8. Significant Details for the Big Picture

In the last chapters we considered three large keys to unlock the Tunguska mystery – the "mechanical," "thermal," and "magnetic." And now we must look at five smaller keys discovered in the course of Tunguska investigations. Practically every time such a new key emerged, the investigators were highly surprised. These are the supposed material remnants of the Tunguska space body (TSB): the "material" key, the "botanic" key (the superfast restoration of the Tunguska forest), and the "genetic" key (mutations in trees and other living things). But also there are fluctuations of radioactivity (the "radioactive" key), and last but not least, evidence of the ionizing radiation that had probably affected the Tunguska soil in 1908 (the "thermoluminescent" key).

Although the word "large" is a synonym of "primary" and "important," the word "smaller" does not necessarily mean "unessential" or "secondary." Quite the contrary, the first trace from the group of "smaller Tunguska traces" – possible material remnants of the TSB – is probably the most important of all potential traces of this enigmatic event. Factually, it is only these remnants that may be called its direct trace; any other piece of evidence, even one so massive as the radially leveled forest over an area of 2,150 km^2, is only indirectly connected with the TSB.

Professor Nikolay Vasilyev, when summing up the experience of his 40-year Tunguska studies, said: "The main paradox of the current situation is that no cosmic substance has been found as yet that could be reliably identified as the substance of the Tunguska meteorite."[1] Does it mean that this substance had mysteriously left our world, and we should give up all attempts to retrieve it? Of course not. In this case, we would simply have abandoned any hope of solving the Tunguska problem. Indirect traces, even important and informative, can at best outline a border between the possible and impossible, rather than give the final answer to the question of the nature of the Tunguska phenomenon. To find out

V. Rubtsov, *The Tunguska Mystery*, Astronomers' Universe,
DOI 10.1007/978-0-387-76574-7_8, © Springer Science+Business Media, LLC 2009

what was the nature and origin of the TSB, we must find its material remnants; otherwise this mystery will remain unsolved forever.

It's a pity that neither spacecraft debris nor meteorite pieces have been found, despite long and intensive searching. Why? Did the Tunguska researchers use methods that were not sufficiently sensitive? As Professor Vasilyev has written, several varieties of space dust that continually fall onto Earth's surface have been discovered. Of course, if these methods were sensitive enough to find traces of dust from space they should have been good enough to discover remnants of a huge space body dispersed in the soil and peat.[2] Does it mean therefore that there are none?

Tunguska researchers have always believed that the TSB substance is still preserved somewhere in the taiga and may be found. The only exception is probably Lincoln La Paz and his antimatter hypothesis, according to which the Tunguska meteorite was completely annihilated in the terrestrial atmosphere. But this is an extreme viewpoint. A piece of antimatter would hardly have penetrated Earth's atmosphere so deeply – it would have been annihilated at a higher altitude. Also, as astronomer Vitaly Bronshten has demonstrated, small bodies of antimatter could not even traverse the Solar System without being destroyed when interacting with interplanetary gas.[3]

Of course, specialists in meteoritics looked for more normal matter. First, they tried to find in the Great Hollow large pieces of meteoritic iron (Leonid Kulik) and then small metallic spherules (Kirill Florensky). Leonid Kulik was absolutely sure that the TSB had consisted of nickelous iron, which was perfectly reasonable because all large meteorites found on Earth's surface are blocks of iron. The largest known mass of cosmic iron, the Hoba meteorite that landed near Grootfontein in northern Namibia, weighs about 60 tons. It collided with Earth approximately 80,000 years ago.

Some researchers used to speak ironically about Leonid Kulik's bent for the iron-meteorite model of the TSB, but in fact he knew well that other types of meteorites had little if any chance to reach Earth's surface. Stony meteorites are split into many pieces in the upper layers of the atmosphere and their small pieces could not have produced such devastation in the taiga. But not every rational hypothesis in science turns out to be correct. Yet even though Kulik had failed in his search, Florensky became certain that the metallic spherules found in the taiga in 1961 were the TSB substance. At least, so he said.

In the early years of the space era one could assume that the main mass of a large piece of cosmic iron would burn up during its flight through the atmosphere. The laws of such flights had been scantily investigated. But specialists soon proved that an iron meteorite would leave a pronounced trace in the soil. So given that the TSB was an iron meteorite, about 90% of its mass would have fallen at the central area of the Great Hollow and only 10% would have dissipated in the upper layers of the atmosphere.[4]

The ITEG tried every way to find the TSB substance, and some spherules of meteoritic iron were found. But to prove or disprove that these spherules have something to do with the TSB, they had to be reliably dated. It was the Siberian botanist Yury Lvov (1932–1994) who saw how this could be done simply and effectively. One of various mosses that grow on Siberian peat bogs is the so-called golden sphagnum. This plant has two characteristics that proved to be very useful for Tunguska studies. First, it obtains mineral nutrition not from the soil but from atmospheric substances, absorbing fine particles including falling space dust. It also grows at a steady rate, making it possible to determine the age of its yearly layers with high precision. Consequently, a vertical column of peat shows the past history of space dust falls for many tens and sometimes hundreds of years.

Lvov's method had been tested on peat bogs both in Siberia and in European Russia. Everywhere it proved to be effective and could therefore be used at Tunguska, although technically it turned out not to be that easy. Since outside the taiga the samples collected could have been contaminated with industrial dust, this research was being carried out in a forest. Among all research programs carried out by the ITEG, the "Peat" program was probably the most laborious. Samples have been dug up over an area of more than 14,000 km^2, the number of peat columns exceeding 1,000. The peat layers were burned in a muffle furnace and exposed to strong acids. What remained was scanned by a microscope in the search for fused microscopic spherules.[5]

Both silicate and metallic spherules, some 100 microns in diameter, were discovered in the peat, including the layer dated 1908. Significantly, in several places the number of spherules in the 1908 layer was much greater than in the lower and upper peat layers. But strangely enough, the concentration of the particles extracted from Tunguska soil and peat did not match other traces of the catastrophe of 1908, such as the borders of the area of leveled forest, or the light burn, or the direction of the TSB flight before the explosion. But if this dust had had anything to do with the TSB, this association would have been practically inevitable. And besides, the number of these spherules was simply too small even for a comet core, to say nothing of a huge stony meteorite. When extrapolating the data obtained, the overall mass of space matter spread over the Great Hollow in 1908 was somewhere between 200 kilograms and one ton. But, according to the well-justified estimation of Academician Vasily Fesenkov, the mass of the hypothetical Tunguska comet could not have been less than a million tons. A powerful explosion of the comet core entering Earth's atmosphere could have happened only if both its mass and its velocity had been very considerable. And now – 200 kg... Strange indeed. So most probably the main part of these microscopic spherules was due to the usual background fall of extraterrestrial matter.

Well, the *main* part, perhaps. But does it mean that there is among this space dust not a single microscopic particle of the Tunguska body? Deposits of usual microscopic space dust cover the surface of our planet unevenly, as do the radioactive fallouts after nuclear explosions in the atmosphere. By analogy, one can assume that after the Tunguska explosion there must have formed on the surface a patchy structure, within which there may be found spots more or less enriched with the TSB substance. Therefore, the researcher must not be nervous of different results of analyses even in two neighboring places. Statistical data are definitely important, but information obtained at some specific points may also hint at the nature of the Tunguska "meteorite."

True, at first the patchy character of the fall of space dust had somewhat embarrassed Tunguska researchers. But experienced radiochemists (i.e., specialists in the chemistry of radioactive materials) Sokrat Golenetsky and Vitaly Stepanok, who worked on the Tunguska problem together with Alexey Zolotov at a geophysical institute in the Russian city of Tver, succeeded in transforming the patchy character of cosmic matter into a new opportunity. If the cosmic matter is distributed over the Great Hollow nonuniformly, let's look for individual locations contaminated by the TSB substance. "Empty" columns of peat or soil may safely be ignored, whereas "rich" columns should be studied in detail.

