4. Ideas Become Bizarre

After World War II, the Soviet Union found itself with many problems. Most pressing was the need to rebuild the economy and to develop new weapons. The United States ended the war as the world economic leader, whereas the USSR, which hardly had been an economic giant before the war, had about a third of its national wealth destroyed. Its war casualties reached 27 million. So it was on this foundation that the country had to meet the minimal needs of its citizens while building up its military capability. Naturally enough it made use of German expertise, since Germany caused the war. So several groups of military, science, and intelligence officers were sent to Germany to find and bring back to the Soviet Union plants, machine tools, and high technologies, as well as German scientists and engineers who could help in developing new weaponry in the country. One of those Soviet specialists was Colonel Alexander Petrovich Kazantsev (see Figure 4.1) – the science fiction writer already mentioned – who, in 1945, was chief engineer at a large Soviet research center. At the time he was already the source of several important inventions and had started to write science fiction. Just before the war his first novel, *The Burning Island*, was published.

Alexander Kazantsev was born on September 2, 1906, in the old Russian town of Akmolinsk (now Astana, the capital of Kazakhstan). His paternal grandfather was a merchant millionaire, and his maternal grandfather, a participant in the Polish Uprising of 1863, was sent into exile by the Tsarist government. Before the 1917 revolution, Alexander's father had worked in the family's trading firm, and after the revolution served first in the White Army and then in the Red Army, just as Leonid Kulik had. His mother was a gifted piano player and a music teacher, but Alexander himself graduated at Tomsk Technological Institute in 1930 (not without difficulties because his social origin was not exactly proletarian). This author had the good fortune to become acquainted with

V. Rubtsov, *The Tunguska Mystery*, Astronomers' Universe,
DOI 10.1007/978-0-387-76574-7_4,

FIGURE 4.1. Alexander Kazantsev (1906–2002), an engineer and sci-fi writer, whose hypothesis about the catastrophe of an extraterrestrial starship over Central Siberia gave the main impetus to the Tunguska studies in the USSR in the mid 20th century (*Source*: *The Tunguska Phenomenon: 100 Years of an unsolved mystery*. Krasnoyarsk: Platina, 2007, p. 43.).

Alexander Kazantsev in 1969, and our correspondence, which started as far back as 1963, testifies that he was an outstanding personality. He was not only an inventor and science ficition writer but also a famous chess master, the author of many brilliant end-game studies, and an International Master of chess composition. But what was most important was that he did not fear to think logically, no matter how far this logic might lead him. So it was not an accident that in the mid-1940s Alexander Kazantsev gave a new impetus to the Tunguska studies.

In the spring of 1945, the chief engineer at the All-Union Institute of Electromechanics, Alexander Kazantsev, was given the rank of colonel and appointed the official representative of the State

Committee of Defense (the highest government body in the USSR during World War II) at Vienna. The war was still in progress but it was already time to remove the equipment of Hermann Goering's plants in Styria and to dispatch them to the Soviet Union.[1] Kazantsev completed this task, having survived a serious car accident, and in August 1945 he left Austria for Russia. While driving through Hungary and listening to the radio he heard about Hiroshima and the atomic bomb.

It is worth noting that Kazantsev remembered well Kulik's adventures of the 1920s. In those years he was a student in Tomsk, avidly reading the *Mirovedeniye* and *Vestnik Znaniya* journals, where the circumstances of the Tunguska space body fall were reported, including articles by Viktor Sytin. In 1928, Sytin participated in Kulik's second expedition to Tunguska. And now, while driving back to Moscow, Kazantsev was surprised by the close similarity of the Tunguska and Hiroshima explosions. Having returned to Moscow, he met Sytin, who reassured him that no crater had been found at Tunguska. There had in fact been a zone of standing trees at the center of the area of the fallen forest. Couldn't this mean, thought Kazantsev, that the Tunguska space body exploded in the air and that perhaps the explosion was nuclear? Maybe the meteorite contained a high level of uranium? At that moment, Kazantsev did not think about extraterrestrial spacecraft. He simply tried to bring together the curious aspects of the Tunguska catastrophe into a whole picture. His idea was that the meteorite, or whatever it was, had exploded at altitude over the taiga.

As we know, Leonid Kulik perished in the war, and in January 1945 the other big player in the Tunguska mystery, Academician Vladimir Vernadsky, at 82 years old, also died. So Academician Vasily Fesenkov replaced him as Chairman of the Academic Committee on Meteorites (KMET), and Evgeny Krinov, who was Kulik's deputy in the largest expedition to Tunguska, became its Learned Secretary. The state of affairs in the meteoritic establishment had changed considerably. Vernadsky had been one of the most distinguished geochemists of the twentieth century and a great intellectual, whereas Fesenkov was a noted astronomer and administrator of Soviet science. While Kulik had striven fanatically to discover pieces of the Tunguska meteorite, sweeping away all obstacles from his path, Krinov's approach was different. Even though he had participated in Kulik's searches, he was not at all a fanatic but rather a normal scientist. The science of meteorites interested him much more than the Tunguska meteorite as such. Very probably, when personally visiting the site he understood well (certainly better than Kulik) that hopes of finding any material remnants of the space body were flimsy.

However, in 1945 Evgeny Krinov remained the most authoritative person on the Tunguska problem. Being well aware of this, Alexander Kazantsev planned to contact the scientist, but first decided to meet with other specialists, those who were engaged in nuclear research. After all, he was just a mechanical engineer and science fiction writer, not a physicist or an astronomer, and he wished to make sure that his idea about the nuclear nature of the Tunguska explosion had a rational basis. At the Institute of Physical Problems of the USSR Academy of Sciences, run by the future Nobel Laureate Academician Pyotr Kapitsa (1894–1984), another future Nobel Laureate, Academician Lev Landau (1908–1968), explained to Alexander Kazantsev the principles of atomic explosions. Kazantsev then went to Moscow University to meet a third future Nobel Laureate, Academician Igor Tamm (1895–1971), one of the most prominent Soviet physicists. Tamm had worked in the Soviet nuclear project and later led a group of young physicists, including Andrey Sakharov and Vitaly Ginzburg, who greatly contributed to the creation of Soviet thermonuclear weapons. Both of them, by the way, have also become Nobel laureates.

Kazantsev asked Tamm whether uranium-containing meteorites might exist in outer space, and if so, could one explode like an atomic bomb when entering Earth's atmosphere? No, replied Tamm, it's absolutely impossible. Only atomic bombs can explode as atomic bombs – or at least a similar device built by someone.

