3. A Shocking Discovery

Soon after its spectacular flight and devastating explosion over the Siberian wasteland, interest in the Tunguska space body practically evaporated. Turbulent times were approaching, and cosmic stones began to look less important. With war breaking out in Europe in 1914 and all that happened afterward, there was much to keep the science community from exploring the Tunguska catastrophe. That war proved to be a turning point that determined the catastrophic nature of the twentieth century. If there had been no war there would have been no October Revolution of 1917 in Russia, and history would have followed a very different path. If we believe in the "many-worlds" interpretation of quantum mechanics, we can suppose that "somewhere" a better world history has materialized. But not here, alas.

One participant in that war was the mobilized student of the Mineralogical Faculty of St. Petersburg University, Leonid Kulik, who became the future pioneer of Tunguska studies (see Figure 3.1). By that time Kulik was already 30, with mineralogy the passion of his life. He was born on September 1, 1883, in the Russian town Derpt (now the Estonian town Tartu). His family belonged to the gentry, although they were not rich, and after the early death of his father the family moved to Troitsk in the Urals. Here, in 1903, Leonid Kulik gained a gold medal at the Troitsk Classical Grammar School and entered the St. Petersburg Imperial Forest Institute, where he was influenced by the craze for "leftish ideas." A year later, in 1904, he was expelled from the institute for taking part in student disturbances and was called up for military service. But a military career was not for him, and the stormy year of 1905 found Kulik participating in an armed revolt in Kazan. The revolt was suppressed, and Kulik soon ended his military training and returned to Troitsk in the Ural Mountains, which is probably the most suitable place in the world for a lover of stones.

V. Rubtsov, *The Tunguska Mystery*, Astronomers' Universe,
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FIGURE 3.1. Dr. Leonid Kulik (1883–1942), the pioneer of Tunguska studies (*Source*: Krinov, E. L. *The Tunguska Meteorite*. Moscow: Academy of Sciences of the USSR, 1949, p. 4.).

While working at the Mining department, Kulik studied mineralogy as well as botany and zoology. At heart, Kulik was a naturalist and an empiricist, a devout successor of those who studied lightning, meteorites, and volcanoes and created herbaria – quite unlike modern theoreticians and experimenters. Another of his passions seems to have been underground work for the Revolution. In 1911, police arrested him, and he spent three weeks in the Troitsk citadel, which was used as a prison. He was hardly an "innocent victim" of the Tsarist regime, but his guilt was not established and he was released, although he remained under police surveillance. The country still had laws, not all of which were draconian. For some time Kulik worked as a forest warden, but the path of his life changed abruptly when he met a member of the Imperial St. Petersburg Academy of Sciences, Dr. Vladimir Ivanovich Vernadsky, a famous geochemist and authority on radioactivity (see Figure 3.2). The

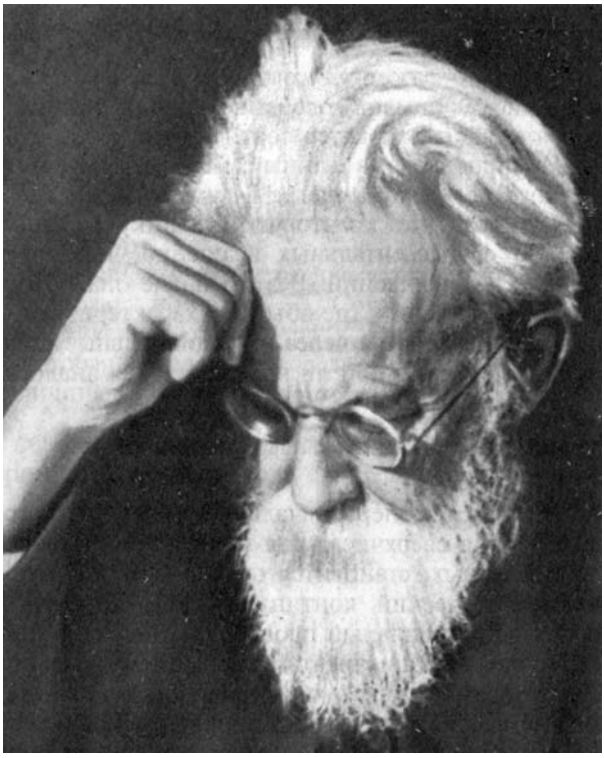

FIGURE 3.2. Academician Vladimir Vernadsky (1863–1945), an eminent geochemist and inspirer of Tunguska investigations in the 1920s and 1930s (*Source*: Zhuravlev, V. K., Rodionov, B. U. (Eds.) *Centenary of the Tunguska Problem: New Approaches.* Moscow: Binom, 2008, p. 418.).

subject of radioactivity in the first decade of the twentieth century was a hot topic in science – too hot for some researchers who died from studying it – and Vernadsky, being attracted to new lines of inquiry, had been trying to broaden scientific investigations in the field of radioactivity.

The Academy of Sciences listened to Vernadsky and decided to allocate funds for his expeditions to look for radioactive minerals. So, in the spring of 1911, with some colleagues, he visited the Caucasus and the Ural Mountains. The expedition needed a specialist in geodesy, someone who could determine exact geographical positions for the expedition, and the chief of the Mining Department recommended Leonid Kulik. Thus Kulik met Vernadsky, and their long association and joint research work commenced. Later this

proved to be of considerable importance for the problem of the Tunguska meteorite. Without Academician Vernadsky's support, Kulik would hardly have succeeded in organizing his expeditions to Tunguska.

From August 20, 1912, Kulik was on the staff of the Academy of Sciences. This helped the Ministry of Internal Affairs to exonerate him from his former political charges and allowed him to live in both capitals of the then Russian Empire – in St. Petersburg and Moscow. Immediately he moved to St. Petersburg, where he cataloged minerals at the Peter the Great Geologic and Mineralogical Museum until the war in 1914 interrupted his studies. He enlisted in the engineer battalion of a cavalry brigade, the Dragoon Regiment of Finland (then part of Russia) that took part in some bloody battles in eastern Prussia. Kulik was decorated for bravery and later made a lieutenant.

In July 1917, the Provisional Government of Russia began to realize that the country needed the specialists who were perishing in the trenches of the Great War, and Kulik was recalled from Field Forces to St. Petersburg (which had been by that time renamed Petrograd). He then enlisted in the Central Scientific and Technological Laboratory of the War Ministry. Although the coup of October 1917 had been welcomed by Kulik as a "long-awaited victory," that victory turned into years of almost biblical calamities. The strife of Civil War brought Kulik into various regions of the country. He evacuated his family from starving Petrograd, looked for ocher in the Ural Mountains, taught mineralogy in Tomsk University, served initially in the White Army and then in the Red Army (in both cases for a short time), and again taught mineralogy in Tomsk.

Kulik's first encounter with the arrival of a new meteorite occurred at the beginning of the Civil War in April 1918, when a "sky stone" fell near the town of Kashin. The Academy of Sciences commissioned him to discover the circumstances of this event and to bring the meteorite back to Petrograd. Alas, the stone itself had already been sent to Moscow by the local authorities, although when Kulik arrived he obtained small fragments for the Academy. But his work was temporarily terminated for the next three years while his country, with a revolution and the Civil War, was in no mood for meteorites.