If in addition to the very powerful and high-altitude main explosion, there were at Tunguska several more low-altitude explosions, then some places of the Great Hollow could be contaminated by the TSB substance.[6] Of course, the microscopic silicate spherules were too few to be considered as the main mass of the Tunguska comet. (Golenetsky and Stepanok generally shared the cometary hypothesis to explain the TSB.) However, a great part of its substance could have been dispersed in the air as an aerosol or simply vaporized. That is why attention had to be concentrated on the anomalies in the elements in the soil and peat, not on the spherules.

Even though they supported the cometary hypothesis, Golenetsky and Stepanok knew that it would have been premature to consider this as the final solution of the Tunguska problem. Aerial photographs taken by Leonid Kulik in 1938 demonstrated that there were in the Great Hollow several local centers of forest leveling. So the soil and peat in these centers might be enriched with the TSB substance, and finding it could help to solve the Tunguska problem. Sokrat Golenetsky had personally collected in one of these centers – near the Suslov's crater – samples of moss and peat from various depths. Two other columns of peat were taken at some distance from this place. As it turned out, in the "catastrophic" layer (dated 1908) and the neighboring peat layers of Column 1, concentration of certain chemical elements, such as sodium, potassium, chromium, zinc, bromine, rubidium, barium, mercury, and gold, was unusually high. High concentrations of zinc (an element of limited occurrence in meteorites), bromine, gold, and mercury looked very enigmatic, especially that of mercury – since when the peat was ashed for investigation, this element must have actively evaporated and therefore its *initial* concentration must have been still higher.

Two other peat columns did not demonstrate evident anomalies. The "patchy pattern" of the cosmic matter falls showed itself once again, but judging from the first peat column the composition of the TSB substance seemed to differ radically from all known types of iron or stony meteorites. What alternative might have been found? Perhaps a comet core, but first Golenetsky and Stepanok put forward a more original idea: it was an archaic space body, older than usual comets and carbonaceous chondrites, which had survived until now from an early epoch of the Solar System's formation.[7] To erect a new astronomical hypothesis on the basis of a single column of Siberian peat would be, according to all scientific standards, more than risky, and Alexey Zolotov expressed his negative opinion on this hypothesis very bluntly. One cannot say his criticism was unjustified. But the creativeness of Golenetsky and Stepanok does deserve respect.

This author happened to be a witness, if not a participant, of this dispute. It was hot indeed and, as sometimes happens in scholarly discussions, it soon went beyond a peaceful talk. Sokrat Golenetsky broke off friendly relations with Alexey Zolotov and left Tver. Subsequently he worked hard in the Chernobyl zone, examining the consequences of the greatest nuclear energy disaster in history, which probably precipitated his untimely death in 1996. But until the very last days of his life, Golenetsky remained active in Tunguska studies. With time, both his and Stepanok's positions in the Tunguska problem shifted from an archaic space body from the protoplanet cloud to a normal comet core. It was their research results that drew the attention of Dr. Evgeny Kolesnikov, a geochemist at Moscow University, and gave him the idea to check their validity, applying more sophisticated analytical methods.

At first, Kolesnikov verified that in the Tunguska peat layer dated 1908 concentrations of sodium, zinc, gold, and some other elements had really been increased. That is, Golenetsky and Stepanok were right. He also found that the concentration of iridium (a very hard and dense metal from the platinum group) in the 1908 layer was abnormally high. Iridium is very rare on Earth's surface but relatively common in meteorites. And having analyzed his data, Evgeny Kolesnikov concluded that the TSB had been a comet's core.[8]

Unfortunately, attempts to verify his conclusion when looking for traces of the Tunguska-related iridium anomaly in Antarctica and Greenland failed.[9] Yet, if a giant stony meteorite or a comet core had disintegrated over central Siberia in 1908, noticeable quantities of this metal must have remained in the pure ice of these distant regions of our planet. A deadlock? But are the soil and peat the sole possible repositories of microscopic TSB remnants? What else could harbor significant evidence?

Trees, of course! Since they were standing in the Great Hollow in 1908, scattered particles of the enigmatic space body could remain in them, too. Although it would be difficult to determine the age of those particles that have stuck in tree trunks and branches, there still remains tree resin. In the early 1990s specialists from Bologna University took resin samples in the central area of the Great Hollow to examine in Italy.[10] With a scanning electron microscope (in which the surface of a sample is scanned by a beam of electrons that are reflected to form an image) they found in separate layers of the resin a number of microscopic particles and determined their chemical composition. The Italian scientists examined more than 7,000 particles, each a few microns across. And they also found the same chemical elements that had been discovered by Golenetsky, Stepanok, and Kolesnikov in Tunguska peat. In particular (and especially), these included copper, zinc, gold, barium, and titanium. But also there were calcium, iron, silicon, and nickel. The Italian scientists paid their main attention to the latter group of elements. From the data they decided that these microscopic remnants were the remains of a small stony asteroid.

The final answer? Not yet, alas. It so happened that the Tunguska catastrophe occurred between major eruptions of two volcanoes: Ksudach on Kamchatka in 1907 and Katmai on the Aleutian Islands in 1912. These eruptions ejected into the atmosphere an enormous mass of volcanic ash. Early in 1908 Ksudach's ash fell even on Germany.[11] Consequently, as the resin layers containing enigmatic microscopic particles in Tunguska trees can be dated with an accuracy of 2–3 years, how can we be sure that these particles got there in 1908? Also, in 1980, Professor Claude Boutron of the Laboratory of Glaciology of the French National Center of Scientific Research discovered volcanic ash in Antarctic ice dated 1912 whose composition is very similar to that of particles found in the resin of Tunguska trees by the specialists from Bologna University. Whether the particles discovered by the Italian scientists were due to the Tunguska explosion or to the two volcanic eruptions remains unknown.[12]

The most systematic search for elemental anomalies in Tunguska soils and peats has been conducted by the ITEG people. It was after the ITEG-1 expedition of 1959 that the chemical composition of the samples taken at Tunguska was studied for the first time. The researchers had expected to find the usual meteoritic elements of iron, nickel, and cobalt. Instead, the spectral analysis demonstrated an increased concentration of some rare earths (lanthanum, ytterbium, cerium, and yttrium, which are designated in chemistry as lanthanides – from lanthanum, the first element of this series).[13] The concentration of such rare earth metals exceeded the norm by tens and even hundreds of times. Soon it turned out that the samples enriched by rare earths are found only around the epicenter and in the northwestern direction from it.[14] This chemical anomaly was spread through soils, plants, and peat, having a peak in the peat stratum dated 1908. So the TSB might have been composed of lanthanides.

Nevertheless, to avoid possible errors and to prove this supposition statistically, the ITEG started a special research program. It was necessary to find out if the rare earth anomaly was not connected with geochemical peculiarities of the region. The main attention was paid to the area lying in the west-northwestern direction from the epicenter, where, as John Anfinogenov had supposed, remnants of the TSB might have fallen. To carry out this work, members of an ITEG expedition cut a straight path 12 km in length through the taiga, running from the epicenter to the west-northwest through a peat bog that was subsequently named "Lvov's bog" after Dr. Yury Lvov. In the 1980s, having examined this place in detail, Lvov's pupil Emelyan Muldiyarov found that before the Tunguska explosion there had been at this place a normal forest, not a bog. This appears to be *the only place* at Tunguska where the landscape had changed drastically after the catastrophe. As such, it was definitely worth the researchers' special attention.

In an area 12 km long and 6 km wide, they took some 1,300 samples of soil and peat. After drying, milling, and sifting them, these samples were spectrally analyzed at a geological institute in Novosibirsk that was engaged in uranium ore prospecting and other nuclear-related work. Their measuring equipment, run by specialist Lidia Ilyina, could reliably determine the presence of 50 chemical elements, and from these they found 30 elements, including rare earths. And Ilyina noticed an astonishing fact: in some samples concentrations of yttrium and ytterbium were very close. In other samples there was plenty of ytterbium and no yttrium. But from the geological point of view this was simply impossible. In terrestrial rocks and minerals these two elements are inseparable, and the content of yttrium always exceeds the content of ytterbium by a factor of 10. As was mentioned above, meteorite specialists were not interested in rare earths, since these elements are far from typical for meteorites and comet cores.

