11. The Theory is Dead: Long Live the New Model

Dozens of books and hundreds of articles have been published about Tunguska. This subject has appeared in academic journals as well as in popular scientific and fringe periodicals. Several dissertations for degrees have been defended and many papers have been read at conferences. Researchers have collected a wealth of evidence of the Tunguska catastrophe, and this information has been thoroughly analyzed. But strange though it may seem, nowhere can you find a complete and objective reconstruction of the Tunguska event. As a rule, having depicted almost exactly some aspects of Tunguska, the author of an article or a book immediately jumps to the description of the event – *how it should have looked from the viewpoint of the hypothesis that this author is supporting.* For example, "The core of a small comet came flying into the terrestrial atmosphere with the speed of about 30 km/s and began to intensively evaporate," or "a stony asteroid with a mass of 300,000 tons, gradually collapsing under the action of the powerful air resistance, was moving at an enormous velocity over Siberian wastes." Always a purely "theoretical" picture. "Here is how the phenomenon must have looked, and those Tunguska traces, which do not correspond to the proposed picture, have nothing to do with this event." So say these authors.

Undeniably, to discriminate between information bearing on the problem at hand and unrelated information is an important stage of scientific investigation. The trouble is, however, that some "theoretically irrelevant facts" may turn out to be very relevant, especially when we are investigating a natural phenomenon and not just analyzing results of an experiment that was carried out in a laboratory. Experiments are the basis of the scientific method of cognition because they are conducted in artificially clean conditions. Due to this, their results may be considered as reliable and precise. But when we are working with an out-of-laboratory phenomenon, whose origin and nature are a priori unknown, we are at risk,

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when filtering out "useless data," to throw away the essential together with the inessential.

So, let's forget for a moment about theories and pay attention to empirical facts. After all, it was the "unpleasant facts" (such as the overground explosion of the Tunguska space body) that have provided the basis for investigations at Tunguska covering many years. Even though the meteor specialists have after all succeeded – not without difficulty – in finding a theoretical explanation of the overground meteorite explosion with the help of the theory of the swift fragmentation that we described in the previous chapter, the credit for this success goes more to Alexander Kazantsev than to these specialists. If he had not paid attention to this subject, why should anybody have attempted to explain it? Most probably, every astronomer would have believed even now that a meteorite may explode only when striking a hard surface.

Of course, a "purely empirical" image of the Tunguska phenomenon cannot be absolutely unambiguous – otherwise the Tunguska mystery would have been solved long ago. It would have been enough to take the existing elements of this jigsaw and assemble from them an evidently correct picture. But *sufficiently* definite and sufficiently *accurate* it must be. We have at present a lot of important empirical data, collected in the swamps and copses of the Great Hollow, which can be used for this purpose.

The traces of the Tunguska event that were considered in previous chapters are its direct and indirect consequences, providing valuable information about various parameters of the Tunguska explosion, the dynamics of the TSB flight, and the TSB itself. To be revealed, this information requires effort and persistence on our part. Let's therefore try to reconstruct these parameters and traits. But first we should agree upon an important precondition, that is, not to start work by separating the sheep from the goats and bringing in a verdict, which has often happened in the past. Let's put our trust in the results of long studies conducted in the Great Hollow and eyewitness testimonies collected in the villages surrounding it. Also, keep in mind that we are not trying to answer here the question about the nature of the Tunguska phenomenon. We are just describing it as objectively as possible.

Will the final reconstruction be comprehensive? Not necessarily. We cannot be sure that science at present possesses *all* the facts needed for a complete reconstruction of the Tunguska event. But our reconstruction will definitely be much more complete – and more reliable – than theoretical descriptions of this event, based on hypotheses rather than on facts. Of course, it might have happened that by a miracle, that is "intuitively," the researcher could hit upon the correct answer to the problem. In this case, the theory would certainly have made it possible both to correctly reconstruct the Tunguska event and to convincingly explain the traces it has left. But this hasn't yet been possible. This is why we have to use another method to solve the problem – a purely empirical one. We will remove hypothetical schemes of the Tunguska event and simple-mindedly follow the facts we have. No guesses – just objectivity, empiricism, and taking into account all reliable data.