Eventually the Civil War came to an end, and in March 1921 Leonid Kulik returned to Petrograd to the post of Secretary to the Meteoritic Department at the Mineralogical Museum, which was headed by no less a person than his friend and mentor Vladimir Vernadsky. And a few days after his return an event occurred that changed the course of his life. "How distinctly I remember that moment," wrote Kulik seven years later. "It was March 1921 and Daniil Svyatsky, the Editor of the *Mirovedeniye* journal, approached me with an old page from a wall calendar dated July 2, 1910. 'Look at the back of this page,' he said. 'It is rumored that a giant meteorite fell in Siberia in 1908 near the Filimonovo railway station. And you know there's no smoke without a fire'."[1] Both these men proved to be very perceptive, Svyatsky because he recognized significant data in an old calendar and Kulik because he realized that he might follow up on its contents and make important discoveries.

As a matter of fact the calendar had a reprint of the most fictitious newspaper report on the Tunguska phenomenon, which Leonid Kulik called the "Filimonovo meteorite" after the railway station of Filimonovo. The journalists on the *Siberian Life* of July 12, 1908, had grabbed the public's attention with the title "A Visitor from Heavenly Space." The article told of a huge hot meteorite that had fallen near the station at Filimonovo and that eyewitnesses and scientists had examined it. The only doubt expressed by Kulik was that "its size might have been exaggerated by the author of the article." But he thought the story itself had been based at least partly on facts. Kulik went on: "The author gave the very natural circumstances of the meteorite fall as well as its exact date and place. Therefore, it can hardly be considered idle fantasy of a smart journalist to arouse our mystification." In fact the article was almost nothing but "idle fantasy." In retrospect, one can congratulate the reporter Alexander Adrianov, since his ability to compose fantastic stories helped to stimulate interest in the Tunguska event and encourage future expeditions and research.

The Russian Society of Amateurs of Cosmography, and the editor of its journal the *Mirovedeniye*, became most important in collecting and promoting information on the Tunguska event when the subject was almost forgotten. But its editor, Daniil Osipovich Svyatsky (see Figure 3.3), suffered cruelly at the hands of the Soviet authorities and the Society was disbanded in 1930. Its many

FIGURE 3.3. Daniil Svyatsky (1881–1940), a Russian historian of astronomy, the chief editor of the *Mirovedeniye* ("Cosmography") journal, who enthusiastically supported the search for the Tunguska meteorite in the 1920s (*Source*: Bronshten, V. A. *The Tunguska Meteorite: History of Investigations*. Moscow: A. D. Selyanov, 2000, p. 80.).

members were sent to gulags and Daniil Svyatsky was arrested in the spring of 1930 and kept in prison for many months. He was accused of being a secret monarchist because he had proposed naming a nova star that became visible in 1670 in the constellation of Vulpecula after the Russian emperor Peter the Great. For this, Svyatsky was condemned and sent with other State convicts to build a canal from the White Sea to the Baltic. In less than two years some 100,000 of these political prisoners had perished, though Svyatsky survived to be released in 1932. He then lived in Leningrad but was exiled to Alma Ata in 1935, when the authorities started a witch hunt for purported conspirators against Sergey Kirov, a noted member of the *Politburo* who was murdered in December 1934. This outstanding Russian historian of astronomy never returned from exile. He died in January 1940 when only 58. Although late in the 1920s and afterward, the leading part in Tunguska studies was

played by the Academy of Sciences, it was the *Mirovedeniye* journal in the 1920s that held most information about the phenomenon and also argued for an expedition to investigate the place where the meteorite had fallen.[2]

Fortunately in that period several influential members of the Academy of Sciences, including Academician Vladimir Vernadsky, conceived a plan to organize the first large expedition through Russia to collect meteorites. (And it was through Russia because before December 1922 there was no Soviet Union, although the various states were moving toward forming such a union.) By that time, the academic archives contained many reports about meteorite falls in various parts of the country. So, on April 20, 1921, a meeting of the Physical and Mathematical Branch of the Academy of Sciences took place at which Vernadsky read a report prepared by Leonid Kulik entitled "New data about meteorite falls in Russia." The state of affairs in Russia at the time hardly favored the planned expedition. According to Kulik, the Academy of Sciences had no funds for it, while the "scientists themselves were emaciated and ragged."[3] Nevertheless, thanks to the support of the People's Commissar of Public Education, Anatoly Lunacharsky, the government allocated funds from the state budget.

The expedition led by Leonid Kulik numbered some 20 people, and with a private railcar they left Moscow on September 5, 1921. Searching for the "Filimonovo meteorite," as Kulik had labeled it, was not the only purpose of this trip, but the search did start in central Siberia in the town of Kansk, where the scientists distributed some 2,500 questionnaires to local inhabitants, hoping to collect information about what happened on June 30, 1908. While visiting the station at Filimonovo, Kulik concluded that no meteorite had ever fallen there, though the information gathered by the expedition proved that the rumor about the "giant meteorite" was not groundless.

As Kulik reported to the Academy of Sciences: "At about 5–8 am, June 30, 1908, an impressive meteorite flew over Yenisey Province from the south to the north and fell near the Ogniya River... The fall was accompanied by a brilliant light, a small dark cloud, and some very loud claps of thunder. The catastrophic impact of the leading air wave must be emphasized because according to reports from the Tungus it not only broke and felled many trees but also

dammed the Ogniya River, having brought down the riverside cliffs."[4]

The expedition also investigated other meteorite falls in Siberia and the European part of Russia before returning to Petrograd on October 19, 1922. It lasted more than a year and covered some 20,000 km, gathering for the Mineralogical Museum specimens from ten meteorite falls.

Nevertheless, Kulik and his team did not reach the actual area of the Tunguska event, being aware that it would be impossible to get there without more extensive preparations. So, the material collected by the expedition provided only indirect evidence and evoked a skeptical reaction from many academics. Eyewitness reports (especially from native inhabitants of Siberia) about the flight and explosion of a "brilliant body" appeared to them scientifically worthless and did not justify more funds for an expedition to the place where this body fell. For several years, Leonid Kulik regularly submitted applications for another expedition, and the Academy refused his requests no less regularly. The absence of Vladimir Vernadsky, who was at this time lecturing at the Sorbonne and conducting experiments in French laboratories, also seems to have been a negative factor.

But in 1925 the situation began to improve. The *Mirovedeniye* journal published an article called "About the place of the 1908 Great Khatanga meteorite fall."[5] The article was by geologist Sergey Obruchev,[6] the son of the geologist and investigator of Asia, Vladimir Obruchev (mentioned earlier), who also wrote some of the most popular science fiction novels in the first half of the twentieth century. (English translations of his "Plutonia" and "Sannikov Land" are still available today from bookstores and the Internet.) When living in Tomsk in 1908, Vladimir Obruchev had tried to verify the newspaper reports about the Tunguska meteorite immediately after the event but had failed.