Besides, this geochemical anomaly at Tunguska was not easily noticeable. But the ITEG included not only geologists and meteor specialists but also radio physicists. And one of the most important tasks that are solved by specialists in radiolocation is detecting a signal whose peak value is considerably lower than the level of the background noise. Radio physicists have developed sophisticated methods for extracting such signals from a chaos of radio waves. Dr. Dmitry Demin used this approach in Tunguska studies to create a special statistical method aimed at the search for "hidden anomalies" veiled by the surrounding "noise." Components of the TSB were considered as the "signal" and mundane chemical elements inherent in the soils and peats of the Great Hollow as the "noise."

To prove the strength of this method, ITEG researchers experimented with a simulated hidden anomaly. They took a map of nickel distribution in the Great Hollow and increased the figures, as if adding to the whole area 10 tons of this metal. An iron meteorite weighing just 100 tons (or a stony one weighing 1,000 tons) that had disintegrated over this area would have contained such an amount of nickel. At first glance nothing in the distribution of nickel in this area changed, but when the figures were processed on a computer the simulated anomaly was immediately detected.[15]

Having proved the effectiveness of Demin's method, it became possible to look for real hidden anomalies of distribution of chemical elements in the Great Hollow. If some element had showed a peculiar distribution associated with the epicenter or a probable TSB trajectory, this would have meant it had been part of the TSB. And after processing the results of the spectral analysis, the researchers obtained a significant result. They found that the maximum of ytterbium concentration was at a point near Ostraya Mountain where, according to John Anfinogenov, the remnants of the TSB must have reached Earth's surface. And the minimum of ytterbium fell on the "epifast," that is, the epicenter of the Tunguska explosion determined by Wilhelm Fast. Also, the straight line connecting these two points coincided with the first TSB trajectory calculated by Fast (see Figure 8.1.)

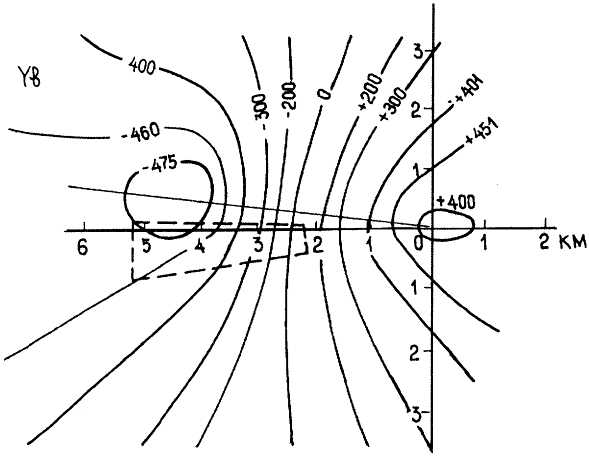

FIGURE 8.1. Pattern of ytterbium distribution at Tunguska following the projection of the TSB trajectory on the Great Hollow (*Source*: Zhuravlev, V. K., and Zigel, F. Y. *The Tunguska Miracle: History of Investigations of the Tunguska Meteorite*. Ekaterinburg: Basko, 1998, p. 110.).

Patterns of similar shapes have been formed in the Great Hollow for the surface distributions of lead, silver, and manganese, but for iron, nickel, cobalt, and chromium, the patterns of their distribution had no association with any special points or directions of the area of the leveled forest. These elements were therefore just natural components of the soil and rocks.

Here again the "negative" result seems almost more interesting that the "positive" one: calling a spade a spade (or, in Russian, calling a cat a cat), we should conclude that *typical meteoritic elements – iron, nickel, cobalt – have nothing to do with the Tunguska space body*.

But the "positive" result from this research is also worth attention. As the Siberian scientists state, from the 30 chemical elements discovered in the soils and peats of Tunguska, it is first of all ytterbium that can be reliably associated with the TSB. Also, possibly lanthanum, lead, silver, and manganese.[16] Certainly, with this composition, it could have been neither a meteorite nor a comet core.

Besides, let us not forget about the enigma of the rare earths' *ratio*. It looks very puzzling. Geochemists and geologists are well aware that in the presence of lanthanum there have to be cerium, neodymium, praseodymium, and other members of this family.

What is more, mutual ratios of their concentrations in rocks are fairly stable, fluctuating insignificantly. Not so at Tunguska.

In the 1980s, Dr. Sergey Dozmorov, a specialist in the chemistry of rare earths, who ran a chemical laboratory at a research institute in the Siberian city of Omsk, became interested in this enigma. He tested samples of soil, taken near Ostraya Mountain, for the presence of all lanthanides, not only of lanthanum, cerium, and ytterbium. Dozmorov discovered that, apart from ytterbium, these samples were enriched by thulium, europium, and terbium as well (these are also rare earth elements). And their ratio had been sharply disrupted. The contents of terbium exceeded the norm by 55 times, that of thulium by 130 times, that of europium by 150 times, and that of ytterbium by 800 times. Such things never happen in nature – only in special alloys. Even being a cautious scientist, and not a sensation-seeking journalist, Sergey Dozmorov had to conclude that:

> Together with the known data on the above-average barium content in the area of the Tunguska explosion, the results obtained may favor the most unusual composition for the TSB, namely the presence in the TSB of some systems that contained a superconducting high-temperature ceramic made on the basis of a combination of barium – a lanthanide – and copper. Such a ceramic keeps superconductivity up to the temperature of liquid nitrogen (–196°C) and can be used for constructing effective energy and information storage devices. Obviously, such a substance cannot be natural.[17]

Dozmorov was planning to continue and develop his research, but soon after obtaining this striking result he perished at night in his laboratory. Police investigators, who looked into this case, concluded that it was just an accident. Somehow the experienced chemist was poisoned by a toxic chemical compound. Such things happen. At that moment Sergey Dozmorov was 36 years old and was one of the leading Russian specialists in rare earth elements.

However, after this fatal accident the ITEG people did not give up. They continued to investigate the rare earths at Tunguska. During the expedition of 2001 a team guided by Dr. Victor Zhuravlev took from Lvov's bog a large column of peat. In Novosibirsk the samples were spectrally analyzed in three independent laboratories and it was found again that concentrations of some lanthanides (ytterbium, lanthanum, and yttrium) were considerably higher than normal.

Then the peat was examined through optical and electron microscopes, and Dr. Leonid Agafonov at the Institute of Geology of the Russian Academy of Sciences noticed several metallic particles that were, according to him, definitely artificial (see Figure 8.2). It was for the first time in the history of Tunguska investigations that someone had discovered microscopic artifacts in the peat layer dated 1908. And these are definitely not small pieces of Evenk teapots.

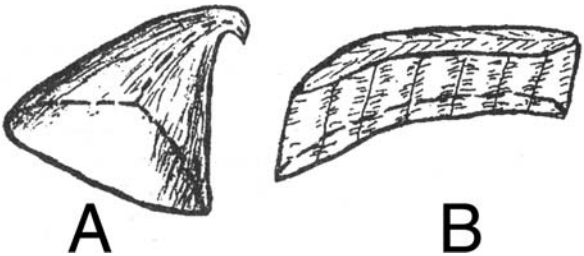

FIGURE 8.2. Peculiar microscopic artifacts discovered by Dr. Leonid Agafonov at the Institute of Geology of the Russian Academy of Sciences in the Tunguska peat layer dated 1908. The small trihedral pyramid **A** consists of pure titanium; the "shaving" **B** of aluminum (*Source*: Zhuravlev, V. K., Agafonov, L. V. Mineralogical and geochemical examination of the samples of soils taken in the area of the Tuguska bolide's disintegration. – *The Tunguska Phenomenon: Multifariousness of the Problem*. Novosibirsk: Agros, 2008, p. 151.).