If it had been someone other than Alexander Kazantsev talking with Academician Tamm, the whole story might have ended there. Impossible means impossible, and his hypothesis, however attractive, now looked groundless. But Kazantsev was not only an engineer but also a science fiction writer. And as such he thought in a nonstandard way. If the object that vanished in the blaze of a nuclear explosion over the taiga was not natural, it had to be artificial. And since nobody on Earth could have made a device to cause such an explosion in 1908, it had to have been produced by something extraterrestrial.

By that time Kazantsev was going to retire from the army and return to writing. It is therefore hardly surprising that, instead of writing a factual science article, he put his hypothesis into a science fiction short story. The story was entitled *The Explosion*, and it was published in the popular geographical journal *Vokrug Sveta* (*Around the World*) at the beginning of 1946. On the one hand, it was a science fiction story, a literary work with an imagined plot and characters. (There was a black woman claiming to be the sole surviving member of an extraterrestrial expedition, who survived the catastrophe and became a medicine woman in a Tungus tribe.) But on the other hand, the story contained quotations from the papers of Leonid Kulik and real accounts of witnesses of the Tunguska explosion, plus a fairly accurate description of the area of leveled trees. There were some mistakes as well. Kazantsev had overestimated by four times the area of the leveled forest – up to 8,000 km^2 – and underestimated the altitude of the explosion: down to 350 m, approximately that of the explosion at Hiroshima, which was at an altitude of 580 m.

Of course, nobody could have known the exact figures at that time. They were imagined and given simply to fascinate readers. In the story, the superstitious Evenks were wandering through the leveled forests soon after the catastrophe, dreading the wrath of the god of fire and thunder – the dazzling Ogdy. All people who visited the damned place perished from a fearful and unknown disease that covered their internal organs with ulcers. The poor Evenks had become victims of atomic decay from the miniscule remnants of the meteorite scattered in the region of the catastrophe. Yes, remnants of the meteorite. Despite the authoritative explanation of Academician Tamm, Kazantsev proposed that his hypothetical uranium meteorite had caused the explosion. The spaceship hypothesis was mentioned almost in passing at the very end of the story, its author being probably well aware of the potential risk.

It was especially important that Kazantsev plainly stated that the zone of "upright telegraph trees" did testify to the aboveground character of the explosion. He wrote: "Just imagine that: at the very center of the catastrophe, at the swamp that was formerly considered as the main meteoritic crater, where results of the explosion must have been seen most clearly, the forest is still standing upright. To the distance of 30 km all the trees have been felled, but not here. Enormous poles are sticking from the ground... All their branches have been cut by the terrible whirlwind, charring every knot. These trees are so similar to telegraph poles. But why has this dead forest remained upright? Only because the trees were perpendicular to the front of the blast wave. And this could happen only if the explosion did occur at a high altitude above the ground".[2] The lack of a crater and the presence of the "telegraph pole forest" are the main but not the only arguments from Kazantsev for the non-meteoritic nature of the enigmatic space body. His third argument was that the explosion was too powerful for a usual meteorite explosion. His fourth argument was the lack of any meteoritic substances.

Well, perhaps the arguments were rational, but let's not forget that they were set out in a science fiction story, not in a scientific paper, though fantastic stories may sometimes be useful for science, as was so in this case. As it turned out, his readers became fascinated by meteoritics in general and the mysterious event of the Tunguska explosion in particular.

Kazantsev's story was seen by the staff at KMET as a worthwhile piece of science fiction, and Evgeny Krinov accompanied Kazantsev to the Moscow Planetarium to persuade its director Efim Gindin (1898–1966) to start in January 1948 a new teaching program to dramatize the enigma of the Tunguska meteorite. The main role was performed by Felix Zigel, a superb astronomy lecturer, then 26 years old. The plot of this lecture-debate developed dynamically, and its participants came to the conclusion that neither a normal meteorite nor a uranium meteorite could explain the Tunguska explosion and that it could have resulted from an exploding alien spaceship.

In the 1970s, when in Moscow, this author talked with some of the spectators who were at this show. The "first night" of the lecture was attended by leading Soviet astronomers, in particular by Academician Alexander Mikhaylov, Chairman of the Astronomical Council of the USSR's Academy of Sciences and Director of the Pulkovo Observatory. He not only approved Kazantsev's initiative but also congratulated the Moscow Planetarium's team.[3] In the following weeks, the Planetarium's attendance beat all records. Everyone was happy – the author of *The Explosion*, the lecturer, the listeners, and especially Krinov and Fesenkov because they believed it would greatly assist the KMET in popularizing meteoritics.

All this interest could have ended in time. The show would have been removed from the Planetarium's placards and the "Tunguska spaceship" idea would have been forgotten. But both professional astronomers and science amateurs (who were very numerous in the former Soviet Union) were well aware of the results of Kulik's prewar expeditions. They soon saw that Kazantsev's idea was not a simple literary device. It did explain the most unusual aspects of the Tunguska phenomenon. As early as February 1948, Kazantsev's idea became the subject of a serious discussion at a meeting of the Moscow branch of the All-Union Astronomical and Geodetical Society (AAGS).[4] Naturally enough, opinions about Kazantsev's hypothesis were divided, but at the end of the discussion one of the most distinguished Soviet astronomers, Professor Pavel Parenago, said: "I think all of us would agree that it was a space body that fell in 1908 in the Tunguska taiga. What space body it was remains unclear. As for me, I would estimate the chances of it having been an extraterrestrial spaceship as opposed to a usual meteorite as 30–70."[5]

Western specialists at the time would have probably put the chances as no more than 1–99, but the point was that it was a hypothesis worth testing. The idea itself was not mad and could be discussed on a rational level. But the science establishment flew into a rage. It could tolerate a science fiction story, even a staged lecture on the subject, but an attempt to introduce an alien visitation into a scientific hypothesis was not to be tolerated. Why? Nobody knows for sure. Most likely Fesenkov, Krinov, and their colleagues were afraid of the invasion of "dilettantes" into their field of science that dealt with serious astronomical subjects.

In the spring of 1948, there appeared in the newspaper *Moskovsky Komsomolets* (*The Moscow Young Communist Leaguer*) a satirical article entitled "It's strange but a fact" by a Comrade Grekov. Its author expressed his indignation over the "propagation of pseudoscientific figments of imagination" promoted by the Moscow Planetarium. However, soon after this Kazantsev's hypothesis, which the science establishment considered "fantastic," was taken under the protection of the *Komsomolskaya Pravda* (*The Truth of the Young Communist League*) by a noted writer and geographer Nikolay Mikhaylov. The *Komsomolskaya Pravda* ranked higher as a newspaper in the Soviet mass media, but *Moskovsky Komsomolets* did not retreat. Soon it published another article on the subject, authored by three noted scientists: Evgeny Krinov, Kirill Staniukovich, and Vsevolod Fedynsky.[6]

This article was more politically than scientifically oriented. According to its authors, Kazantsev was trying "to propagate under cover of a popular lecture a reactionary cosmological theory of the bourgeois astronomer Edward Arthur Milne" as well as "to intimidate readers with horrible details of explosions of American atomic bombs." These were rather grave accusations at the time – and rather mean as well. In Stalinist Russia in the late 1940s, such accusations were no laughing matter. They could easily bring the accused to the Lubianka cells.