But back to his son Sergey Obruchev, who in 1924 was sent by the Geological Committee to examine geological features of the region by the Podkamennaya Tunguska River. Here he happened to discover that the fallen forest area of the Tunguska event was not far away. He wanted to visit the site but failed to persuade any Tungus guides to accompany him. According to Obruchev they "flatly denied that a meteorite had fallen." As Obruchev said in

1925: "The lack of time and means did not allow me to make a survey of such a large space covered by dense forest. Therefore, I had to restrict my investigation to collecting new eyewitness reports." In fact, these "new eyewitness reports" contained no new information about the Tunguska event, but they confirmed what was already known from the newspaper publications of 1908 and the work of the Meteoritic Expedition of 1921. Nonetheless, Obruchev's report prompted Arkady Voznesensky, the leading figure in the subject at the time, to publish a paper about the instrumental data obtained at his Irkutsk Observatory way back in 1908, which had confirmed that a large space body had fallen in Central Siberia.[7] Consequently, the contributions from Obruchev and Voznesensky greatly strengthened Leonid Kulik's position in scientific society, even though it did not influence the Academy of Sciences to finance a new Siberian expedition.

Soon, however, a new personage in the form of Innokenty Mikhaylovich Suslov (see Figure 3.4) entered the Tunguska

FIGURE 3.4. Innokenty Suslov (1893–1968), an anthropologist, the Chairman of the Krasnoyarsk Committee for Assistance to Northern Peoples, and one of the pioneers of Tunguska studies (*Source*: *The Tunguska Phenomenon: 100 years of an unsolved mystery*. Krasnoyarsk: Platina, 2007, p. 16.).

community. He was an anthropologist and a representative of Soviet power in Siberia. He first heard about the Tunguska catastrophe in the autumn of 1908, when a student at the local gymnasium. And helped by his teacher, the young Innokenty tried "to determine the location of the meteorite fall (or explosion) and to find out how it would be possible to get there."[8] The extraordinary event remained in Suslov's memory, and in March 1926 he questioned some Tungus people (now known as Evenks) who, at the moment of the Tunguska explosion, were near its epicenter. This new information, which contained important details, had been missed by newspaper reporters and by Kulik's Meteoritic Expedition of 1921–1922. In particular, Suslov talked with brothers Chuchancha and Chekaren (whom we met earlier), who described to him the sequence of several flashes and explosions over the Tunguska taiga.

Suslov's article "The search for the great meteorite of 1908," which was based on his talks with numerous Evenks, was published in the *Mirovedeniye* journal. It again confirmed the flight of a space body over central Siberia in 1908 as well as the probable location of the fall. However, another expedition to this region would have probably been postponed again had not Vernadsky returned from abroad and insisted on organizing one. So in February 1927 Kulik and his assistant Oswald Guelich left Leningrad for Siberia. In the middle of March they reached the Angara River and traveled downstream to the old Russian village of Kezhma, then occupied by *starovers* (old believers who escaped religious persecution after the church reform in 1655 and 1656). Here they obtained more information about their route and left for Vanavara, the village that was 70 km from the Tunguska event and the closest to it. They arrived at Vanavara on March 25.

On arrival, Kulik hired a guide – not without difficulties because the Evenks didn't want to visit places declared forbidden by their shamans. However, an Evenk named Luchetkan did agree to take them on horseback to the site of the meteorite fall, but the snow was still too deep for horses and they were forced to return to Vanavara. This made Kulik and his companion realize why the Evenks preferred deer to horses for their transport. A herdsman named Okhchen, the owner of a dozen deer, then agreed to help the expedition, providing his services were paid for, and on April 8 the travelers started out again. Apart from Kulik and Guelich, there

was the herdsman Okhchen who took his younger wife, daughter, nephew – and even his baby. Five days later they entered the area of fallen wood (see Figure 3.5). Kulik described the scene: "All large trees on the mountains were leveled in dense rows, whereas in the valleys one could see both roots and trunks of age-old giants of the taiga broken like reeds. The tops of the fallen trees were directed to us. We were going north towards the super-hurricane that had raged here almost 20 years ago."[9]

FIGURE 3.5. The forest completely leveled by the shock wave of the Tunguska explosion. The photograph was taken in 1929, by Evgeny Krinov (*Source*: Krinov, E. L. *Foundations of Meteoritics*. Moscow: Gostekhizdat, 1955, p. 99.).

On April 15, Kulik climbed the Shakrama Mountain and for the first time saw the unbelievable "Land of Dead Forest." "I am still unable to sort out the chaos of the impressions that I took from that excursion," Kulik wrote in his diary, "and I even cannot imagine the whole colossal scale of this extraordinary meteorite fall. Here is a very hilly, almost mountainous locality, extending for tens of kilometers behind the northern horizon. Distant mountains along the Khushmo River are covered by a blanket of snow half a meter deep. And from our observation point one can see no sign of living forest:

everything has been leveled and scorched, but around this dead area a young (not older than 20 years) growth appears, striving towards the sun and life... It is so terrible to see the giants with a diameter ten to twenty *vershoks* [up to one meter] broken in two like a thin reed with their tops thrown aside for many meters to the south."

The aim of the expedition seemed to have been attained. But it only seemed so. By that time herdsman Okhchen happened to remember the shamans' ban on visiting this area and flatly refused to go further, and on April 19 the travelers had to begin their return. The Evenks were so eager to leave the forbidden area that the deer caravan got back to Vanavara in just two days.

Being disillusioned with the Evenks, Kulik decided to make arrangements with some Russian settlers living by the Angara River. Two hunters helped the scientists to build an intermediate camp on the Chamba River about 75 km from Vanavara, and the expedition members knocked up two rafts for nine people – and a horse. The horse sometimes pulled the rafts and sometimes traveled on them. It was spring, and the Chamba River was seething, but having reached the mouth of the Khushmo River they moved upstream, their one horse towing the two rafts.

On May 30, the expedition arrived at the mouth of the Churgim Creek, which provided too little water for a boat or a raft. The expedition set up "Camp No. 13" nearby, from which they began their examination of the surrounding area. They soon found to the north of the camp a vast hollow surrounded by mountains, which Kulik named the Great Hollow.[10] He then surveyed the directions of the fallen trees within the Great Hollow and discovered to his surprise that the whole forest had been put down in a radial manner.

"On a mountain pass," wrote Kulik, "I made my second camp and began to circle around the Great Hollow, passing by the mountains. First I went to the west and covered tens of kilometers by lonely mountain ridges, but always the fallen trees were oriented to the west! Then I circled the hollow to the south and the fallen trees, as if enchanted, turned to the south as well. I returned to my camp and went further by mountain slopes, now to the east, and the leveled trees started to shift their tops in the same direction. Finally, straining every muscle, I moved to the south once again, almost reaching the Khushmo River, and the lying bristle of the fallen wood

turned to the south as well. . . There could be no doubts: I had circled the center of the fall."[11]

Finding the radial pattern of the fallen forest around the epicenter of the Tunguska explosion was an opening shot in the whole of Tunguska studies. Of course, at that time, Kulik did not use the term "epicenter." He believed that the meteorite – as any normal stone or iron meteorite would have done – did fall into the "Great Hollow." As he wrote, "It is with a fiery jet of burning-hot gases and cold bodies that the meteorite struck the hollow with its hills, tundra, and marsh. . ." He was completely sure that this pictured the event of 1908. But even though this proved to be wrong, it was Leonid Kulik who discovered the only area of radially leveled forest existing on our planet.