The particles were curiously shaped and had an unusual chemical composition. There was a small trihedral pyramid with an edge of one-fourth of a millimeter consisting of pure titanium with some quantity of rhodium (a noble metal from the platinum group). A second particle looked like a bent microscopic plate (a "shaving") of about 250 microns in length. It consisted of aluminum with slight manganese and copper impurities. There were also found in these samples two small flattened balls of pure gold. As Dr. Zhuravlev noted in 2008, "We should not jump to conclusions from these findings. Yet we can probably hope to find in this area, near Ostraya Mountain, a larger remnant of the Tunguska space body. There seems to be at this area a 'geochemical halo' surrounding the place of its fall."[18]

In recent decades, Tunguska researchers have suggested as possible chemical constituents of the TSB a lot of various elements. These were aluminum, barium, bromine, calcium, carbon, cesium, cobalt, copper, gold, hafnium, iron, lanthanides (ytterbium, lanthanum, samarium, europium, thulium, terbium, cerium, dysprosium, gadolinium), lead, manganese, mercury, molybdenum, nickel, rubidium, silicon, silver, sodium, strontium, tantalum, tin, titanium, tungsten, zinc, and zirconium. A long list indeed! But only five elements in it – ytterbium, lanthanum, lead, silver, and manganese – have patterns of distribution in Tunguska soils and peats that follow the projection of the TSB trajectory on the Great Hollow, and only ytterbium follows this path strongly enough to be considered as the most probable main ingredient of the TSB substance.

An amazing outcome, one should note. In fact, there is nothing special in this chemical element ytterbium. This soft silvery-white rare earth metal, discovered in 1878, has at present very limited technical applications: it is used mainly for improving the hardness of stainless steel as well as in making high-power lasers. In the Solar System its occurrence is much rarer than in Earth's crust.

With such a peculiar composition, far from typical for normal meteorites, it is hardly surprising that the spectrum of theoretical interpretations of this data is so broad. Sokrat Golenetsky and Vitaly Stepanok saw in the TSB an archaic space body from an early epoch of the Solar System's formation, whereas Evgeny Kolesnikov believes it was a comet, and Giuseppe Longo and Menotti Galli consider it a stony asteroid. Each time these conclusions were well justified. Let's not forget, however, that the main elements, constituting all normal small cosmic bodies – iron, nickel, and cobalt – although discovered at Tunguska, do not display any correlations with the structure of the leveled forest area. This is curious indeed, since such correlations *must* have existed – *if* the TSB was such an ordinary space object. And if its chief chemical component was ytterbium, the nature of the TSB becomes still more incomprehensible. As far as we can judge, there are no known small space bodies in the Solar System consisting mainly of this element.

Let's remember that "ballistic" calculations, considered in Chapter 6, have also led to three equally well-justified hypotheses about the nature of the TSB: a comet, a stony asteroid, and an unknown space body. It seems that the "material" key to the gate of the Tunguska fortress turns freely in the same three directions, not stopping anywhere... What a maze! So where should we look for an exit from it? Probably it would be reasonable to pay attention to some other traces of the Tunguska phenomenon, rather biological than chemical, but also having a close relation to the question of the composition of the TSB.

Some years ago, Academician Nikolay Vasilyev, together with botanist Lyudmila Kukharskaya, tried to find out whether a watery extract from Tunguska soils, taken near the epicenter, would influence the process of the sprouting of pine and wheat seeds. It did influence them – and very positively, stimulating their germination. And what is more, it turned out that of all 35 chemical elements discovered in the Tunguska soil, only rare earths – lanthanum, ytterbium, and yttrium – had this "stimulating property."[19] Why is this so important? Because there exists one more enigma of Tunguska – the unusually fast restoration of the area in the aftermath of the catastrophe.

This mysterious phenomenon was discovered during the first academic expedition to Tunguska after World War II – in 1958, by Dr. Yury Emelyanov. Together with Dr. Valery Nekrasov, he examined the region thoroughly. Especially strange seemed the fact that even old trees, which had been burned by the light flash and seriously injured by the blast wave of the Tunguska explosion, did also accelerate their growth. From the viewpoint of forestry science this was incomprehensible. Even mosses in open marshy terrains started to grow much faster after 1908. Emelyanov and Nekrasov eventually concluded that this effect could not be explained by the improvement of environmental conditions for those trees that had survived the Tunguska catastrophe. Rather, it must have had to do with some stimulating substance that had dispersed over the Great Hollow after TSB's disintegration.

Why did scientists put forward this idea? First, because the boundary of the area of the superfast forest restoration was completely different from the boundaries of the zones of the wood fire and leveled trees (see Figure 8.3). The blast wave of the Tunguska explosion caused the major devastation in the southwestern and northeastern sectors of the Great Hollow, whereas trees grow unusually fast mainly in the opposite sectors – located to the northwest and southeast from the epicenter.[20] If this effect had had any relation to the ash fertilizers from incinerated vegetation or better light conditions in the devastated area, this certainly could not have happened. Besides, the axis of symmetry of the zone of the superfast forest restoration runs from the south-east to the north-west – coinciding with

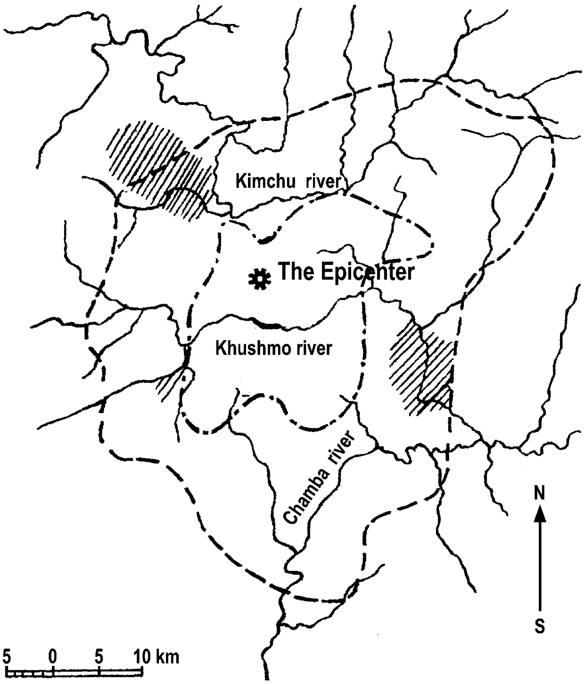

FIGURE 8.3. The hatched spots designate the areas in which trees, burned by the light flash and injured by the blast wave of the Tunguska explosion, grew at an abnormally fast rate (up to 36 times). This effect is incomprehensible from the viewpoint of forest science (*Source*: Vasilyev, N. V. *The Tunguska Meteorite: A Space Phenomenon of the Summer of 1908.* Moscow: Russkaya Panorama, 2004, p. 197.).

the "first TSB trajectory" determined by Wilhelm Fast. It is "under the trajectory" that this effect is most prominent. Here, before the catastrophe, diameters of larches had increased at about half a millimeter per year, whereas after this event, their average annual growth rate increased by an amazing 36 times than what was normal, reaching almost 2 cm (see Figure 8.4).

It is remarkable that there are near the epicenter some fairly large groves of pines and larches that have no signs of thermal burn or leveling. And these trees also grew abnormally fast after 1908. However, between the Kimchu and Moleshko rivers, where the forest was felled by the blast wave, no unusually swift wood restoration has been discovered. And finally, the scale of this effect goes far

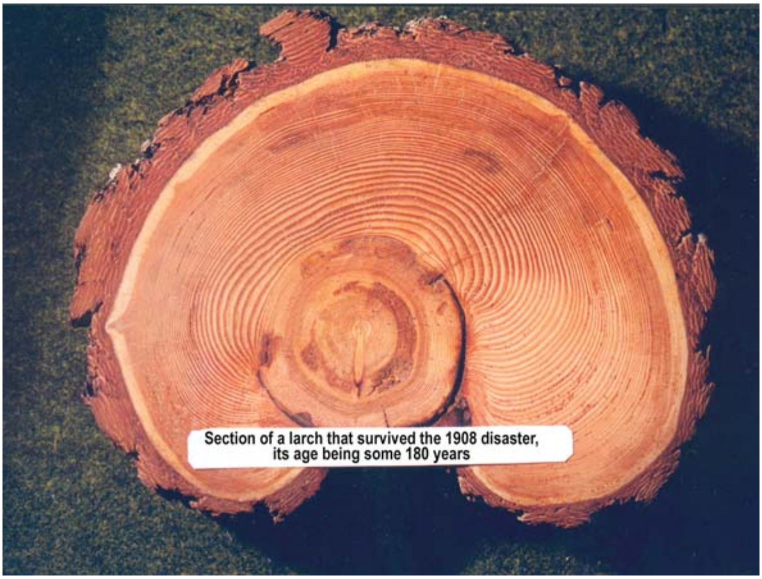

FIGURE 8.4. A section of a larch that survived the 1908 disaster. Its rings after 1908 are noticeably wider than before (*Credit*: Vitaly Romeyko, Moscow, Russia.).

beyond the limits known to specialists in forestry. This is the *only* case when a forest suddenly began to grow so fast.