Not all members of the scientific community shared the attitude of these astronomers to Kazantsev and his hypothesis. Several scholars who supported him wrote a letter to *Komsomolskaya Pravda*, but the Komsomol journalists did not dare to publish it, although some excerpts were published in the popular science journal *Tekhnika-Molodyozhi* (*Engineering for Youth*) in the article "On Science Fiction and Wingless Men," written by the reporter Sofya Baratova. The letter defended Kazantsev's hypothesis and was signed by seven professionals in astronomy, including Academician Alexander Mikhaylov and Professor Pavel Parenago, as well as by the faithful associate of Kulik, Victor Sytin.

They wondered on what grounds Krinov, Staniukovich, and Fedynsky had stated that there was no enigma in the Tunguska space body's fall. How could they assert that Leonid Kulik had explained everything when the reality was absolutely different? Also, "such an erroneous approach to this problem precludes the continuation of truly important and – unfortunately – unfinished research that was started by L. A. Kulik."[7]

Academician Alexander Mikhaylov and his colleagues seem to have attempted to return the Tunguska discussion to the field of science free from political overtones. However, the "meteoritic establishment" had taken Kazantsev's encroachment upon their right to decide about the nature of bodies coming from space as an act provoking holy war. Their position was clear: extraterrestrial spaceships belong between the covers of science fiction books; meteorites are a subject for science. When fighting the "dilettantes," meteorite specialists did not mince their words: such terms as "rubbish," "absurd," "antiscientific nonsense" poured from their pens. Soon it became indecent for professional scientists to even consider Kazantsev's hypothesis. In short order, almost all those who defended the hypothesis in the first stage had fallen silent, which was probably a wise move. Few of the scientists involved wished to risk their professional reputations over a spaceship. Academician Mikhaylov hastily went over to the "meteoritic camp" and gave in the summer of 1951 an interview to the popular magazine *Ogonyok* (*A Little Flame*) in which he characterized Kazantsev's hypothesis as fiction.[8] Somehow he also managed to kick the "venal American press" in the same interview because "it had made immediate use of this false hypothesis and had ignored the true scientific facts about the Tunguska event as established by Soviet scientists." He even said that American journalists had written that the Martians also had the atomic bomb ready to invade Earth – probably he was thinking of the Orson Welles radio drama, which caused panic in the streets, and the American press's reaction to it.

Luckily, the indignant newspaper articles denouncing Alexander Kazantsev and his hypothesis as politically harmful did not evoke interest in the Soviet secret police. The State and Party authorities kept mum and left it to the scientists. But in the fall of 1951, after publication of several new anti-Kazantsev articles,[9] the Moscow Planetarium director, Efim Gindin, got sick of constant persecution in the press, and the lecture "The Enigma of the Tunguska Meteorite" was at last closed. The science establishment had achieved a victory.

By that time the KMET people were dealing with another problem that was much more pleasant and promising. A perfectly normal large iron meteorite had hit Earth in full accordance with the rules of meteor science. Like any decent meteorite, it hit the ground and broke into many pieces, which, naturally enough, remained on the site. It was on the clear frosty morning of February 12, 1947, that a bright fiery ball rushed over the Ussury Territory of the Soviet Far East. The duration of its flight was as brief as some ten seconds, but it left behind a long smoky trail that remained in the sky, gradually spreading, for the whole day. Immediately after the bolide disappeared, local people heard loud sounds, like the firing of large-caliber pieces of ordnance, and then a powerful explosion. Witnesses from nearby settlements said that doors in their houses were flung wide open, some window glass broken, and ashes and firebrands thrown out from Russian stoves.

A few days later two pilots were flying at low altitude over the western spurs of the Sikhote-Alin mountain range and saw among the trees a number of fresh craters. To explore them, the Far-Eastern Geological Board sent an expedition from Khabarovsk, which reached the site on February 24, and the geologists found among crushed rocks numerous pieces of an iron meteorite. When the expedition returned to Khabarovsk, a telegram was sent to the Committee on Meteorites of the USSR's Academy of Sciences to report that in the Far East of the country a gigantic iron meteorite had fallen – a very rare event. Later it was named the Sikhote-Alin meteorite. According to the estimates made by Academician Fesenkov, its initial mass, before entering the atmosphere, was about 2,000 metric tons. But almost 95% of this mass vaporized as the meteorite fell through the atmosphere, leaving some 100 tons of first-rate meteoritic iron to reach the ground. The scientists found 106 craters, the largest of them being 28 meters across and 6 meters deep.

Against the background of the Tunguska controversy, which was already flaring up, the Sikhote-Alin cosmic shower proved to be a real heavenly gift to Soviet specialists in meteoritics. The Sikhote-Alin meteorite fall is often compared with that at Tunguska, whereas they are in fact completely different. The former was a normal meteorite fall with craters and iron fragments. The Tunguska event was the explosion of an enigmatic space body with no meteoritic substances or craters. Also, the Tunguska phenomenon produced a noticeable earthquake and the Sikhote-Alin meteorite did not. Even the Vladivostok seismic station, located nearby and possessing very sensitive equipment, did not record any tremor, so the mass of the Tunguska meteorite must have exceeded that of the Sikhote-Alin meteorite by several orders of magnitude. But where is this mass? That is the question.

The results of Sikhote-Alin studies proved to be of prime importance to the world of meteoritics. The collection of meteorites of the USSR's Academy of Sciences, one of the best in Europe, had received many thousands of new meteoritic samples, their total weight being more than 23 tons. At the same time, in the late 1940s and the early 1950s, some attention was still paid by Soviet astronomers to the Tunguska phenomenon as well as to the Sikhote-Alin meteorite. The meteoritic community, despite having become involved in dubious polemics with Alexander Kazantsev and his supporters, continued to work seriously in this direction as well. And Evgeny Krinov, then KMET's Learned Secretary, summed up results of the prewar investigations of the Tunguska event in the brilliant monograph, *The Tunguska Meteorite.*[10]

The main achievement of meteor science after World War II was the theory of crater-forming meteorites, developed in 1946–1947 by Kirill Staniukovich and Vsevolod Fedynsky.[11] Generally speaking, it was always evident that a meteorite moving at a great speed and striking land would most likely vaporize. Thus, in Kazantsev's short story "The Explosion," written in 1945, a supporter of the meteoritic model of the Tunguska phenomenon explains how the taiga was leveled: "The meteorite that flew at a great cosmic velocity hit the ground, and all its kinetic energy was transformed into heat. Hence the explosion."[12] It was Staniukovich and Fedynsky who provided the mathematical support for this conclusion. They showed that if a meteoritic body is moving faster than 5 km/s *just before its impact*, then, immediately after the meteorite strikes Earth's surface, shock waves spread through both the surface material and the meteorite itself. And the meteorite is vaporized completely by the released energy. The shock wave inside the ground projects material upward and outward from the point of impact, thus forming a crater – and no remnants of the meteorite are preserved on the site. But this occurs only if the meteorite's final velocity is really great; otherwise its fragments may be found (as happened at the Sikhote-Alin mountain range).