Unfortunately or fortunately, depending on one's viewpoint, there were in the northeastern part of the hollow several dozen flat craters similar to lunar craters. Naturally, Kulik, who was looking for evidence of a giant meteorite, decided that they had been formed by the fallen pieces of the space body. Later on, when the non-meteoritic nature of these craters was convincingly proved, some armchair researchers hurled plenty of unfair accusations at the pioneer of Tunguska studies. But what else should he have thought, having got to the place of the catastrophe and seen these craters? Yes, Kulik did make a mistake – but it was a "happy mistake." If he had understood at once that these craters were simple thermokarst holes, formed in this region when ice-rich permafrost melted, he could have decided that the Tunguska meteorite had fallen at another place and that the leveled forest was due, say, to an "untypical hurricane." In this case, Kulik would have started a long fruitless search for this "other place" – since he was a specialist in meteoritics looking for a meteorite and not for traces of hurricanes. The real "mega-trace" of the Tunguska explosion was the taiga itself, with its radially leveled trees over an area of some 2,100 km^2, which suggested a high-altitude explosion of an enigmatic space body. And this might not have been realized without Kulik's exploration of the site.

Leonid Kulik's second important discovery during this expedition was a vast zone (8 km across) of trees scorched and devoid of branches, but standing upright like telegraph poles at the center of the radially leveled forest. However, Kulik did not understand the

true meaning of this amazing zone of standing trees and explained its existence superficially as caused by a "wave interference." He considered it self-evident that pieces of a meteorite had hit Earth to form the "lunar-like" craters. And although the pattern of the standing trees did appear to him fairly interesting, he thought this of no great importance. Twenty years later, this "fairly interesting" phenomenon led Alexander Kazantsev to the conclusion that the Tunguska space body had exploded in the air, not on hitting the ground.

Kulik's third discovery was to follow. Traces of "unusual burns" were found on both fallen and living trees. "All former vegetation in the hollow and on the neighboring mountains," wrote Kulik, "out to several kilometers, has distinctive traces of a continuous and even burn, which is very different from the traces of a forest fire. These burns have been preserved both on fallen and standing trees, as well as on remains of bushes and moss. They may be seen on the slopes and tops of mountains, in the tundra and on set-apart isles in water-covered swamps. The area showing traces of the burn is several tens of kilometers across." Here Leonid Kulik does deserve praise for his keenness of observation as a true naturalist. Subsequently it became evident that this burn resulted from a powerful light flash during the Tunguska explosion. In the 1960s, having examined the traces of burning, other scientists calculated that the heat radiation from the light flash, in the overall radiation of energy from the explosion, was not less than 10% and perhaps even 25% of the total energy released. The explosion was therefore not only a high-altitude one but, in this respect, rather like a nuclear explosion.

Kulik's discoveries in 1927 were therefore sufficient to understand that the space body that exploded over the taiga in June 1908 could not have been an iron meteorite, although this conclusion was reached only by the great effort of many scientists. And it wasn't just mental effort. When Kulik and his companions had to leave the taiga, their food reserves were running so low that they were tempted to eat their poor horse. "We had provisions just for three to four days, and we were faced with a long trek. Far from being triumphal it was a flight in the literal sense of this word." Although having become noticeably thinner, the members of the expedition (the horse included) reached Vanavara on June 24, and in September both Leonid Kulik and Oswald Guelich returned to Leningrad.

To call Kulik's expedition of 1927 just "successful" would be to underestimate its true significance. It was definitely epoch-making, but somehow the Academy of Sciences was not in a hurry to acknowledge this fact. After all, what did Kulik find? A leveled forest? But that could have been due to a hurricane, something not exactly rare in the taiga! So there were traces of a burn and a forest fire, but no meteor craters, only some holes in the ground! These were not the voices of the uninformed; they were the views of scholars who were familiar both with wind-generated wood falls and with the results of forest fires. The only difference between the critics and Leonid Kulik was that Kulik had visited the place and they had not. And he was sure that the place of the Tunguska meteorite fall was worthy of further investigations, especially as pieces of the meteorite, which could weigh tons, might still be excavated from the ground.

In February 1928, Vernadsky convened a special conference in the Mineralogical Museum on one question only: whether or not the Academy of Sciences should continue the search for the Tunguska meteorite? Opinions at the conference were divided. Some scholars, after studying the photographs taken by Kulik, could not see anything strange or anything needing further investigation. The Academician A. A. Grigoryev, an expert in forestry, suggested that the leveled forest in the "Great Hollow" could have resulted from a forest fire. He did admit, however, that the scale of the event would have had to be extraordinary. The craters at the center of the area of the leveled forest seemed especially doubtful to many at the conference, even to those who generally supported Kulik's work. Nevertheless, they did not rule out the possibility that a large meteorite had fallen in the area in 1908. So the conference resolution was positive: Kulik must go to the taiga once again and finish his work. Either the remnants of the space body would be found or he would find nothing unusual. That was the thinking at the time, but nobody suspected that the unanswered questions about the Tunguska space body would drag on into the twenty-first century.

The Academy of Sciences was then, as always, in straitened circumstances and had to appeal to the government for further funding. The Council of People's Commissars responded favorably so that on April 6, 1928, Kulik was able to leave Leningrad again for

the Tunguska taiga with a staff of two people. It's interesting that Kulik took with him not a geologist or an astronomer but a simple enthusiast in the search for the meteorite, a 21-year-old zoologist and hunter Viktor Sytin (1907–1989). Later Sytin, who became a well-known writer, recounted his impressions of this expedition to Alexander Kazantsev, a science fiction author who was to play a sensational role in the Tunguska mystery. Sytin's recollections intrigued the science fiction writer, who began to realize that here was an enigma to explain and that the word "meteorite" was just being used as a convenient label.

On April 25, 1928, the expedition reached Vanavara. There Kulik and Sytin met Nikolay Strukov, a cameraman from *Sovkino* (a state-owned company that controlled the film industry in the USSR from 1924 to 1930), to make a film about the expedition. Kulik hired five local workers, and within a month they had built three *shitiks* (traditional boats). He named them "Comet," "Bolide," and "Meteor." On May 21 with eight in the expedition, they moved downstream to the Podkamennaya Tunguska River and then upstream to the Chamba River, where they hired two extra men to help tow the heavy boats against the flow and the dangerous rapids. On the fifth day, the expedition approached the Burkan mountain range, where the Chamba was rushing down through a narrow gorge. Strukov filmed the expedition surmounting this obstacle where Kulik barely escaped sudden death. Later, Sytin wrote: "The *shitik* was momentarily swamped, turned sideways to the stream, and overturned, and Kulik vanished in the whirlpool... For several seconds, or maybe even minutes, we could not see him. The overturned boat was the only thing that appeared and disappeared amongst the waves and foam... But finally he emerged. We threw him a rope and he clambered on to the bank..."[12] All Kulik said was: "Look here, friends, my spectacles are intact."