All these facts demonstrate that neither the forest leveling (that led to better light conditions in the taiga) nor the usual after-catastrophe fertilizers (wood ash) had anything to do with this enigmatic effect. Of course, they could contribute to it, but definitely they were not its main cause. But if the soil enrichment and more light may have only an indirect relation to this effect, what was its main cause? Which stimulant could affect so strongly the quality of the Tunguska trees?

Sokrat Golenetsky and Vitaly Stepanok thought it was cometary or "protoplanetary" substances that had fallen in the Great Hollow and enriched the soil with some microelements that turned out to be effective fertilizers.[21] To verify their hypothesis, they made a compound that reflected their ideas of the TSB's composition and conducted a series of experiments at the Research Institute of Land Reclamation, giving a top dressing of this compound to meadow grass, potatoes, and flax. They carried out the experiments in full accordance with the requirements of agronomy and achieved interesting results. The yield of potatoes rose by 30% and that of meadow grass by 20%. Good, but far from the growth acceleration by 36 times as occurred at Tunguska. Let's recall that before the Tunguska catastrophe the average width of the annual rings was only 0.2 mm, whereas after the explosion it reached in some places of the Great Hollow 1.8 cm.[22] Then, perhaps is what we have here a genetic mutation?

Golenetsky and Stepanok have waved the matter of mutations aside with some flippancy. "Attempts to explain the effect of superfast forest restoration by genetic mutations, allegedly produced by the 'hard radiation of the explosion,'" they wrote, "cannot be accepted seriously since all 'nuclear' hypotheses of the Tunguska explosion have been completely refuted."[23] This statement seems more emotional than rational, owing to the quarrel between Sokrat Golenetsky and Alexey Zolotov over the cosmochemical constructions built by Golenetsky on the foundation of one peat column, taken near the Suslov's crater. Both Golenetsky and Stepanok, as clever people and experienced specialists, were to understand that declaring the nuclear hypothesis "completely refuted" was an exaggeration. Besides, as we will see, genetic mutations at Tunguska do occur. This question has been studied by specialists for a long time and their final conclusion was in fact positive. Therefore, the abnormally fast restoration of the taiga could also be a genetic phenomenon.

But first, let us start from a basic question: what is mutation? In terms of modern genetics, a mutation is a change in a gene that alters the genetic message carried by that gene. Mutations may be lethal (resulting in a swift elimination of their carriers) or neutral (not affecting the further lot of living organisms). There are also point mutations that cause slight alterations of an organism's outer appearance, behavior, and so on. It is the point mutations that are the driving mechanism for changes by natural selection, which can lead to biological progress.

It was as far back as the early 1960s when the Commander of the Independent Tunguska Exploration Group, Gennady Plekhanov, understanding that an atomic explosion would have left too feeble radioactive traces to be detected after 50 years, attempted to find evidence in an indirect way. The hypothetical Tunguska radionuclides could have already decayed, but results of their influence on local plants might be preserved. Then at the Research Institute of Cytology and Genetics of the Siberian Branch of the USSR's Academy of Sciences, a group of scientists carried out experiments in which pine seeds were exposed to gamma radiation. Normally, a needle cluster of Siberian pine consists of two needles only. However, when a pine tree grows from a seed subjected to a small dose of gamma rays, there appear a considerable number of three-needle clusters. Plekhanov therefore decided to look for a similar effect at Tunguska – and he discovered it! Pines with three needles in a cluster did occur more often near the Southern swamp, their number diminishing with distance from the epicenter of the Tunguska explosion. And the maximum number of pines with three needles in a cluster was found to be where there was the maximum amount of ytterbium on Ostraya Mountain. Also the second maximum was on the canyon where the Churgim Creek flows, where in 1927 Leonid Kulik had set up a camp of his first expedition to Tunguska. Subsequently, these findings have been corroborated by several expeditions organized by the ITEG, and a catalog of 5,000 entries of such pines has been compiled.

Does this mean that we are dealing here with some sort of mutation? Opponents of the nuclear hypothesis point to the fact that the same effect occurs after usual forest fires – which did happen at Tunguska. Generally, they are right. The percentage of three-needle clusters in pines may increase due to both causes – "ecological" (occurring after forest fires) and "mutational" (as, say, occurred in the zone of the Chernobyl disaster). Yet these causes can be reliably differentiated: the "mutational" effect is more intensive than the "ecological" one. At Tunguska its scale greatly exceeds usual "ecological" figures. For example, at the epicenter were found several pines with an unbelievably powerful anomaly: more than half of all clusters on these trees turned out to have three needles.

But the strongest evidence that the three-needle clusters in Tunguska pines are due to a genetic mutation is their inheritability. This effect does exist in pines that are the second and third generations of the trees grown in the taiga after the catastrophe. And it is only genetic mutations that may be inherited.

There also exists at Tunguska another genetic effect – discovered by Academician Victor Dragavtsev, who mathematically processed the data collected by ITEG scientists… Any living thing belonging to the same species has, naturally enough, like traits: say pine trees of the same age grow at comparable rates. Comparable, but not identical. In fact, these rates fluctuate around an average figure, these fluctuations depending first on individual hereditary characteristics of the trees and second on environmental conditions in which they are growing. In other words, the trait dispersion consists of two components: innate and acquired. To find out which of these two components we are dealing with is not that easy, but geneticists have developed mathematical methods that make it possible to discriminate between them. Early in the 1970s Victor Dragavtsev, then a scientific worker of the Institute of Cytology and Genetics in Novosibirsk and later the director of the largest genetic bank in the world – the N. I. Vavilov Institute of Plant-Growing in St. Petersburg – proposed a new mathematical method to perform this task.[24] Having taken an interest in the Tunguska problem he paid attention to the data accumulated in the above-mentioned catalog of 5,000 Tunguska pines. When examining the pines, the ITEG scientists measured 20 parameters of each tree, including their yearly growth rates. Dragavtsev decided to use these data for further processing with the help of his method.[25]

His main conclusion was that over an area of about 200 km^2 the frequency of genetic mutations increased by a factor of 12 over what is normal. The unknown agent promoting these mutations acted on this territory 10 times more effectively than gamma rays in control experiments. Again, the two peaks of the Dragavtsev effect fall on the Ostraya Mountain and the Churgim Canyon, just as for the three-needle clusters in Tunguska pines. In the mid-1990s, Dr. Yury Isakov confirmed Dragavtsev's result by a different method.

The answer to whether or not the Tunguska taiga trees underwent a genetic mutation could have been obtained rather simply. All one had to do was to analyze the DNA in the seeds of living pines. So, Academician Nikolay Vasilyev invited several researchers from the N. I. Vavilov Institute of General Genetics of the Russian Academy of Sciences to participate.

Dr. Olga Fedorenko carried out all necessary analyses and signed a research report, which stated that some genetic effects in the region of the Tunguska catastrophe have in fact occurred. To continue and develop this investigation, agreement was needed on the collaboration with Dr. Fedorenko's chief at the institute – Professor V. N. Shevchenko. Academician Vasilyev took the report to the professor and proposed that he carry out some joint research. Professor Shevchenko dismissed the matter with a wave of his hand: "Mutations at Tunguska? Absurd!" Then Vasilyev showed him the report signed by scientific workers of his own department.

