{14}C-free material, one would conclude the "impact" carbon was about +97‰ ."

So the conclusion of the authors of [Jull et al., 2001] was the following:

> "We dispute the conclusion of Rasmussen *et al.* (1999) that the variations of ^{14}C at the Tunguska site must be explained by addition of ^{14}C-free carbon from the impactor. The distribution of ^{14}C at the site reported by Rasmussen *et al.* (1999) does not deviate significantly from the known distribution of ^{14}C during the last 400 years. We conclude that there is no evidence to conclude that the impactor was of unusual isotopic composition or that a measurable signal of the carbon deposited in the atmosphere has been observed."

A reply by the authors of [Rasmussen, et al. 1999] was added to the article [Jull et al., 2001] in the publication. Here are several fragments from the reply:

> "In their comment Jull *et al.* argue for another interpretation of our ^{14}C data, namely that the depression in $^{14}C/^{12}C$ ratio seen in our data at a depth of ~56 cm below the 1994 surface is caused not by an influx of ^{14}C void cosmic carbon, but is due to the known combustion of fossil fuel following the onset of the industrial revolution. Jull *et al*. produce an alternative depth vs. age curve for our data in accordance with this scenario (their Fig. 1). <...>
> If we assume - as a conservative guess - that the Tunguska peat has an effective annual growth season of 100 days, a 2% decrease in ^{14}C activity correspond to 2 days of growth on pure ^{14}C-dead CO_2. <...>
> An alternative explanation could be that the cosmic carbon was not taken up by the peat plants but was present in a form that allowed it to adhered to the peat. <...>
> In conclusion we must reject the interpretation of Jull *et al.*, which is only possible if the Ir peak is placed at A.D. 1945-54, when no impact took place in the Tunguska area. Our interpretation is still the most likely one, although not the only one possible."

One of the authors of the article [Rasmussen, et al. 1999] later published several more articles (with various co-authors) about the discovery of the Tunguska cometary substance. Here are several fragments from [Kolesnikov et al., 2005] (TCB is the Tunguska Cosmic Body):

> "The results of the analyses of the other two peat columns from the explosion epicentre were not very successful [42]. <...> On repeating sampling at the Northern peat bog, the peat columns did not show appreciable abundance in the elements. In the next peat column, sampled

by us at Southern peat bog (Klyukvennyy island), the increase of Ir content has only been revealed [44]. Furthermore, the results of the layer-by-layer analyses of other peat columns made by spectral method [45, 46] were not very successful as well. <...>

Rasmussen et al. [57] found the Ir (39.9 ppt) anomaly and 14 C depletion in the event layer of the Nearkhushma peat bog column. This may imply that in the explosion area the distribution of the TCB fallout is highly inhomogeneous. <...> This means that, if the TCB was a comet, its core would have probably been almost pure ice with admixtures of soot, hydrocarbons and other organic compounds. Such a core, with a very low content of dust, is very different from the core of Halley's comet, which has a high dust fraction content of approximately 40% [74].

The Author already points many times in his previous works on the spotty character of many manifestations of the Tunguska event near its epicenter.

The results of the team's long-term research on the search for the substance of the alleged Tunguska spacebody were presented in [Kolesnikov and Rasmussen, 2008]. Here are several fragments from [Kolesnikov and Rasmussen, 2008] (TCB is the Tunguska Cosmic Body):