To begin with, let's remember which empirical data we possess at present. There are three large Tunguska traces: the area of the leveled forest, the light burn, and the local geomagnetic storm. And there are seven lesser traces: genetic mutations of plants, insects, and humans; an accelerated growth of the Tunguska vegetation; fluctuations of the radioactive background in the Great Hollow and a radioactive contamination in the tree rings dated 1908; the thermoluminescence anomaly; the paleomagnetic anomaly; the Weber effect; and, importantly, the geochemical anomalies in Tunguska soil and peat. In addition to these traces we have got instrument recordings of seismographs and barographs, as well as a great number of testimonies of eyewitnesses who saw the flight and explosion of the TSB. Also, there are detailed descriptions of the atmospheric optical anomalies – both preceding the event and following it (the latter being especially intensive). So, there is extensive data available. Let's agree, this is far from naught!

The area of the leveled taiga may be considered as the very foundation of the Tunguska problem. Had there been no forest leveling (which could have been the case if, say, the TSB had exploded at an altitude of 50 or more km), then nobody would have ever bothered to study anything in the epicenter of the explosion. Some 30 million leveled trees do, therefore, have some significance. This is the "main" Tunguska trace, not the "first among equals" but the very first. That it was mapped before the trees had rotted is probably the main achievement of the Independent Tunguska Exploration Group and of Wilhelm Fast personally.

The light burn is also very informative evidence of what took place in 1908 over the Great Hollow. The share of the light emission in the whole radiation from the fiery ball of the Tunguska explosion was for a long time considered as the critical parameter for the choice of the hypothesis explaining its nature. If it was high enough, the explosion must have been nuclear; if not, then nonnuclear. It has since been proved that such an option was invalid, because if a meteorite or a comet core flying through the atmosphere was heated to a high-enough temperature, the share of the light emission in its radiation would be comparable to what would be produced by a nuclear explosion. Moreover, a vapor cloud explosion (definitely a chemical one), having a relatively low temperature – just 2,000–3,000°C – generates a powerful stream of infrared radiation that could also have left the observed imprint on Tunguska vegetation.

The local geomagnetic storm several minutes after the Tunguska explosion is perhaps its most unusual consequence. The only model that convincingly explains it is the model in which this effect was produced by the ionizing radiation of the fiery ball of the Tunguska explosion. Attempts to explain this geomagnetic storm via the action of the blast wave or the ballistic shock wave from the flying TSB on the ionosphere have failed. But by admitting that there was ionizing radiation, it would be necessary to consider a difficult question: where did this ionizing radiation come from? Few Tunguska investigators are daring enough to go so far as to accept that the Tunguska explosion was accompanied by nuclear reactions – even though such reactions would not necessarily imply an extraterrestrial visit.

Fortunately, even though we do not yet know what the TSB was, we know fairly well how the Tunguska event occurred. Therefore, an examination of the known facts can lead us to a justified conclusion about this phenomenon. To start with, judging from eyewitness testimonies, at least one space body of enigmatic origin traveled through the atmosphere some 1,000 km before it exploded over the Great Hollow. ("At least" means that there might be more than one flying object, but there was a space body, in any case. Fantasies about unusual hurricanes and earthquakes have remained in their proper place – in the 1920s.) This is both the most general picture of the Tunguska event and the starting point from which we can proceed further.

Is this too little? Not at all. For instance, the great length of the atmospheric path of the TSB tells us that the space body was flying at a small angle to Earth's surface. This angle could not have exceeded 10–15°; otherwise, the altitude at which the TSB began to emit light would have been too great.[1] And as we already know, the body could not have been in a sharply increasing descent in the final stage of its flight, or else it would have been destroyed by the g loading.

Now what was the TSB's velocity? After processing the eyewitness testimonies, the ITEG scientists have established that the space body was flying over Siberia for about 5 min.[2] Taking into consideration the distance it had covered – some 1,000 km – we can assess its *average* speed to have been about 3 km/s. Of course, this is just a tentative estimation, but it's not devoid of interest because meteorites usually fly into the atmosphere at much greater velocities.

But as for the speed of the TSB at the end of its path over the Great Hollow, it can be determined more precisely and could not exceed the speed of a hypersonic aircraft. Otherwise the body, flying in a flat trajectory, would have left in the leveled forest a more pronounced trace of its ballistic shock wave than it did. A steep TSB trajectory and great velocity (tens of kilometers per second), which appear in many Tunguska hypotheses, are only there because these figures are necessary to justify an amount of kinetic energy that would be needed for a thermal explosion or a swift fragmentation of the body. But a flat trajectory and a low final speed (a couple of kilometers per second at best) are what the empirical facts indicate. If the TSB was seen at a distance of 800 km from the epicenter (in fact, it was seen at distances of more than 1,000 km!), and its flight lasted some 5 min, it means that its trajectory *had* to be flat and its speed low. By the way, the low speed of the TSB eliminates the problem of its strength over which the cometary hypothesis has stumbled. With a low speed, even such a fragile object as a comet core could have reached the Southern swamp intact.