The professor became somewhat nervous, being unable to explain anything, but remained adamant in his reluctance to conduct any genetic studies at Tunguska. When Vasilyev spoke to Dr. Fedorenko, she confirmed for him that both the initial data and her conclusions had been correct. As for the panic that had overwhelmed her chief, she did not understand its cause and definitely could not be responsible for it. But it seems that Professor Shevchenko was shocked by a scientific result that was both reliable and anomalous.[26]

It is appropriate, however, to ask one more question. Would the Tunguska mutations have occurred only in trees? What about the Tunguska fauna? True, animals in this region are few and far between, and those present at the time of the catastrophe have died – and their descendants could have left the area. But there are ants at Tunguska that lead, so to say, a very settled life. The ants living now in the region of the Tunguska explosion are, most probably, direct descendants of those living there in 1908. Having studied some characteristics of ants dwelling in various parts of the Great Hollow (the length and width of the head, the width of the eyes, and so on), geneticists V. K. Dmitrienko and O. P. Fedorova found that the insects living near Ostraya Mountain and at Churgim Creek did sharply differ from those caught in other places.[27] In other words, these differences were greatest where peaks of mutations in local pines were also greatest. This seems to be significant. It would therefore seem that the ancestors of these ants did also undergo mutations at the Tunguska catastrophe of 1908.

But again, this is not the whole story. Although this region of Siberia was then (and still is) very sparsely populated, it turned out that the Tunguska phenomenon affected human genes as well, not only those of trees and insects. In the 1960s, 1970s, and 1980s, the leading Soviet specialist in the field of human genetics, Professor

Yury Rychkov (1932–1998), carried out an ambitious program of composing the complete Atlas of Genetic Geography of the USSR. Rychkov had worked at the same N. I. Vavilov Institute of General Genetics, where subsequently the Tunguska findings of its own researchers were treated so badly. His expeditions, aimed at studying genetic pools of various peoples, traveled all over the country and one fine day came to the Evenks of central Siberia. And here, to the great surprise of Professor Rychkov, he met with a Rhesus-negative person.

Generally, Rhesus factor (or Rh-D antigen) is the name given to a special protein that is attached to the surfaces of red blood cells. Individuals either have it (85% of the population in Europe and North America are Rhesus-positive) or do not have it (15% are Rhesus-negative). It is dangerous for the fetus if it inherits from its father an Rh-D antigen that differs from that of its mother. Then its mother's organism mistakenly recognizes the fetus as something alien and begins to "fight" with it, which may lead to a miscarriage. This is the so-called Rhesus conflict.

Among the Mongoloid inhabitants of Siberia, Rhesus-negative persons are exceptions. But as it turned out, Olga Kaplina, then 47 years old, was Rhesus-negative, and her children died increasingly earlier with every childbirth – which is the typical pattern of a Rhesus conflict. Professor Rychkov had examined this case in detail and had come to the conclusion that the source of this conflict was a mutation that affected Olga Kaplina's parents, who had experienced the Tunguska catastrophe. In 1908 they lived between the Northern Chunya and Teterya rivers and were eyewitnesses to the event. Olga Kaplina gave her parents' impressions as "a very bright flash, a clap of thunder, a droning sound, and a burning wind."[28]

Nikolay Vasilyev (the leader of the Tunguska studies and a noted immunologist) thought that the conclusion of Professor Rychkov was probably correct. "Organisms and inhabitants of the territories that were several decades ago exposed to small dozes of ionizing radiation demonstrate similar genetic changes," wrote Vasilyev. "This occurs, in particular, in those areas of the Altai Mountains that experienced radioactive fallouts from the nuclear tests at Semipalatinsk."[29]

Thus, we can conclude that genetic mutations at Tunguska do exist – in trees, ants, and human beings – probably due to the

Tunguska explosion. There is, of course, more to do on mutations in the region; let's hope these investigations will progress. And since the ionizing (or hard) radiation is the most typical cause of such mutations, let's now return to the question of radioactivity at Tunguska, which was touched upon in Chapter 5.

One can frequently read or hear that this question was settled long ago: no increase of radioactivity in the region of the Tunguska explosion has been detected. In fact, this is not so simple. Just when, half a century ago, the search for radioactive isotopes at Tunguska commenced, the researchers expected to obtain an immediate and definite result: yes or no. But like the Tunguska problem in general, the problem of radioactivity turned out to be much more complicated and "shadowy" than had been imagined initially.

Dr. Alexey Zolotov, when starting his own studies of radioactivity at Tunguska, realized that measurements of radioactivity of the soils gave very uncertain results. He also understood that he would have to date exactly any discovered effect; otherwise it would be impossible to associate it with the Tunguska explosion. With this aim in view, Zolotov developed the method of layer-by-layer measuring of the radioactivity of tree rings. More than 1,000 samples of Tunguska trees were examined, and it was found that before 1908 there had been no traces of radionuclides. But immediately after 1908 there exists in tree rings a small but noticeable peak of radioactivity – produced, according to Zolotov, by the radioactive isotope Cesium-137, whose half-life period is 27 years. There is also a second peak – after 1945 – and this one is definitely due to American and Soviet nuclear tests in the atmosphere.

But how about the first peak? Could it be due to the Tunguska explosion? To agree with this conclusion would have been too risky. Critics assumed that radioactive fallout from the nuclear tests could have penetrated into the living trees and accumulated around the tree rings of 1908 that had been damaged by the blast wave. However, the peak of radioactivity dated 1908 has been found not only in living trees but also in those that had withered *before 1945*, when no contamination from atmospheric nuclear tests would have been possible.

Notice that the problem of Tunguska radioactivity was studied not by amateurs but by the most distinguished Russian radiochemists, in particular by Academician Boris Kurchatov, the father of

Soviet radiochemistry, and his close associate Dr. Vladimir Mekhedov. And they confirmed all results obtained by Zolotov.[30] First, the radiation effect did exist near the epicenter, but not far from it, being therefore a consequence of the Tunguska explosion. Second, the two peaks in tree rings proved to be real. And last but not least, the peak dated 1908 was found in the trees that by 1945 were already dead.[31] Alas, after the premature deaths of Academician Kurchatov and Dr. Mekhedov this line of research ceased.

In 1965, the famous American scientist Willard Libby, a Nobel Laureate and inventor of radiocarbon dating, attempted to verify the hypothesis of Lincoln La Paz, an American pioneer in the field of meteoritics, according to whom the TSB had consisted of antimatter.[32] Annihilation of such a body in the atmosphere would lead to forming a powerful neutron radiation that, in turn, would produce a considerable amount of radiocarbon ^{14}C. This radiocarbon would then be dispersed by air streams through the whole of the northern hemisphere. If the energy of the annihilation were about 25 Mt of TNT, the total amount of radiocarbon in the atmosphere would increase by 7%. And Libby did discover in tree rings of the years 1908 and 1909 (of two trees in the United States – one in Arizona and another in California) an increased concentration of radiocarbon.[33]

Some other scientists immediately tried to check the finding of such a world-renowned specialist, analyzing samples of wood taken in other places in the northern hemisphere. And they also succeeded. In particular, Libby's result was corroborated by Academician Alexander Vinogradov – an eminent Soviet geochemist and pupil of Academician Vladimir Vernadsky.[34] Increased concentrations of radiocarbon have been found in the Great Hollow as well. True, some authors associate it with a fluctuation of solar activity, not with the hypothetical ionizing radiation from the Tunguska explosion.[35]

Indeed, during a minimum of the 11-year solar activity cycle (i.e., a period when sunspots become rarer) concentrations of radiocarbon in the atmosphere usually increase. This is an empirical fact, although various astronomers explain it in different ways. And it so happened that such a minimum had fallen on the year 1909. However, the radiocarbon at Tunguska is distributed patchily, just as many other traces of this enigmatic event, which makes it difficult to explain in terms of the Sun's activity.