Early in June the expedition arrived at "Camp No. 13," built a year before on the Khushmo riverbank. It was a good base, because the distance between the camp and the center of the leveled forest was only a few kilometers. They built a bathhouse and a *labaz* (storehouse on poles: see Figure 3.6). On June 22, the expedition moved closer to their work area – into the "Great Hollow." And near the foot of the Stoykovich Mountain they organized another

FIGURE 3.6. A *labaz* (storehouse on poles) built in the course of the second Kulik expedition (1928) (*Credit*: Dr. Gottlieb Polzer, Lichtentanne, Germany.).

camp. Here they built a log cabin and a second *labaz* and named the place "Meteoritic *zaimka*," a Siberian term for a hunter's house or lodge.

Having finished his filming, Strukov left the expedition with three other workers. Later he made a documentary "To the taiga in search of a meteorite," which contained important material both about the second of Kulik's expeditions in 1928 and about the area of the Tunguska meteorite fall. The rest of the expedition remained to do surveys and prepare magnetometric measurements to try and find the large iron mass of the meteorite that everyone thought was under the ground or in the swamp. They also cleared paths through the taiga to examine the central part of the leveled forest and attempted, without success, to dig up two supposed "meteoritic craters." But as they dug the holes just flooded with subsoil water.

Despite it being summertime, the expedition soon began to feel the shortage of food and vitamins. Their hopes for food from hunting and fishing turned out to be too optimistic, and the explorers had to feed on flour and tea with sugar. There was nothing else and no money left to buy provisions in Vanavara. Sytin and both the remaining workers suffered vitamin deficiency, but Kulik stayed

healthy and cheerful. Unfortunately, the measurements for evidence of magnetism in the craters needed to detect meteoritic iron could only be carried out in autumn, when the first frosts would strengthen the soil. So what was to be done? Kulik decided on the risky option of remaining. "We have a food reserve that will last me three months," he told Sytin. "During that time you will reach Moscow and Leningrad, obtain additional funds, and go to Kezhma to arrange for a string of carts to return here for me and our collections."

Kulik's decision to remain on his own was risky, since the taiga even in summer is not completely safe. But even with the food reserves consisting of only flour, tea, and sugar, it proved to be a good decision. Sytin obtained money from the Academy of Sciences and arranged with local Siberian authorities to send a rescue expedition to Kulik. Heading this rescue mission was none other than Innokenty Suslov, the very man who had questioned the Evenks in 1926 about the Tunguska meteorite fall, and he now at last had an opportunity to see with his own eyes where it all happened. On October 20, 1928, they reached Kulik's *zaimka*, and as it was already freezing and snowing they could check for meteoritic iron – mainly in the largest crater that Kulik named "Suslov's crater" after the enthusiastic ethnographer. Alas, no magnetism from such a source was found. But Kulik remained completely unaware of the surprise discovery that this crater would give him the following year.

On October 27 the expedition set out for home as the frost became harder and harder. After two days rest in Vanavara, they journeyed on through snowdrifts in a temperature that was never better than –39°C. When the party arrived at Kezhma on November 6 all were ill, even the iron man Leonid Kulik. Innokenty Suslov had a frost-bitten nose and boils. But after a week's rest these incredible people moved on to the railway station at Taishet from where a fast train – the *Trans-Manchurian Express* connecting Beijing to Moscow – carried them back to civilization.

Soon after arriving back in Leningrad, Kulik started to prepare for the next expedition to Tunguska. It was obvious that a new visit to the "Land of the Dead Forest" must be better organized, or it would fail. On January 2, 1929, at a conference held by the Mineralogical Museum, Kulik read a paper before a large audience on the results of his explorations. He was absolutely certain that the craters

in the Tunguska taiga were meteoritic craters, but specialists in the natural life of Siberia disagreed. These are not craters, they said, only natural thermokarst holes. The only way to resolve this disagreement would be to drill holes in several craters until bedrock was reached, but this would need a new expedition.

On January 5, 1929, the Academy of Sciences decided that the new expedition would be sent within the year. Its main aim would be the excavation and drilling of the supposed craters, as well as hydrological investigations of local marshes. The Academy was not slow to act. On February 24, 1929, the third Tunguska expedition left Leningrad and on April 6 it arrived at its place of work. This time it was a well-equipped expedition with 10 well-qualified members, not just a couple of specialists and a few workers. The Academy appointed Evgeny Krinov (see Figure 3.7) as Kulik's deputy. He was then a young astronomer, although after World War II he became a

FIGURE 3.7. Dr. Evgeny Krinov (1906–1984), an eminent meteor specialist, Chairman of the Committee on Meteorites of the USSR Academy of Sciences since 1972 till 1984, a participant of the Great Tunguska expedition of 1929–1930 (*Source*: Zhuravlev, V. K., Rodionov, B. U. (Eds.) *Centenary of the Tunguska Problem: New Approaches*. Moscow: Binom, 2008, p. 24.).

member of the Soviet scientific establishment and a leading specialist in meteoritics. The expedition also had a skilled driller and six young meteorite enthusiasts. They had food for one and a half years, plus hand drills, pumps, spades, crowbars, cameras, measuring instruments, meteorological devices, a theodolite, and chemical reagents. All this equipment and food needed 50 carts to transport it to the taiga.

This Great Expedition lasted 20 months and, of course, included a Siberian winter. Its main aim was to find and dig up that meteorite. And every effort was made to do so. Kulik even prohibited his colleagues from going farther than 3 km from their base, and the exploration of the leveled forest was postponed. First they had to dig the soil, especially in Suslov's crater. The level of water within it exceeded that in the similar nearby depressions, so Kulik decided to drain the water to an adjacent hole. For that they had to dig a trench from Suslov's crater to the adjacent crater. By May 25, 1929, a trench 38 meters long, 1.5 meters wide, and 4 meters deep was finished and water gushed from Suslov's crater into the other depression. At the same time, the upper sphagnum cover, still frozen, sank to the silty bottom of the crater, making it look like a huge bowl. What else could this be, thought Kulik, if not evidence of a meteorite fall?

Alas, while cleaning Suslov's crater from silt and moss, the researchers found near its center the stump of a tree broken near its roots. This was an amazing and shocking discovery. The stump stood in its natural position with its roots penetrating the soil. The discovery was utterly unexpected and destroyed all hope that the crater had been produced by the impact of a meteorite. It was now no more than a hole in the ground.

For Leonid Kulik the discovered stump was a catastrophe. He forbade members of the expedition to take photos (although Krinov did take a photograph secretly) and then ordered the team to drill another borehole on the northern edge of Suslov's depression. But after drilling to 30 m no fragments of a meteorite were found. Kulik then shifted his attention to another promising place, the so-called "Cranberry hole." And until the very end of the expedition's explorations he remained sure that this was a "definite meteorite crater."[13]

So Kulik persisted in his hopeful delusion, although his colleagues who were not so fanatical began to accept that their searches

had reached a dead end. On one lucky day, when Kulik had left for Vanavara with a sick worker, Krinov took a long walk through the neighboring area and established that all "meteoritic" crater-like holes were only on low-lying marshy lands. This was one more telling argument against their celestial origin. A swarm of iron meteorites would hardly have preferred to impact only on low-lying land, while ignoring the surrounding mountain slopes.