Evgeny Krinov immediately attempted to apply this theory to the Tunguska problem. He believed it could explain all phenomena that had accompanied this event.[13] Recall that the enormous magnitude of the Tunguska explosion was one of Kazantsev's arguments in favor of the spaceship hypothesis. Kazantsev believed the explosion was "too powerful" for a normal meteorite, but research has shown that an iron meteorite hitting the land could have produced a huge amount of energy without leaving fragments. However, the problem is that a very large crater would have been formed – and Krinov himself, having spent almost a year at Tunguska, had seen no crater.

Of course, the KMET should have sent a new expedition to Tunguska to try to find a drowned crater, if not the vaporized meteorite itself, thus putting an end to Kazantsev's fantastic invention. The KMET people did think about this, but the Sikhote-Alin meteorite fall had grabbed their attention. However, in the summer of 1953, the geochemist Kirill Florensky (see Figure 4.2; a son of the great Russian theologian and philosopher Pavel Florensky, who had been shot in a gulag in 1937) found himself at Tunguska, when exploring gas fields in central Siberia. Evgeny Krinov asked Kirill Florensky to look around and inform the KMET if anything had changed at the Tunguska site during the past 14 years since Kulik's last expedition. He wanted to know if a new expedition would meet with any appreciable difficulties if sent to Tunguska. Also – the

FIGURE 4.2. Dr. Kirill Florensky (1915–1982), a Soviet geochemist and planetologist, a pupil of Academician Vladimir Vernadsky, who headed several Tunguska expeditions organized by the USSR Academy of Sciences (*Source*: Bronshten, V. A. *The Tunguska Meteorite: History of Investigations*. Moscow: A. D. Selyanov, 2000, p. 108.).

question of prime importance – would Florensky look for a meteoritic crater? The geochemist did look, visiting Kulik's *zaimka* and also making a reconnaissance flight over the area of the leveled forest. Florensky made sure that the felled trees were still clearly visible, despite the young growth, but he could find no trace of a crater. His main conclusion was that a new expedition could reach the place with relative ease.[14]

Nevertheless, the next four years passed in vacillations – whether or not such an expedition would justify the expense. Then in July 1957 Alexander Yavnel, a KMET scientist, discovered meteoritic iron in Kulik's Tunguska samples. KMET possessed 89 samples of soil brought back by Leonid Kulik from Tunguska and had kept them in cardboard boxes with tightly closed lids. They had been discovered only by chance when the KMET people were sorting out their archives. Since the most probable place for the fall of the Tunguska space body was the Southern swamp, Yavnel selected 13 samples from that area. Each sample had been ground and a strong magnet had extracted magnetic iron, which was examined under a microscope. The following components were found:

1. Crystals of magnetite.
2. Metallic particles of silver-white color only several tenths of a millimeter long.
3. Oxidized metallic particles with slightly fused surfaces and edges. Usually, they were flat and acute-angled, or looked like bars of a few millimeters in length.
4. Bright black spherules consisting of magnetite, with a diameter of 30–60 microns. There was also a spherule of silver-white color.

The spectral analyses showed that the metallic and oxidized particles consisted of nickelous iron. They were checked at the Institute of Geochemistry and Analytical Chemistry and found to contain 10.5% of nickel. This surprising result seemed to indicate that the Tunguska event had been due to a natural iron meteorite.

"One can say with a fair degree of confidence," Yavnel concluded, "that we possess here the substance of the Tunguska meteorite, and it strongly suggests that it was an enormous mass of iron."[15]

Yavnel sent his paper to *two* scholarly periodicals: *Geokhimiya* (*Geochemistry*) and *Astronomichesky Zhurnal* (*Astronomical*

Journal),[16] and it was soon published in both journals – which was unusual. Papers could wait a year or more for publication. Since the Tunguska polemics were mostly carried out in the popular press, Evgeny Krinov at KMET also invited two well-informed journalists to share the sensational news. Their article, "The Tunguska Meteorite Has Been Found," was soon published in the popular science journal *Znaniye-Sila* (*Knowledge is Power*).[17] The article informed readers that the enigma of the Tunguska meteorite had been solved. It was no spacecraft but a normal piece of cosmic iron. The particles discovered by Alexander Yavnel testified to this. The same news was also published in an article by Yavnel and Krinov in *Komsomolskaya Pravda* (*The Truth of the Young Communist League*).[18] Alexander Kazantsev and other enthusiasts of the spaceship hypothesis were taken aback. Some in despair suggested that the shell of the alien spaceship could have been made of nickelous iron, but KMET specialists kindly explained that this was sheer nonsense. Anyway, the Academy of Sciences decided that an expedition must be sent to Tunguska, to provide a final answer to the question.

Yavnel's discovery, however, was not the only reason for this decision: the jubilee of the Tunguska event was approaching. Half a century had passed since the enigmatic explosion in this remote corner of Siberia; now it was time to solve the mystery. Besides, the first *Sputinik* was launched in 1957, and the spiritual atmosphere in the country was, so to say, space-oriented, making Kazantsev's hypothesis very popular among the young scientific and technical intelligentsia. This worried the KMET people. But then it only remained to go to Tunguska to find there particles similar to those discovered by Alexander Yavnel, preferably in the meteorite crater, and the question would be closed forever.

In the 1950s, specialists in meteoritics stubbornly refused to believe that the Tunguska space body had exploded in the air. Nobody at KMET suspected that there could be neither meteor particles nor meteoritic craters in the taiga – with a probable exception of the experienced but tight-lipped Evgeny Krinov.