Besides, one should not forget about two important circumstances. First, the Tunguska explosion occurred at a considerable altitude – between 6 and 8 km over the ground. Judging from nuclear tests, radionuclides formed when atomic or thermonuclear charges detonate at such altitudes are swiftly dispersed in the atmosphere over the whole globe, only slightly contaminating the region of the explosion. Second, it had happened 100 years ago, and the first attempts to find radioactive traces were made half a century after the event when the sensitivity of the measuring equipment was rather low.

Equipment is now better, but the time interval from the moment of the explosion has obviously increased. Let's recall that just 10 years after the explosion of the American atomic bomb over Hiroshima (which was only about 13 kt of TNT but exploded only 580 m above the surface), there were no direct traces of radioactivity in the territory of the city. This is why American and Japanese physicists, who attempted in 1955 to reconstruct the picture of the radiation effects in Hiroshima, had to look for an indirect but more sensitive technique of measuring very weak radiation traces, which was called the method of thermoluminescence (TL).

By that time this was already used in geology for age determination of rocks and in archaeology for dating ancient ceramics. Some minerals, being exposed to hard radiation, store in their crystal lattice the energy of the radiation. When these minerals are gradually heated up to 400°C, they begin to glow, releasing the stored energy. This is the effect of TL. Analyzing the relationship between the temperature and the intensity of the emitted light (the TL pattern) one can obtain information about the geological history of the mineral. Naturally, while heated, the whole energy stored in the mineral is released, and therefore repeated attempts to heat it will not produce any TL effect. All information about its past is obliterated – and the mineral begins to accumulate new energy from radioactive sources surrounding it.

Archaeologists have excavated – and dated in this way – piles of ancient ceramic pots and their fragments. Ceramics are made from clay – and clay consists of minerals (in particular, feldspar), which is noted for its high thermoluminescent properties. While being produced, ceramic pots are subjected to annealing; consequently, the stored energy is wiped out by heat, and the material becomes "thermoluminescently blank." This moment is the starting point in its further "thermoluminescent history." Under the influence of various sources of radiation it begins to gather energy anew. The rate of this accumulation is known to specialists, so when an ancient ceramic pot is found its TL properties can be examined and its age determined. And vice versa. If the age of such an object is known, we can determine the dose of radiation that it has obtained during its history. In Hiroshima, this effect helped when examining the levels of TL of ceramic tiles from roofs to measure exactly the weak radiation effects around the epicenter of the atomic explosion.

Taking into consideration the very high sensitivity of this method, it was reasonable to use it at Tunguska for the same purpose. Nikolay Vasilyev hit upon this idea as far back as 1960, but it took a long time to put it into practice. Since the Evenk *chums* (Siberian tepees) were never covered by tile, and the Evenks themselves used pottery only rarely, the researchers had to concentrate their efforts on natural TL indicators – first of all, quartz and feldspars. These minerals, having wonderful thermoluminescent properties, are common in the Tunguska explosion area. If the explosion was accompanied by ionizing radiation, its TL influence can be traced.

Yet when trying to put this idea into practice, difficulties emerged. As distinct from ceramics, the thermoluminescent characteristics of natural minerals are very unstable. Radiation of dispersed radioactive elements, such as uranium, thorium, and radium, increases the energy accumulated in their crystal lattice, while the interior heat of our planet and the solar ultraviolet radiation release this energy and therefore reduce its amount. The resulting TL pattern is therefore far from unequivocal. And an additional flow of hard radiation (say, from a nuclear explosion) would have just changed a little this complicated picture.

Nevertheless, the ITEG member Boris Bidyukov, who had been running the research program "Thermolum" at the Independent Tunguska Exploration Group since 1976 (see his photo in Figure 8.5) and is still doing so, has cracked this problem. He designed and built four models of an installation to determine TL patterns of Tunguska rocks. On these installations Bidyukov has examined several hundreds of samples.

FIGURE 8.5. Boris Bidyukov, an engineer and psychologist from Novosibirsk, the long-standing head of thermoluminescent investigations at Tunguska that made it possible to discover traces of the hard radiation from the Tunguska explosion. Founder and chief editor of the *Tungussky Vestnik* (*Tunguska Herald*) journal (*Credit*: Boris Bidyukov, Novosibirsk, Russia.).

Thus it was discovered that within 10–15 km from the Tunguska epicenter the TL level considerably exceeded the background level. The zone of the increased TL level also has an axis of symmetry coinciding with the second TSB trajectory calculated by Wilhelm Fast. This trajectory runs almost directly from the east to the west. But apart from the abnormally increased thermoluminiscence, there exists within this zone a smaller area (some 5–6 km in radius) of a *decrease* in the TL level, as if superimposed on the former one. And the boundary of the zone of decreased TL coincides well with the boundary of the area of the thermal burn of the trees. Most probably, the decrease in the TL level was generated by the light flash of the explosion. (It heated the rocks and soils, reducing the thermoluminescent effect.)

But what about the *increased* TL? Is it just a fluctuation of the natural TL level or is it associated with the Tunguska explosion? Can we differentiate between these two possibilities? Yes, we can.

As was recently discovered, the artificially induced TL effect radically differs from the naturally induced one.[36] In nature, the energy inside the crystal lattice of minerals is accumulated gradually, but when there occurs a nuclear explosion its amount increases abruptly. If such a mineral is then exposed to a flow of ultraviolet radiation, the naturally induced TL effect is swiftly reduced, reaching the minimal level typical for this mineral. But the level of the artificially induced TL effect does not alter.

Boris Bidyukov has exposed to ultraviolet radiation a set of Tunguska samples, as well as a sample taken far away from the region of the catastrophe. He found that the ultraviolet radiation did not affect the TL of the Tunguska sample, as distinct from the TL of the control.[37] This means that the Tunguska explosion was probably accompanied by a burst of hard radiation.

Thus, the Tunguska event left behind, in addition to the flattened and burnt forest and geomagnetic disturbances, five smaller traces: the possible microscopic remnants of the TSB substance; anomalously fast post-catastrophic restoration of the taiga; genetic mutations in plants and other living things; radioactive fallout in tree rings; and evidence of the influence of hard radiation on local minerals and rocks. These are, however, no less important than the larger traces. These traces are material, objective, and reliable, and therefore they must be taken into consideration when creating models that are supposed to explain the nature of the Tunguska phenomenon.

Remember that the distribution of all these traces on the surface of the territory of the Great Hollow forms similar patterns around the epicenter of the explosion and the axes of symmetry of the leveled forest area. This regularity is further proof of their association with the Tunguska event.

But did these five smaller keys to the gate of the Tunguska fortress help us to get inside? Frankly speaking, more "no" than "yes." They have just limited the spectrum of possible interpretations of larger keys, restricting their "freedom of turning." If, for example, there are at Tunguska genetic mutations (a "small" key), then the "nuclear" explanation of such a "large" key as the local geomagnetic storm becomes more acceptable and its "ballistic" explanation less acceptable. When someone tries to turn a large or small key in the direction of a stony asteroid or a comet core, he or she can hear an unpleasant grinding. That's a wrong direction! On the other hand, the outlines of the strange space body (or bodies) flying slowly over the wastes of central Siberia in 1908 and exploding due to inner energy and emitting hard radiation become now somewhat more distinct. But the nature and mechanism of the Tunguska explosion still remain enigmatic.

Well, how then can we build the correct model of the phenomenon? The only way is by analyzing empirical facts and comparing them with the theoretical constructions developed by Tunguska researchers during the long history of this problem. But since the objective traces are not yet handing us a ready solution, it only remains to try and use the "subjective" information about the event. These are the testimonies of those people who saw the flight of a fiery body on the sunny morning of June 30, 1908, heard the sounds accompanying its motion through the atmosphere, and witnessed the final explosion. The amount of information is vast and instructive; perhaps it could help. Now let's proceed to its analysis.