But Kulik was absolutely deaf to such arguments and insisted on even more digging and drilling. Who knows, he reasoned, perhaps some pieces of the Tunguska meteorite could have fallen at other places of the "Great Hollow"? The best way to verify this idea seemed to be aerial photography, and he eagerly expected the Academy of Sciences to provide an airplane and a photographer. But alas his request was shelved for a whole year, and in 1929 the sky over Tunguska remained empty.

In November 1929, while going from the Great Hollow to Vanavara, Krinov got his feet frostbitten so badly that he left Vanavara for Kezhma, where he spent several months in the hospital. To avoid gangrene, a surgeon amputated a big toe, and in March 1930 he had to quit the expedition. Apart from the health problem, there was also tension between him and Kulik, who considered any doubts about the meteoritic origin of the crater-like holes as a "betrayal." Krinov, however, did not bear a grudge against his chief, and after returning to Leningrad he started to campaign for the requested aerial photography. He convinced the Academy of Sciences to apply for a special plane from *Osoaviakhim* (the so-called Union of Societies of Assistance to Defense and Aviation-Chemical Construction of the USSR, a powerful militarized organization with its own aerodromes, radio clubs, and airplanes that existed in the USSR until World War II). Unfortunately, the plane with Boris Chukhnovsky as the pilot arrived at Kezhma only in July 1930, when it was continuously raining. One day Kulik and Chukhnovsky did take off from Kezhma in the direction of Vanavara only to encounter pouring rain that forced Chukhnovsky to turn back. Taking the aerial photographs of the leveled forest in the Great Hollow had to be postponed indefinitely.

By the autumn of 1930 it became clear that there was no sense in continuing the expedition. Despite it being well organized and equipped, no pieces of the Tunguska meteorite had been found, and

in October Kulik returned to Leningrad. His mood was not optimistic. He had lost a battle but did not intend to give up. The unsuccessful searches for meteorite fragments in other holes had led him to a new hypothesis: the huge space body fell in the Southern swamp and exploded there, but the craters were hidden in the waters of this swamp. Pieces of the meteorite, each weighing "several hundreds tons at least" would be there. There was simply no other place. Again and again Kulik tried to convince the academic authorities that a new expedition must be sent to the taiga to search and drill and excavate. And the aerial photography of the region must be done as soon as possible. "It is exceptionally important to photograph this area from a plane," he wrote, "and to create from the photos a large-scale map. This would allow us to understand the nature of the phenomenon much better. There is no other method whose efficiency would be comparable to aerial photography."[14]

But attitudes toward the Tunguska problem had changed – both in society and at the Academy of Sciences. One member of the expedition, Sergey Temnikov, sent a report to the authorities accusing Kulik of incompetence: "He has squandered the people's money, inventing a fantastic meteorite whereas the forest in the Great Hollow was leveled by a hurricane." This was, by the way, not the first and not the last "hypothesis" of this sort. However, leading academics, in particular the president of the Academy of Sciences A. P. Karpinsky, supported Kulik, and Temnikov's report was officially ignored. Temnikov was somewhat too hasty. A few years later this affair might not have ended so easily for Kulik. He might have been accused of "sabotage on the meteoritic front" and joined other exiled scientists in his beloved Siberia, or even further away.

Nevertheless, the Academicians were no longer in a hurry to ask for money from the state budget for Kulik's proposed expeditions. And they were right: it was time to ponder the problem. The picture of the falling space body that had recently looked to be an understandable phenomenon became stranger and stranger, something that Vladimir Vernadsky, who called the Tunguska meteorite an "enigmatic phenomenon," had already realized. It seemed that something important had been missed. At the time there was no accepted theory of crater formation from impacting meteorites, but it was obvious that the vast area of leveled forest testified to the release of an enormous amount of energy whatever the precise

nature of the phenomenon. But a meteorite would certainly have left a colossal crater, and no crater existed.

There was a need to just sit down and think, but not for Leonid Kulik. He wanted a tangible stone or piece of iron from space, not a lengthy discussion about abstract questions. For that reason Kulik took almost no part in further theoretical considerations of the problem. He was quite content with the iron meteorite hypothesis that he had accepted at the very beginning of his searches, although he did admit that it might need minor modifications. But certainly, the main impetus to theoretical Tunguska studies came from none other than Leonid Kulik through the discoveries he made himself in the Siberian taiga.

The first major modification of the meteorite hypothesis was that a comet had caused the explosion. This was a reasonable idea since the Solar System has plenty of comets and – as far as we know – only two types of objects can collide with Earth: meteorites and comets. Initially, the Tunguska event was ascribed to a meteorite because of eyewitness reports – and no one knew anything about comets hitting Earth in the past. So a large meteorite provided a ready and acceptable explanation, and even today the world's encyclopedias still describe the Tunguska event as the greatest meteorite impact in recorded history. (One actually carries a photograph showing an alleged piece of that meteorite.) But when the meteoritic model did not match the reported circumstances of the event there seemed to be only one other option: a comet. In one sense, this was not a revolutionary conclusion. Leonid Kulik himself in 1926 thought that the Tunguska meteorite could have been an iron body from a group accompanying the Pons-Winnecke's comet, which could easily be seen in the sky in 1927.[15] This comet, discovered in 1819, was seen in the sky in 1909, fairly soon after the Tunguska event. By the way, on June 26, 1927, it flew past Earth at a distance of only 6 million kilometers – closer than any other comet except one. (Only Lexell's comet in 1770 is known to have approached closer.)

At that time astronomers believed the comet core was probably a conglomerate of stones and dust, or even a simple swarm of meteoroids.[16] So any serious difference between an individual meteorite and a comet seemed difficult to define. However, it was Francis Whipple, then chief astronomer at Kew Observatory in

London, who took the crucial step in 1934 of supposing that the Tunguska meteorite was not just a modest stone – one of a comet's escort – but the comet itself or its nucleus.[17] Unlike Kulik, Whipple thought the cause of the catastrophe was not the Pons-Winnecke's comet but a minor comet that could have been missed by astronomers. As a matter of fact, the same hypothesis was proposed, four years before Whipple, by the American astronomer Harlow Shapley – but in a book, not in a scientific paper.[18] This may be why Shapley's idea went practically unnoticed: scientists prefer their professional journals to books. However, Whipple's hypothesis did offer a reasonable explanation for the puzzling atmospheric phenomena of June 30–July 1, 1908. But his idea did not go far enough. He wrote about a collision of just a comet's core – *consisting of a number of meteorites* – with Earth's surface. This would have left pieces of the comet core and craters at the impact site, but none had been found.

One could probably be sarcastic about Francis Whipple, a theorist who had never visited the Tunguska site. His modification of the Tunguska meteorite model was too limited and his notion of the structure of comets very vague. But this sarcasm would be unfair. Science progresses through the failure of most hypotheses, and if we know more today about the world we live in it is due to former generations of scientists who had to think and work with less knowledge than we enjoy today. Francis Whipple did lay a foundation stone for the model of the Tunguska space body that 30 years later became the favorite of the astronomical community.