In 1958, Kirill Florensky, no novice in the taiga, was appointed to lead the new academic expedition. Apart from him, the team, consisting of 11 people, left by train and then plane for Vanavara's new airport. The whole population of this settlement, closest to the Tunguska explosion site, was then about a thousand. It was one of three district centers of the Evenk Autonomous Region (or Evenkya). The region did, however, remain very sparsely populated: in an area of about 800,000 km^2 there were only 12,000 inhabitants, less than half of them Evenks or Tungus.[19]

The new KMET expedition possessed precise maps of the Tunguska region that Kulik had lacked. Their itinerary was also different. On June 3, 1958, they left Moscow by train for Krasnoyarsk, from where they went by plane to Vanavara, where the local authorities provided the scientists with 40 deer needed for the last stage of their journey. The expedition reached Kulik's *zaimka* on June 27. Three days later they celebrated the 50th anniversary of the enigmatic event that had occurred at that very place. As participants of the expedition later recalled, they marked the occasion with a special bottle of champagne.

According to its final report, the aims of the expedition were (1) search for the crater, (2) search for meteoritic substances, (3) exploration of the leveled forest, and (4) evaluation of further research prospects. The main problem and the main research target was in fact the crater – more than the substance of the meteorite. The problem of the remains of the meteorite appeared to have been successfully solved by Yavnel a year earlier, so that control tests on the site seemed nothing but a formality. But the lack of any crater still made the KMET people nervous. If a crater existed, then the explosion occurred on the ground, and the academic position was correct. If not, then the explosion must have occurred in the air. That is why the expedition had to first examine the Southern swamp – since it was the only possible location of the hypothetical crater – to look for any signs of explosion-related alterations in its bed. Their main concern was to answer this question, but no signs of any meteoritic crater were found. As they reported: "We were unable to find traces of a ground explosion. All members of the expedition have agreed that the Southern swamp could not be the place where the explosion happened that leveled the forest around."[20]

The second task in order of importance was to take soil samples and test them for nickel as a sign of the presence of nickelous meteoritic iron. Fesenkov and Krinov assumed that the expedition would find the dispersed substance of the Tunguska meteorite and be able to determine the area of its highest concentration, indicating the very place where the meteorite had fallen. This was not to be.

Florensky and his colleagues did find in Kulik's *zaimka* samples of soil that had been left there by Kulik himself. A year before, in similar samples, Alexander Yavnel had found meteoritic iron. So Kulik's samples were immediately analyzed. Alas, there was no meteoritic iron in them. The expedition scientists then became even more circumspect and started a very accurate and systematic gathering of samples from the Tunguska soil. Almost every sample contained some small quantities of iron, but never any nickel. But meteoritic iron contains a lot of nickel. So, there was iron at Tunguska – but not meteoritic iron. True, there were in the soil some microscopic silicate and magnetite spherules that could have been of space origin. But these spherules did not differ in composition and amount from the usual space dust that is regularly falling on Earth.

The expedition brought to Moscow almost a hundred new samples of the Tunguska soil, as well as 50 of Kulik's samples that had been kept at his *zaimka*. And these were carefully analyzed with up-to-date equipment – for the year 1958. There were no signs of meteoritic iron in the samples. The content of meteoritic dust corresponded well with usual fluctuations of the background fall of space dust. So the academic expedition had failed to solve the two primary research tasks. Its members could not establish the meteoritic nature of the Tunguska space body, but this "failure," as it turned out, proved to be a great success – the work of the expedition demonstrated that the iron meteorite hypothesis should be rejected.

Of course, having no crater and no meteoritic iron was hardly sufficient to compose a substantial scientific report. Luckily enough, however, the third direction of research – the examination of the leveled forest – proved to be more informative and its results rightly still hold a prominent place in the final report. True, the expedition was unable to determine the borders of the leveled wood with sufficient accuracy, it being just too small for this task. But the expedition collected important data about the felled trees. There were six types of damage recorded that would greatly help in compiling a detailed map of the leveled wood. Making such a map was very reasonably listed under number one in the plan of future investigations, but it was not the Committee on Meteorites that subsequently implemented this important project. A few years later the map was composed by members of the Independent Tunguska Exploration Group (ITEG).

Florensky and his colleagues paid great attention to the "telegraphnik" – the central zone of standing trees. Naturally enough, many of the branchless "telegraph trees" had by that time fallen down in high winds and were lying chaotically. Having crossed this zone several times, members of the expedition realized that it was asymmetrical in relation to the borders of the leveled wood area. This meant that the blast wave had also been asymmetrical.[21] There seemed to be in the Tunguska taiga no usual ellipse of dispersion typical for meteorite showers. The zone of leveled forest was oddly complicated.

The expedition also tried to solve the problem of the "unusual burn," which, according to Leonid Kulik, had evenly covered vegetation in the Great Hollow for many kilometers across. This burn had been very different from the traces of a usual forest fire. Generally, they did not doubt the real existence of this phenomenon, described by the Tunguska pioneer himself, but they were unable to discover its traces and therefore decided that the evidence had already disappeared. Subsequently it turned out that some traces of the anomalous burn persisted but could not be easily found. Analysis of these traces of burning has even formed a separate direction for Tunguska studies. But in 1958 this subject encountered a problem when geologist Boris Vronsky found two old larches in the Southern swamp that had safely survived the Tunguska catastrophe. These were more than 50 years old, but both trees were alive, healthy, and not even burned. One was cut down, and the scientists determined its exact age from the annual rings. It was 108 years old. That two robust trees still existed on the swamp that had been considered a probable meteoritic crater demonstrated that the swamp could not be a crater. At the same time this fact seemed to testify no less convincingly against the nuclear hypothesis. How could the larches have survived an atomic explosion at its epicenter without any burns? Impossible!

After the discovery of the larches, the problem of the anomalous burns lost its topicality for the academic expedition. Its chief decided that there could not have been a powerful light flash at Tunguska. Today, however, there is reason to believe that the undamaged larches on the surface of the Southern swamp may be interpreted differently – as evidence of the uneven character of this light flash. But the flash itself had been powerful indeed; this was subsequently proven by specialists who examined the traces of the light burn.

The accelerated growth of the forest on the territory affected by the Tunguska explosion was another important – and unexpected – discovery made by Florensky's expedition of 1958.[22] Unusually wide tree rings (up to 9 mm wide) were found at the central part of the leveled forest, both in trees that had grown after the explosion and in trees that had survived the explosion. Before the Tunguska catastrophe, the average width of the annual rings was only 0.2–1.0 mm.[23] At first, this effect appeared understandable because due to the explosion the taiga in this region became thinned out and the soil enriched with ash (which served as a fertilizer), which must have led to better growth of all the trees. But this simplistic explanation was subsequently rejected, and the accelerated growth of the forest is now considered as another enigma of the Tunguska phenomenon.