"Tunguska comet material in peat from the explosion epicenter

We analyzed Sphagnum fuscum peat columns in which the peat layer grown up in 1908 can be dated by botanical method. The presence of the comet material is proposed to show up by change, or shift, of isotopic composition of the light elements. In the nearcatastrophic layers of the five peat columns from the explosion epicenter the shifts in the carbon and hydrogen isotopic composition have been revealed. They represent sites at the explosion area enriched in the TCB material fallen down on Earth highly inhomogeneously [3-6]. The shift of isotopic composition for carbon $\Delta^{13}C$ was up to +4.3‰ and for hydrogen ΔD up to –22‰. They are opposite in sign and couldn't be caused by the terrestrial processes: fall out of terrestrial mineral and organic dust, humification of peat, emission of hydrocarbon gases from the earth and so on. <...> Cosmic carbon in peat is very heavy in its isotopic composition: from +51‰ up to +64‰ [3, 6]. <...> Very high C/Ir ratio in peat points to the low concentration of mineral dust in Tunguska comet as compared to Halley's comet [9]. The absence of smoky track among eyewitness's evidences corroborates the conclusion. Chemical composition of the TCB in peat points to its cometary origin as well [10]. <...>

Thus, the shifts in isotopic composition of carbon and hydrogen and as well sharp increase in concentration of number of elements, mainly volatile, clearly point to cometary origin of the TCB."

So they insist of their original interpretation. By the way, regarding "emission of hydrocarbon gases from the earth" here is from [Kolesnikov et al., 2003] how they tested this:

> "In order to test the influence of gaseous hydrocarbon streams released from the Earth, we have analyzed oil sampled at the same region, at the river Dyulyushma oilfield, gaseous hydrocarbon streams from which may have affected peat bogs. Oil carbon, however, proved to be strongly depleted in ^{13}C ($\delta^{13}C_{PDB}$ = - 33.7‰)."

So they tested just oil from the oilfield nearby.

It should be noted that anomalous results in radiocarbon dating of some samples of peat layers near the epicenter (unrealistically high ages, etc.) were also obtained by a number of other Soviet researchers in the 1970s.

Moreover similar anomalous results in radiocarbon measurements were registered in trees near the epicenter. According to [Firsov et al., 1984] in 5 out of 7 trees sampled an increase in radioactivity (due to radiation of the ^{14}C isotope in wood formed in the decade including 1908) almost does not go beyond its normal fluctuations associated with solar cycles. But in two trees a noticeable decrease in the specific activity of radioactive radiation of the ^{14}C isotope was detected compared to other trees or the level specific activity in 1890. So again the spotty character is present...

3. Discussion

The Author is his book [Ol'khovatov, 1997] (while commenting the mentioned above anomalies with ^{13}C) wrote that the isotopic composition of carbon from juvenile gases has been observed to become heavier (an increase in the fraction of the isotope with atomic weight 13) in connection with various earthquakes. Indeed the epicenter is in the middle of the Kulikovskii paleovolcano [Ol'khovatov, 2025e]. The paleovolcano is "a pipe of deep degassing and exhalation, surrounded by denser rocks"(see [Ol'khovatov, 2025e] for details). Moreover there was an upsurge of tectonic activity in the region of Lake Baikal and to NW of it on those days [Ol'khovatov, 1997; 2003]. According to Fig.3 of [Rasmussen, et al. 1999] $\delta^{13}C$ in the "affected" layers was increased from ~ -25.5 ‰ VPDB to ~-24 ‰ VPDB. The content of ^{13}C in volcanic gases is typically much higher [Moussallam, 2025], and by the way the gases are sometimes depleted in deuterium.

Let's consider the radiocarbon depletion discovered in [Rasmussen, et al. 1999]. Carbon dioxide emitted from subsoil geological sources contains effectively no ^{14}C

[Soter, 2011]. This can explain peculiar results in the peat-sampling. Similar explanation can be applied to the anomalous result in [Firsov et al., 1984] where the decrease in the specific activity of radioactive radiation of the ^{14}C isotope was detected.

So there is no need to involve thousands of tons of the cometary matter in the explanation. In the opinion of the Author the geophysical interpretation gives a much better explanation.

In the book [Ol'khovatov, 1997], the Author brought up more aspects that should be kept in mind when analyzing isotope measurements in Tunguska. Here are 2 of them - the possibility of bringing substance from other places and the possibility of nuclear reactions under the influence of electrical discharges. The first aspect is explained in English in [Ol'khovatov, 2020b], the second aspect is rather well-known nowadays - see for example [Gibney, 2024] and references in there.