In the USSR, Whipple's idea was taken up and strongly supported by Igor Astapovich (1908–1976), an investigator of meteors and meteorites whose book *Meteor Phenomena in the Atmosphere of the Earth* is still considered an authoritative work.[19] In the mid-1930s, he was a young but experienced scientist, and the Tunguska meteorite interested him. When on scientific trips to the basins of the Lena and Angara rivers in the years 1930–1932, he visited 27 places where the Tunguska meteorite had been seen or heard and he questioned witnesses.

So, it was Whipple and Astapovich who almost simultaneously and independently began to study the recorded traces of the Tunguska explosion, which had been made in various parts of the world by seismographs and barographs. And in 1930 Francis Whipple published a paper that used this data to make the first estimate of the

magnitude of the Tunguska event. His estimate was 8 kt of TNT. Astapovich in 1933, using almost the same data, arrived at a much higher figure: 25 kt of TNT. Not to be outdone, Whipple revised his calculations and came up with an even higher figure: 50 kt of TNT. At the time the effects of so much TNT were unknown in the real world. Not until an atomic bomb exploded at the Alamogordo Test Range on July 16, 1945, providing the equivalent of 20 kt of TNT, could the effects of such explosive power be seen. A more reliable figure for the Tunguska explosion, calculated by specialists between the 1970s and the 1980s from better data and more precise theories, is 40–50 Mt of TNT. The most powerful hydrogen bomb ever tested on this planet had just this same TNT equivalent – 50 Mt. This explosion took place on October 30, 1961, on the Soviet testing ground of Novaya Zemlya. But in the 1930s the figures obtained looked sufficiently impressive, even though nobody then bothered to measure explosions in kilotons – or still less in megatons.

And what about Leonid Kulik? How did he respond to these findings? He did not respond at all. Certainly, Kulik was still in discussions about the problem of the Tunguska meteorite, but the results of these were only of interest to him as far as they confirmed his own opinion: there was a catastrophic event in the Siberian taiga accompanied by a powerful release of energy. Yes, the results obtained by Whipple and Astapovich strengthened somewhat Kulik's position, but they could hardly be considered crucially important. After his three expeditions, hardly anybody would doubt that "something did fall" in the taiga, even though that "something" had not as yet been excavated. So the skeptics became silent or more cautious when expressing their mistrust. As for Kulik, he understood well that the prospects of further expeditions were uncertain and therefore he temporarily turned to the search for and the examination of other meteorites, enriching the collection of the Mineralogical Museum. Being only slightly interested in theories, he was waiting until there would be a new opportunity to dig the taiga again. But of course Kulik did not forget about the enigmatic Tunguska space body and published articles on this subject from time to time.[20] And he never lost hope that it would become possible to fulfill a long-contemplated plan of taking aerial photographs of the Tunguska site.

Meanwhile, new catastrophic shock waves racked the country: collectivization, industrialization, and, the most terrible of all, the Great Terror of the years 1936–1938. In the 1920s, scientists in the USSR had enjoyed some freedom, but in the Great Terror it was time to stand to attention and be submissive. It is not difficult to understand that in these conditions the Academy of Sciences became less interested in extensive research work in the field of meteoritics. But science still existed and – believe it or not – moved forward. In 1934, by governmental order, the Academy moved to Moscow, closer to the Kremlin. The Mineralogical Museum, including Kulik himself, also moved and for two months, until they obtained a flat in Moscow, Kulik's family lived in his study in the museum, while Kulik slept on his own desk at night.

Soon after the academic institutions arrived in the capital, the Meteorite Department of the Mineralogical Museum was transformed into the Commission on Meteorites. Its academic ranking had definitely risen. Academician Alexander Fersman became Chairman, Vladimir Vernadsky Deputy Chairman, and Leonid Kulik its Learned Secretary. In 1939, the Commission was to become the Committee on Meteorites, headed by Vernadsky, and it would play an important part in postwar investigations of the Tunguska problem.

Eventually Kulik's dream of photographing the Tunguska site from the air seemed likely. And on March 14, 1937, the Presidium of the Academy of Sciences asked for this to be carried out. In May, Kulik arrived at Krasnoyarsk to a city flooded by water from the Yenisey. This delayed him for two months. Only in July when the flood had subsided did a hydroplane equipped with aerial cameras land at Krasnoyarsk. It then took Kulik to Vanavara where, trying to land on the Podkamennaya Tunguska River, the plane crashed. Kulik and his companions survived, but taking aerial photographs was no longer an option, although Kulik visited the Great Hollow before returning to Moscow. His plan to photograph the site had to be postponed yet again.

However, in July 1938 Kulik's persistence and determination were rewarded: a hydroplane was made available to take Kulik and his team to Kezhma, the old Russian village on the Angara River. During the whole of July, photographer S. V. Petrov took pictures that he and Kulik processed, identifying the photos and composing a

photographic map. July is perhaps the worst possible month for aerial photography. A riot of vegetation and leaves overshadowed the trunks of the trees felled in 1908. But the results were not bad. A year later, the journal *Reports of the USSR Academy of Sciences* published Kulik's paper: "Data on the Tunguska meteorite for the year 1939." Kulik wrote: "By assembling a mosaic it is possible to determine the initial point from where the main blast wave originated. This center coincides, not surprisingly, with the point that the author determined in 1928 by direct theodolite surveys of the leveled trees. As for additional separate explosions, we can see on the photo assembly two to four such points." (See Figures 3.8 and 3.9.) So Kulik's work showed the structure of the central zone of leveled forest to be very complicated, which meant that the Tunguska explosion had been remarkable for its intricacy. But these important details would only become understandable several decades later.

Regretfully, the priceless negatives of the aerial photographs taken at Tunguska in 1938 (1,500 negatives, each 18 × 18 cm) were burned in 1975 by order of Evgeny Krinov, then Chairman of the Committee on Meteorites. It was done under the pretext that they were a fire hazard, but the truth may have been the active dislike by official meteorite specialists of anything associated with an unyielding enigma. Fortunately, positive imprints were saved thanks to Nikolay Vasilyev, the leader of the Independent Tunguska Exploration Group (ITEG), and they are now at the Russian city of Tomsk, preserved for future studies that might provide new information about the Tunguska space body.