Having returned to Moscow in October 1958 and reviewed the findings of the expedition, the scientists arrived at two important conclusions. First, there was definitely no meteoritic iron in the soils of the Tunguska region, which meant that Yavnel's result was erroneous. Most likely, Kulik's samples that were kept at KMET's building became contaminated when other meteorites (such as fragments of the Sikhote-Alin meteorite) were sawed during research. At present it is hard to say whether this was so, but in any case Alexander Yavnel's mistake proved to be another happy one in the history of the Tunguska problem. Were it not for Yavnel, the academic expedition would not have been sent to Tunguska in 1958, neither, most probably, in the following years.

Having evaluated the collected data, the members of the expedition wrote: "The absence of large deteriorations in the central zone of the leveled forest – that is, on the Southern swamp, as well as the lack of noticeable meteoritic craters and the presence of the 'zone of indifference' in the center of the catastrophe make it possible to suppose that the shock wave of the Tunguska explosion was moving in this region mainly in a downward direction, its center being located high up."[24]

One translation of this text from its scholarly jargon into a clear English is: *The Tunguska space body exploded at a great altitude in the air, and not when hitting the ground.*

A more general conclusion, having significance for the whole science of meteoritics, should have been: "It would be premature to consider the Tunguska meteorite as a typical crater-forming meteorite. The meteoritic theory must be supplemented with a case when vast ground devastation occurs without forming a crater on Earth's surface."[25]

Somehow, Alexander Kazantsev was not mentioned in the final report of the expedition, yet it was Kazantsev who had predicted the two important facts: that on the site of the explosion there would be no meteoritic substance and that it would be proved that the Tunguska space body had exploded in the air. And he did this by using the "spaceship model," however fantastic it may have seemed. Certainly, in his prediction, Kazantsev leaned upon the results of Kulik's expeditions, but the key thing was his ability to look at them from a different theoretical standpoint. Supporters of the meteoritic hypothesis, who had been persistently defending their model of the Tunguska phenomenon for more than 10 years, now had to look for an acceptable explanation of these two facts – alas in retrospect. In other words, the spaceship model took the lead in Tunguska studies.

This is why after the academic expedition of 1958, its participants – and first of all Kirill Florensky – were so perplexed. Everything looked predictable before the trip: they left for the taiga to find the crater and nickelous iron that would have confirmed the normal meteoritic model. But now they had no crater or meteoritic iron – and it also turned out that the "meteorite" must have exploded in the air. Not a pleasant situation for them. But they were scientists and used to dealing with facts. Even if they thought Kazantsev's hypothesis nonsense, they could not dismiss the new evidence from Tunguska. The "evil spirit" of the enigmatic space body had not vanished into thin air, so a scientific explanation had to be looked for. Being rather confused by his own findings, Kirill Florensky sent some samples taken at Tunguska to the Institute of Geochemistry and Analytical Chemistry of the USSR's Academy of Sciences and asked them to check for radioactivity. Taking into account that KMET considered any attempt to investigate radioactive contamination in the Tunguska region as pseudoscience, it was a bold step. The academic chemists, however, discovered no traces of increased radioactivity, and this question was closed – at least temporarily.

Early in the autumn of 1959 the Moscow Institute of Physical Problems held a workshop on the Tunguska event. Mikhail Tsikulin and Vladimir Rodionov contributed the main paper. These scientific workers of the Institute of Chemical Physics of the USSR's Academy of Sciences[26] suggested that the forest devastation in the Tunguska taiga had been caused by the ballistic shock wave that had accompanied the meteorite flying in the atmosphere and had hit the ground after the meteorite had been disrupted by the forces of air resistance.[27] Of course, this model also faced the same old question: where were the remains of the meteorite?

The fact is, however, that every big scientific problem should be approached in stages. Specialists in ballistics had first to settle the main issue of how a piece of iron from space could fell such an enormous number of trees without touching Earth's surface. To test their hypothesis, Tsikulin and Rodionov performed a series of modeling experiments. In a blasting chamber they placed a thick layer of soil, sticking into it a number of bits of wire to represent trees. Over these "trees" the physicists put a detonating cord with an amplifying charge at its end. The blast wave from the detonating cord served as a model of the ballistic shock wave, propagating from a space body flying in the atmosphere. Tsikulin and Rodionov assumed that the meteorite exploded at an altitude of 100–500 m (apparently using the figures proposed in Kazantsev's short story "The Explosion"). The energy then released would have been 10 Mt of TNT, but the altitude was definitely underestimated. More importantly, in 1959 the true shape of the area of leveled wood remained unknown to the investigators. Evgeny Krinov, who spoke at the workshop after Tsikulin and Rodionov, was still doubtful of the overground character of the Tunguska explosion and severely criticized their report. In time, though, his opinion changed.

Incidentally, Alexander Kazantsev attended the workshop and was even allowed to speak. Physicists, as a rule, were ready to discuss his "spaceship hypothesis" sympathetically, as distinct from meteor specialists who would not have let him through the door of a meteoritic conference. But in this case Academician Pyotr Kapitsa, Director of the Institute of Physical Problems, himself decided who could or could not be invited.

As for the chief of the academic expedition, Kirill Florensky, he generally accepted the ballistic model of Tsikulin and Rodionov, even though stating in some articles that the hypothesis of a crater-forming meteorite had not yet been disproved. At the same time, he was not fully satisfied with the purely "ballistic" approach to the Tunguska event. Having twice visited the site, Florensky felt that the forest could not have been leveled just by the meteorite's "energy of motion." There must also have been an explosion, such as a violent release of energy from a chemical or nuclear reaction, in the substance of the space body. But he wouldn't consider a nuclear reaction, so it only remained necessary to modify the "hypothesis of a ballistic shock wave" by supplementing it with some "chemistry." According to Florensky, the Tunguska meteorite, being a natural space body, could have consisted of substances that could have exploded when mixing with atmospheric oxygen. The meteor specialists, however, ignored Florensky's idea, and it was only much later, after his death, that it was noticed and developed by other researchers.

The "purely ballistic" approach to the Tunguska problem attracted the meteor specialists, first of all by its simplicity. Yet some discrepancies with the facts were noticeable. The trajectory of the Tunguska meteorite was gently sloping – all Tunguska investigators shared this opinion. However imprecise the eyewitnesses' accounts might be, they were sufficient to come to that important conclusion. Meteors begin to emit light at an altitude of 130 km or lower. Even if the most distant points where the Tunguska bolide was seen were about 800 km from the place of its explosion (and there were more distant observations), then the slope of its path could not have exceeded 17°. But the experiments of Tsikulin and Rodionov showed that a slope of 30° was needed to reach an acceptable correspondence between the model and the real picture. It was a new enigma that had to be resolved. Generally speaking, this result was self-evident: to fell trees strictly radially, the ballistic shock wave would have had to move in a very steep path. If it had moved flatly there would have been a long belt of fallen trees shaped like a herring bone.