Notes and References

1. Vasilyev, N. V. The Problem of the Tunguska meteorite on the verge of a new century. – *Transactions of the State Natural Reserve "Tungussky"*. Vol. 1. Tomsk: University Publishing House, 2003, p. 153 (in Russian).
2. Ibid., pp. 156–157.
3. See Bronshten, V. A. *The Tunguska Meteorite: History of Investigations*. Moscow: A. D. Selyanov, 2000, pp. 238–239 (in Russian).
4. See Kirichenko, L. V. About formation of the local fallout trail from the explosion of the space body in June 1908. – *Problems of Meteoritics*. Novosibirsk: Nauka, 1975, p. 121 (in Russian).
5. See Vasilyev, N. V. *The Tunguska Meteorite: A Space Phenomenon of the Summer of 1908.* Moscow: Russkaya Panorama, 2004, pp. 168 ff. (in Russian).
6. Golenetsky, S. P., Stepanok, V. V. Searching for the substance of the Tunguska space body. – *Interaction of Meteoritic Matter with the Earth*. Novosibirsk: Nauka, 1980 (in Russian).

7. Golenetsky, S. P., Stepanok, V. V. Comet substance on the Earth (some results of investigations of the Tunguska cosmochemical anomaly). – *Meteoritic and Meteor Studies*. Novosibirsk: Nauka, 1983 (in Russian).
8. See Kolesnikov, E. M. Isotopic and geochemical data prove that there is cosmic matter in the region of the Tunguska catastrophe. – *Tungussky Vestnik*, 2002, No. 15 (in Russian).
9. See Vasilyev, N. V. *The Tunguska Meteorite: A Space Phenomenon of the Summer of 1908*, p. 183.
10. Longo, G., Serra, R., Cecchini, S., Galli, M. Search for microremnants of the Tunguska cosmic body. – *Planetary and Space Science*, 1994, Vol. 42, No. 2.
11. See Vasilyev N. V., et al. *Noctilucent Clouds and Optical Anomalies Associated with the Tunguska Meteorite Fall*. Moscow: Nauka, 1965, p. 99 (in Russian).
12. See Vasilyev, N. V. *The Tunguska Meteorite: A Space Phenomenon of the Summer of 1908*, pp. 181ff; Boutron, C. Respective influence of global pollution and volcanic eruptions on the past variations of the trace metals content of antarctic snow since 1880's. – *Journal of Geophysical Research*, 1980, Vol. 85, No. C12.
13. Strictly speaking, yttrium is not a lanthanide, but their chemical properties are very close.
14. See Zhuravlev, V. K. Which elements did the Tunguska meteorite consist of? – *Tungussky Vestnik*, 1996, No. 1 (in Russian).
15. See Zhuravlev, V. K., et al. Results of heavy concentrate sampling and spectral analysis of soils from the area of the Tunguska meteorite fall. – *Problems of Meteoritics*. Tomsk: University Publishing House, 1976 (in Russian).
16. Zhuravlev, V. K., and Demin, D. V. About chemical composition of the Tunguska meteorite. – *Cosmic Matter on the Earth*. Novosibirsk: Nauka, 1976, p. 102 (in Russian).
17. Dozmorov, S. V. Some anomalies of the distribution of rare earth elements at the 1908 Tunguska explosion site. – *RIAP Bulletin*, 1999, Vol. 5, No. 1–2, p. 11.
18. Zhuravlev, V. K., and Agafonov, L. V. Mineralogical and geochemical examination of the samples of soils taken in the area of the Tunguska bolide's desintegration. – *The Tunguska Phenomenon: Multifariousness of the Problem*. Novosibirsk: Agros, 2008 (in Russian).
19. See Vasilyev, N. V., et al. Possible mechanism of stimulating the growth of plants in the area of the Tunguska meteorite fall. – *Interaction of Meteoritic Matter with the Earth*. Novosibirsk: Nauka, 1980 (in Russian).

20. Emelyanov, Y. M., et al. Utilizing multivariate analysis for assessing factors influencing the alteration of the rate of growth of trees in the area of the Tunguska meteorite fall. – *The Problem of the Tunguska Meteorite*. Vol. 2, Tomsk: University Publishing House, 1967, p. 136 (in Russian).
21. Golenetsky, S. P., and Stepanok, V. V. Comet substance on the Earth (some results of investigations of the Tunguska cosmochemical anomaly). – *Meteoritic and Meteor Studies*. Novosibirsk: Nauka, 1983, p. 118 (in Russian).
22. See Zolotov, A.V. *The Problem of the Tunguska Catastrophe of 1908*. Minsk: Nauka i Tekhnika, 1969, p. 131 (in Russian).
23. Golenetsky, S. P., and Stepanok, V. V. Comet substance on the Earth (some results of investigations of the Tunguska cosmochemical anomaly). – *Meteoritic and Meteor Studies*. Novosibirsk: Nauka, 1983, p. 118 (in Russian).
24. Dragavtsev, V. A., Nechiporenko, V. N. About distribution of genotypical deviations of statistically elementary features in plant populations. – *Genetika*, 1972, Vol. 8, No. 6 (in Russian).
25. This research work was conducted in the Laboratory of Population Genetics of the Institute of Cytology and Genetics. See Dragavtsev, V. A., Lavrova, L. A., Plekhanova, L. G. Ecological analysis of the linear increment of pines in the region of the Tunguska catastrophe of 1908. – *Problems of Meteoritics*. Novosibirsk: Nauka, 1975 (in Russian); Plekhanova, L. G., Dragavtsev, V. A., Plekhanov, G. F., Influence of some ecological factors on the manifestation of genetical consequences of the Tunguska catastrophe of 1908. – *Meteoritic Studies in Siberia*. Novosibirsk: Nauka, 1984 (in Russian).
26. See Vasilyev, N. V. Memorandum. – *Tungussky Vestnik*, 1999, No. 10 (in Russian).
27. Vasilyev, N. V., Dmitrienko, V. K., Fedorova, O. P. About biologic consequences of the Tunguska explosion. – *Interaction of Meteoritic Matter with the Earth*. Novosibirsk: Nauka, 1980, pp. 192–194 (in Russian).
28. See Rychkov, Y. G. A possible genetic trace of the Tunguska catastrophe of 1908? – *RIAP Bulletin*, 2000, Vol. 6, No. 1.
29. Vasilyev, N. V. *The Tunguska Meteorite: A Space Phenomenon of the Summer of 1908,* p. 206.
30. See Vasilyev, N. V., Andreev, G. V. Radioactivity at Tunguska. – *RIAP Bulletin*, 2000, Vol. 6, No. 2.
31. Mekhedov V.N. *On the Radioactivity of the Ash of Trees in the Region of the Tunguska Catastrophe.* Preprint 6-3311. Dubna: Joint Institute for Nuclear Research, 1967.

32. See La Paz, L. The Energy of the Podkamennaya Tunguska, Siberia, Meteoritic Fall. – *Popular Astronomy*, 1948, Vol. 56, pp. 330–331.
33. Cowan, C., Atlury, C. R., Libby, W. P. Possible antimatter content of the Tunguska meteor of 1908. – *Nature*, 1965, Vol. 206, No. 4987.
34. Vinogradov, A. P., et al. Concentration of ^{14}C in the atmosphere at the Tunguska catastrophe and antimatter. – *Reports of the USSR Academy of Sciences*, 1966, Vol. 168, No. 4 (in Russian).
35. See, for example: Nesvetaylo, V. D., Kovaliukh, N. N. Dynamics of concentration of radiocarbon in the annual rings of trees from the center of the Tunguska catastrophe. – *Meteoritic and Meteor Studies*. Novosibirsk: Nauka, 1983 (in Russian).
36. See Shlyukov A. I., Shakhovets S. A. On the validity of the TL-method of age determination. – *Tungussky Vestnik*, 1997, No. 7 (in Russian).
37. Bidyukov, B. F. The thermoluminescent imprint of the Tunguska event. – *RIAP Bulletin*, 1998, Vol. 4, No. 1–2; Bidykov, B. F. Thermoluminescent anomalies in the area of the Tunguska Phenomenon. – *Tungussky Vestnik*, 1997, No. 5 (in Russian).