There was another expedition in 1939, the last in which Kulik participated. Its purpose was to link the aerial photographs to points on the ground. It was only moderately successful, but Kulik did not miss the opportunity to thoroughly drill the bed of the Southern swamp. No traces of a meteorite were found. Two years later, on June 22, 1941, Hitler invaded the Soviet Union. Kulik, who was already 57 years old, joined the people's volunteer corps and became a first sergeant of the field engineer company of the first battalion of the 1,312th regiment. The Presidium of the Academy of Sciences attempted to recall Kulik, but he refused to return to the home front. In a letter to his family, dated September 28, 1941, Leonid Kulik wrote: "A bivouac. Tents. Dugouts. The magnificent Milky Way

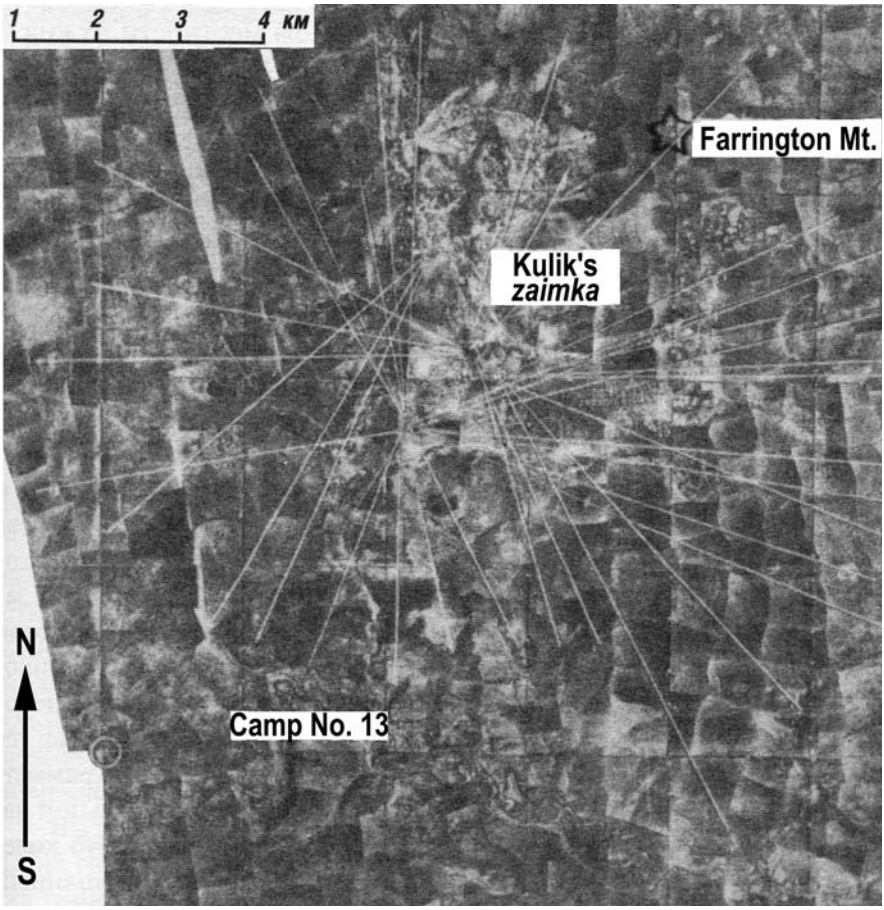

FIGURE 3.8. The photographic map of the epicentral zone of the Tunguska explosion composed by Dr. Leonid Kulik from the aerial photographs taken in July 1938. (*Source*: Krinov, E. L., *The Tunguska Meteorite*. Moscow: Academy of Sciences of the USSR, 1949, p. 155. The whole set of negatives was destroyed in the 1970s by order of Dr. Evgeny Krinov.).

over our heads. A dome of bright lambent jewels covers the Earth, and there flow among this inexpressible beauty the even light of the enormous golden Jupiter, dim leaden Saturn, and the ominous orange-red Mars; the latter leads the way: it rises earlier and stands for a longer time high in the sky, illuminating the lands seized by hurricanes and follies of the war, my poor country among them. . ."[21]

Eventually there was fighting, poorly armed volunteers against professional Nazi troops. The volunteers were encircled and captured.

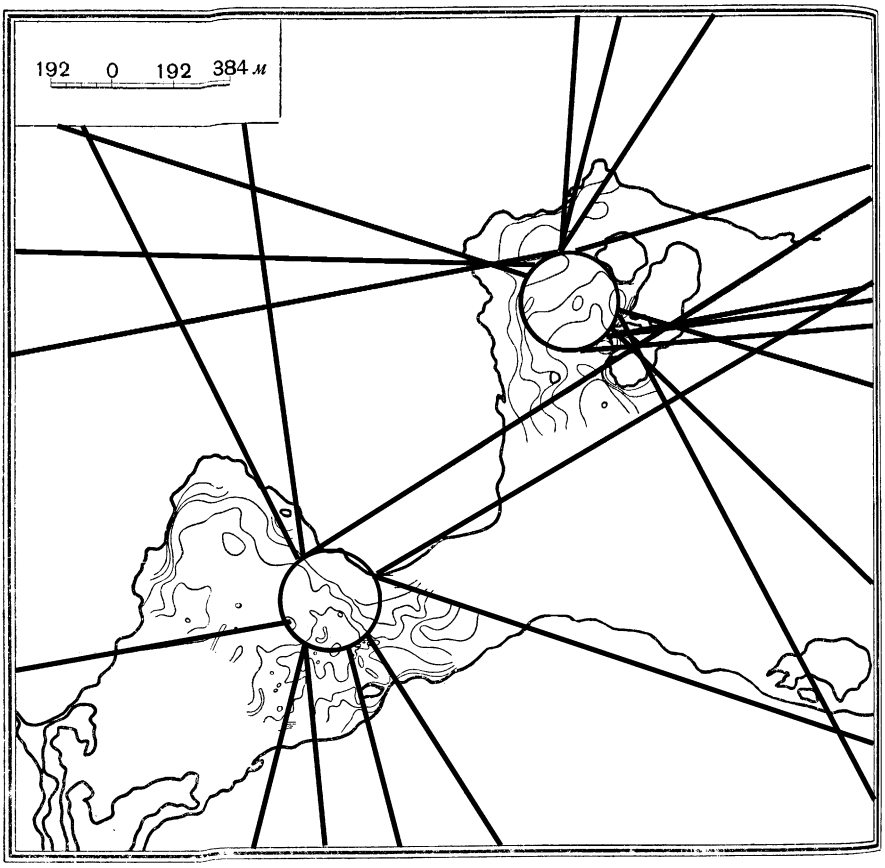

FIGURE 3.9. A drawing of the western half of the Southern swamp with two local epicenters – made by Dr. Leonid Kulik from the photographic map of the epicentral zone. Here two small fragments of the Tunguska space body seem to have exploded (*Source*: Krinov, E. L. *The Tunguska Meteorite*. Moscow: Academy of Sciences of the USSR, 1949, p. 146.).

Kulik was wounded in the leg and became a male nurse in a German concentration camp for Soviet prisoners of war, first in the village of Vskhody and then in the town of Spas-Demensk in the Smolensk Region. It was hellish work, and although his Siberian travels had hardened him he contracted typhus and died on April 14, 1942. By a miracle his grave in the town cemetery has remained intact.

Undeniably, Leonid Kulik's role in the early stages of Tunguska studies was all-important. Were it not for his enthusiasm, which verged on fanaticism, the Tunguska meteorite mystery might have been forgotten forever in the 1920s. Kulik's energies and aspiration

for truth overcame his opponents and established the most essential facts about this event. Leonid Kulik made four crucial discoveries:

First, the radially leveled forest.
Second, the zone of branchless "telegraph trees" standing at the center of the leveled forest.
Third, the "unusual burn" covering trees that both perished and survived the catastrophe of 1908.
Fourth, that there were no fragments of a meteorite to be found anywhere at the site.

But ironically the meteorite that Leonid Kulik did not find has become his most important discovery. This is not a play on words. This is a fact. In the next chapter we will have an opportunity to see why.

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