Florensky's "chemical explosion" looked too exotic for meteorite specialists. So they started searching yet again for an acceptable theory to explain the undeniable fact of the radial character of the leveled forest. Such a theory had to combine two main traits. First it had to be a natural cosmic body that had exploded (a meteorite or a comet, but definitely not a spaceship). Second, this body had to produce not only a ballistic shock wave but a vast blast of energy as well. The strictly radial character of the leveled forest testified to the fact that the space body had definitely *exploded*, not simply collapsed in the atmosphere to liberate a ballistic shock wave that hit the taiga. It was therefore necessary to find a mechanism for *a natural overground explosion in a natural space body*.

Physicist and astronomer Kirill Staniukovich, with his colleague Valery Shalimov, developed this acceptable mechanism.[28] There exists an equation for the heat balance of a meteorite flying in the atmosphere. When moving through the air, a space body gets hot because it's gaining more heat than it's losing. According to the equation, at a certain altitude (for iron meteorites at about 18 km) these two processes become balanced, and the meteorite stops heating up. Instead, it starts getting cooler while simultaneously slowing down, so that it falls on the ground moving at a relatively lower speed. For a stone meteorite the picture is practically the same. But for a lump of ice it's different. Such a lump with a diameter of, say, 10 m, moving at the velocity 60 km/s, heats up very intensely. At an altitude of 50 km the heat supply exceeds 10 times what is being lost, and the space body starts to vaporize very actively, a process that rapidly becomes highly violent. This is the so-called "thermal explosion," which might have explained peculiar aspects of the Tunguska catastrophe (see Figure 4.3).

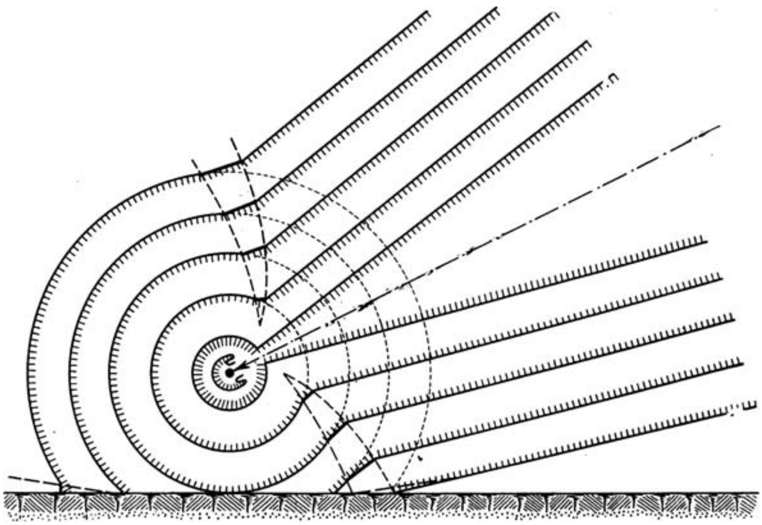

FIGURE 4.3. This is how the thermal explosion of the Tunguska space body must have looked, according to the theory of Dr. Kirill Staniukovich and Dr. Valery Shalimov.

What else was needed to be able to apply the model of Staniukovich and Shalimov to the Tunguska phenomenon? It was ice, no matter whether it be the usual watery ice or frozen gases. Neither stony nor iron meteorites possess properties that would make possible a "thermal explosion." But the icy core of a comet does possess them.

By the 1950s the old model of the comet core as a conglomerate of stones and dust with a small amount of ice (the so-called "flying sandbank" model proposed by the famous English astronomer Richard Proctor in the nineteenth century) passed out of favor. In 1951 the noted American astronomer Fred Whipple developed a new model for the comet core, which much better corresponded to the observational data. In the popular press this model got the name of "dirty snowball," although Whipple himself preferred to call it "the model of icy conglomerates." According to this model, the comet core consists of about one quarter dust, stones, and iron bodies and three quarters ice. And this ice is a mixture of frozen water and frozen gases, such as methane, ammonia, carbon monoxide, and carbon dioxide. Although at one time the comet core was thought to be "stones with some ice," it was now "ice with some stones and iron." Lately, though, specialists in cometary astronomy have started to think that the share of hard substances in comet cores is greater. So we now have the "icy dirtball" hypothesis. The Solar System appears to have *two* types of comets: dirty snowballs and icy dirtballs. And perhaps there are more types we don't know about.

The new stage of the cometary approach to the Tunguska problem is usually associated with the Chairman of KMET Academician Fesenkov. But in fact it was Evgeny Krinov who in 1960 reanimated and substantially revised the "old" cometary hypothesis of the Tunguska space body's origin that had been suggested early in the 1930s by *British* meteorologist *Francis* Whipple. Two years before, Krinov rejected the very possibility that the Tunguska space body could have exploded in the atmosphere and not when striking the ground. Now he wrote: "It comes as no surprise that there is no crater in the area of the meteorite fall, for it exploded in the air".[29] Krinov concluded that the lack of any substance is no wonder either because it was a comet core consisting of watery ice and frozen gases that produced the Tunguska event.

However, somehow this explanation of the Tunguska phenomenon became associated not with Evgeny Krinov, the noted specialist in meteorites, but with the name of his academic boss Vasily Fesenkov. Whether or not Fesenkov was thinking over the possible cometary nature of the Tunguska space body independently of Krinov remains unknown, but his first paper on this subject appeared in the scientific press more than half a year after Krinov's article in *Priroda*. And it was by both Fesenkov and Krinov.[30] But as for the comet's core, Fesenkov still believed it consisted of "very compact dust clouds several kilometers in diameter."

Even a year later, Fesenkov was still vacillating between the "flying sandbank" and "dirty snowball" models of comet cores. He emphasized that if the "dirty snowball" model is correct, then no debris of the Tunguska comet could be ever found. Equally, if the comet core resembled a "flying sandbank," then a swarm of small meteoroids would have been scattered over an enormous territory. At best, he said, we could hope to discover some microscopic spherules that formed from the fused and dispersed cometary substance.[31]

Combining the theory of the heat explosion with a new cometary model of the Tunguska space body proved to be a great achievement for meteor specialists. The overground explosion of the space body had been acknowledged and theoretically explained. And according to this theory, the forest had been leveled not only by the ballistic shock wave but also by a blast, while the lack of cosmic substances on the site of the explosion became explicable. Frozen water and gases (the main components of the comet core, according to Fred Whipple's theory) vaporized, whereas its stony and iron components have dispersed in the atmosphere, slightly contaminating the Tunguska soil.