4. Conclusion

There are problems in attempts to explain the radiocarbon peculiarities near the epicenter in the frames of the asteroidal and cometary interpretations. In the opinion of the Author the geophysical interpretation gives a much better explanation.

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.

ACKNOWLEDGEMENTS

The Author wants to thank the many people who helped him to work on this paper, and special gratitude to his mother - Ol'khovatova Olga Leonidovna (unfortunately she didn't live long enough to see this paper published...), without her moral and other diverse support this paper would hardly have been written.

References

Firsov, L.V., Zhuravlev, V.K., Panychev, V.A. (1984). Rezul'taty analizov kontsentratsii radiougleroda v sloyakh drevisiny listvennitsy iz raiona Tungusskogo padeniya. // Meteoritnye issledovaniya v Sibiri. Novosibirsk, Nauka, pp.67-77 (in Russian).

Gibney, Elizabeth (2024). Mysterious form of high-energy radiation spotted in thunderstorms. // Nature, Oct. 02,
https://www.nature.com/articles/d41586-024-03206-7
https://doi.org/10.1038/d41586-024-03206-7

Jull, A.J.T., Burr, G. S., Kring, D. A.(2001). Comment on “Evidence for a very high carbon/iridium ratio in the Tunguska impactor” by K. L. Rasmussen, H. J. F. Olsen, R. Gwozdz and E. M. Kolesnikov. // Meteoritics & Planetary Science, v.36, pp. 999-1006. https://doi.org/10.1111/j.1945-5100.2001.tb01935.x

Kolesnikov, Evgeniy M. , Longo, Giuseppe , Boettger, Tatjana et al. (2003). Isotopic-geochemical study of nitrogen and carbon in peat from the Tunguska Cosmic Body explosion site. // Icarus, Vol. 161, Issue 2, pp. 235-243. https://doi.org/10.1016/S0019-1035(02)00024-6

Kolesnikov, E.M., Hou, Q. L., Xie, L. W. & Kolesnikova, N. V. (2005). Finding of probable Tunguska Cosmic Body material: anomalies in platinum group elements in peat from the explosion area. // Astronomical & Astrophysical Transactions, v.24, N2, pp. 101-111. https://doi.org/10.1080/10556790500085678

Kolesnikov, E.M. and Rasmussen, K.L. (2008). Tunguska comet material in peat from the explosion epicenter. //International Conference "100 years since Tunguska phenomenon: Past, present and future", Moscow, June 26-28, 2008. Abstracts, p.48

Longo, G., Serra, R. . Cecchini, S. , Galli, M. (1994). Search for microremnants of the Tunguska Cosmic Body. // Planetary and Space Science, Volume 42, Issue 2, p. 163-177 https://doi.org/10.1016/0032-0633(94)90028-0

Moussallam, Y. (2025). Carbon Isotopes in Magmatic Systems: Measurements, Interpretations, and the Carbon Isotopic Signature of the Earth’s Mantle. // Geosciences, 15, 266. https://doi.org/10.3390/geosciences15070266

Nesvetailo, V. D. and Kovalyukh, N.N. (1983). Dinamika kontsentratsii radiougleroda v godichnykh kol'tsakh derev'ev iz tsentra Tungusskoi katastrophy. // Meteoritnye i meteornye issledovaniya. Novosibirsk, Nauka, pp.141-151 (in Russian).

Ol’khovatov, Andrei (1997). Mif o Tungusskom meteorite. Tungusskii fenomen 1908 goda – zemnoe yavlenie. Assots. “Ekologiya Nepoznannogo”, Moskva, 128 p. (in Russian).

Ol'khovatov, A.Y. (2003). Geophysical Circumstances Of The 1908 Tunguska Event In Siberia, Russia. // Earth, Moon, and Planets 93, 163–173. https://doi.org/10.1023/B:MOON.0000047474.85788.01

Ol'khovatov, A. (2020a). New data on accounts of the 1908 Tunguska event.// Terra Nova,v.32, N3, p.234.

https://doi.org/10.1111/ter.12453

Ol'khovatov, A. (2020b). Some comments on events associated with falling terrestrial rocks and iron from the sky.// https://arxiv.org/abs/2012.00686 https://doi.org/10.48550/arXiv.2012.00686Ol'khovatov, A. (2021) - The 1908 Tunguska event and forestfalls. // eprint arXiv:2110.15193 ; https://doi.org/10.48550/arXiv.2110.15193

Ol'khovatov, A. (2022) - The 1908 Tunguska Event And The 2013 Chelyabinsk Meteoritic Event: Comparison Of Reported Seismic Phenomena. // eprint arXiv:2206.13930 , https://arxiv.org/abs/2206.13930 ; https://doi.org/10.48550/arXiv.2206.13930

Ol’khovatov, A. (2023a) - The 1908 Tunguska event: analysis of eyewitness accounts of luminous phenomena collected in 1908. // arXiv:2310.14917 ; https://doi.org/10.48550/arXiv.2310.14917

Ol’khovatov, A. (2023b) - The Evenki accounts of the 1908 Tunguska event collected in 1920s – 1930s. // arXiv:2402.10900 ; https://doi.org/10.48550/arXiv.2402.10900

Ol’khovatov, A. (2025a). The 1908 Tunguska Event and Bright Nights. // arXiv:2502.01645, https://arxiv.org/abs/2502.01645 ; https://doi.org/10.48550/arXiv.2502.01645

Ol’khovatov, A. (2025b). Some mechanical and thermal manifestations of the 1908 Tunguska event near its epicenter. // https://eartharxiv.org/repository/view/8790/ ; https://doi.org/10.31223/X52F0H

Ol’khovatov, A. (2025c). Some Historical Misconceptions and Inaccuracies Regarding The 1908 Tunguska Event. // https://arxiv.org/abs/2505.05484 ; https://doi.org/10.48550/arXiv.2505.05484

Ol’khovatov, A. (2025d). The 1993 Jerzmanowice event in Poland and the 1908 Tunguska event. // https://eartharxiv.org/repository/view/9435/ ; https://doi.org/10.31223/X59F0P

Ol’khovatov, A. (2025e). Some Geophysical Aspects Of The 1908 Tunguska Event. // http://arxiv.org/abs/2507.21296 ; https://doi.org/10.48550/arXiv.2507.21296

Ol’khovatov, A. (2025f). The 1908 Tunguska event and electromagnetic phenomena. https://eartharxiv.org/repository/view/9781/ ; https://doi.org/10.31223/X5RR0T

Ol’khovatov, A. (2025g). The 1908 Tunguska event and the atmospheric optical anomalies. // https://arxiv.org/abs/2510.03239 ; https://doi.org/10.48550/arXiv.2510.03239

Rasmussen, Kaare L. ; Olsen, Hans J. F. ; Gwozdz, Raymond ; Kolesnikov, Euginev M. (1999). Evidence for a very high carbon/iridium-ratio in the Tunguska impactor // Meteoritics & Planetary Science, vol. 34, no. 6, pp. 891-895
DOI: 10.1111/j.1945-5100.1999.tb01407.x

Soter, Steven (2011). Radiocarbon Anomalies from Old CO2 in the Soil and Canopy Air. // Radiocarbon , Volume 53 , Issue 1 ,, pp. 55 - 69
DOI: https://doi.org/10.1017/S0033822200034354

Yonenobu, H. and Takenaka, Ch. (1998). The Tunguska Event as Recorded in a Tree Trunk. // Radiocarbon, vol.40, No. 1, pp. 367-371
DOI: https://doi.org/10.1017/S0033822200018245