Of course, this solution somewhat resembled making the theory fit the data. But why not? In science such methods of finding correct solutions are not forbidden. But whether or not the new version of the cometary hypothesis could be taken as the final solution of the Tunguska mystery remained unclear. The meteor scientists wanted this, but after Yavnel's fiasco they became more cautious.

The framework of the cometary/meteoritic approach to the Tunguska problem resulted from many distinguished specialists studying the problem. Using a high level of mathematics they rigorously analyzed the complicated processes going on when an iron, stony, or icy body is flying through the air. These specialists gave lectures at conferences and published scholarly monographs and papers in scientific periodicals. The results obtained contributed to a better understanding of such processes, helping, in particular, to create manned orbital spacecraft and warheads for intercontinental missiles.

The KMET need not have feared Kazantsev's spaceship. "Pseudoscientific sensations" in the Soviet Union had no chance of survival. Even so, participants of meteoritic conferences and symposia did not forget to pass resolutions condemning Kazantsev's ideas as "antiscientific lies" and "the lightheaded hunt for sensations." These resolutions were regularly sent to high officials of the Union of Soviet Writers, together with severe demands to forbid Alexander Kazantsev from writing about the Tunguska meteorite. The future promised to be serene for KMET. It did not, however, keep its promise. Kazantsev's hypothesis, although suggested by a nonprofessional, caused Alexey Zolotov and a large group of Siberian scientists to start their own investigations in the taiga. In the next chapter we will see how crucially this changed the atmosphere of Tunguska studies.

Notes and References

1. For details see Kazantsev, A. P. *Dotted Recollections*. In: Kazantsev, A. P. *The Ice is Returning*. Moscow: Molodaya Gvardiya, 1981 (in Russian).
2. Kazantsev, A. The Explosion. – *Vokrug Sveta*, 1946, No. 1, p. 43 (in Russian).
3. See Zhuravlev, V. K., Zigel, F. Y. *The Tunguska Miracle: History of Investigations of the Tunguska Meteorite*. Ekaterinburg: Basko, 1998, p. 23 (in Russian).
4. The AAGS was an academic organization of the USSR, carrying out research in the fields of astronomy, geodesy, and cartography, and its members were both professional astronomers and amateurs.
5. Zhuravlev, V. K., Zigel, F. Y. op cit., p. 24.
6. Staniukovich, Kirill Petrovich, 1919–1989, an astronomer and specialist in gas dynamics, professor, doctor of physics and mathematics. Together with Vsevolod Fedynsky, he has developed the theory of crater-forming meteorites. Fedynsky Vsevolod Vladimirovich, 1908–1978, specialist in meteoritics, corresponding member of the Academy of Sciences of the USSR.

7. Baratova, S. On science fiction and wingless men. – *Tekhnika-Molodyozhi*, 1948, No. 9, p. 27 (in Russian).
8. See Mikhaylov, A. A. The Enigma of the Tunguska meteorite is solved. – *Ogonyok*, 1951, No. 24 (in Russian).
9. See, for example, Fesenkov, V. G., Mikhaylov, A. A., Krinov, E. L., Staniukovich, K. P., Fedynsky, V. V. On the Tunguska meteorite. – *Nauka i Zhizn*, 1951, No. 9 (in Russian); Fesenkov, V. G., Krinov, E. L. The Tunguska meteorite or. . . a "Martian spaceship"? – *Literaturnaya Gazeta*, 1951, August 4 (in Russian).
10. Krinov, E. L. *The Tunguska Meteorite*. Moscow: Academy of Sciences of the USSR, 1949 (in Russian).
11. See Staniukovich, K. P., Fedynsky, V. V. On the devastation effect of meteoritic impacts. – *Reports of the Academy of Sciences of the USSR*, New Series, 1947, Vol. 57, No. 2 (in Russian).
12. Kazantsev, A. P. The Explosion. – *Vokrug Sveta*, 1946, No. 1, p. 41 (in Russian).
13. Krinov, E. L. *The Tunguska Meteorite*. Moscow: Academy of Sciences of the USSR, 1949, p. 183 (in Russian).
14. Florensky, K. P. Some impressions about the contemporary state of the region of the Tunguska meteorite fall. – *Meteoritika*, Vol. 12, 1955 (in Russian).
15. Yavnel, A. A. On the composition of the Tunguska meteorite. – *Geokhimiya*, 1957, No. 6, p. 556 (in Russian).
16. Yavnel, A. A. op cit.; Yavnel A. A. Meteoritic substance from the place of the Tunguska meteorite fall. – *Astronomichesky Zhurnal*, 1957, Vol. 34, No. 5 (in Russian).
17. Evgeniev, I., Kuznetsova, L. The Tunguska meteorite has been found. – *Znaniye-Sila*, 1957, No. 12 (in Russian).
18. Krinov, E. L., Yavnel, A. A. The Tunguska meteorite is no longer an enigma. – *Komsomolskaya Pravda*, 1957, September 8 (in Russian).
19. See Vronsky, B. *By the Path of Kulik's: A Tale About the Tunguska Meteorite*. Moscow: Mysl, 1984, p. 34 (in Russian).
20. Florensky, K. P., Vronsky, B. I., Emelyanov, Y. M., Zotkin, I. T., Kirova, O. A. Preliminary results of the work of the Tunguska meteoritic expedition of 1958. – *Meteoritika*, Vol. 19, 1960 (in Russian), pp. 122, 126.
21. Ibid., p. 131.
22. Credit for this discovery must be given to Dr. Yury Emelyanov.
23. Florensky, K. P., Vronsky, B. I., Emelyanov, Y. M., Zotkin, I. T., Kirova, O. A. Preliminary results of the work of the Tunguska meteoritic expedition of 1958. – *Meteoritika*, Vol. 19, 1960 (in Russian), p. 120. Later, there were found at Tunguska yet more pronounced

manifestations of this effect – where the width of tree rings reached almost *two centimeters*.

24. Ibid., p. 131.
25. Ibid.
26. The leading Soviet academic organization involved in investigation of explosions, especially nuclear explosions.
27. See On the Tunguska Meteorite. – *Priroda*, 1959, No. 11 (in Russian).
28. See Staniukovich, K. P., Shalimov, V. P. On the motion of meteor bodies in the atmosphere of the Earth. – *Meteoritika*, Vol. 20, 1961 (in Russian).
29. Krinov, E. L. Where is the Tunguska meteorite? – *Priroda*, 1960, No. 5, p. 61 (in Russian).
30. See Fesenkov, V. G., Krinov, E. L. News about the Tunguska meteorite. – *Herald of the Academy of Sciences of the USSR*, 1960, Vol. 30, No. 12 (in Russian).
31. Fesenkov, V. G. On the nature of the Tunguska Meteorite. – *Meteoritika*, Vol. 20, 1961, p. 30 (in Russian).