Thus, the TSB had a flat trajectory and a low velocity. Not a steep trajectory and a high velocity. Therefore, calculations and models of the Tunguska event based on a steep TSB path and great velocity may be of interest as mathematical constructions, but they have nothing to do with the Tunguska event. Also, the share of the energy from the ballistic shock wave in the whole of the energy released at Tunguska was negligible. All fifty Tunguska megatons are "megatons of explosion" and not "megatons of motion."

The strict radiality of the area of the flattened forest testifies that there was only one powerful Tunguska explosion. If there had been another explosion whose magnitude was comparable to the first one (even after the trees had fallen), this radiality would have been broken and its blast wave would, most probably, have been recorded by seismometers and barographs in Russia and elsewhere. Nothing of this sort occurred, and therefore we can say with certitude that there was no other equally powerful Tunguska explosion – just one. And from the seismograms the time of this explosion has been determined to within ten seconds.[3] Also, as explained earlier, it has been established that the Tunguska explosion occurred in the air at a relatively high altitude – between 6 and 8 km, judging from the diameter of the zone of standing trees at the epicenter of the explosion. Some additional estimations of this altitude were made with the help of seismograms and barograms, and they do not contradict this assessment. And judging from the area of destruction and the energy of aerial and seismic waves, we can accept that the magnitude of the main explosion was several dozens of megatons.[4]

It is, however, probable that apart from the main explosion there were at least two low-altitude and less-powerful explosions. It was Leonid Kulik who had discovered their epicenters on aerial photographs, and later his conclusions were confirmed by Siberian scientists. Dmitry Demin and Sergey Simonov found additional proof when analyzing the subtle structure of the area of the leveled forest, and Sokrat Golenetsky with Vitaly Stepanok discovered one of these local epicenters when examining an elemental anomaly.[5] Remember also the testimony of the Evenk brothers Chuchancha and Chekaren, who confirmed that there were *several* explosions: "We saw another flash of light while thunder crashed overhead followed by a gust of wind that knocked us down. Then Chekaren cried out: 'Look up!' and stretched his hand upward. I looked and saw new lightning and heard more thunder."[6] These less-powerful explosions were, as the main one, accompanied by bright flashes, but their relatively weak flashes could not have burnt the Tunguska vegetation. The vast burn of the vegetation in the Great Hollow was only caused by the light emission from the main explosion.

And what about other Tunguska traces? The local geomagnetic storm testifies that the Tunguska explosion was accompanied by ionizing radiation. At this point this is the only interpretation of the effect that is justified and substantiated by mathematical calculations. The genetic mutations of plants, insects, and humans, as well as the anomaly of thermoluminescence, do back up this conclusion.

The presence of feeble but noticeable radioactive fallout after the Tunguska explosion is another empirical fact, confirmed by finding the peaks of radioactivity dated 1908 in trees that had withered before 1945 (that is, before the year when nuclear tests in the atmosphere started and the artificial radionuclides began to fall from the sky in large numbers). Only the increased radioactivity of the samples taken from the trees that continued their growth after this year may be explained away with reference to contamination from contemporary nuclear tests.

Are "radioactive anomalies" at Tunguska weak? It depends which ones. The peaks of radioactivity in tree rings yes, but to call the thermoluminescent traces of radiation weak would not be correct. Besides, what does the expression "a weak effect" mean? It means that the effect is real; it goes beyond the limits of possible instrumental errors and therefore hypotheses pretending to account for the Tunguska phenomenon must not ignore it.

Incidentally, the most important trace of this phenomenon – the supposed material remnants of the TSB – is, as we know, also indistinct: their mass does not exceed one ton, or even several hundred kilograms. This is much too little even for an icy comet core, let alone a stony asteroid... If, say, in the Tunguska explosion 99% of the TSB substance vaporized then its mass before the explosion was just 100 tons (which is equal to the mass of the orbital stage of the space shuttle) and if it was 99.99% that disappeared then 10,000 tons (which is approximately equal to the mass of three Saturn V carrier rockets that placed the *Apollo* spacecraft in the trajectory of their flight to the Moon). The "million tons," which are frequently considered the mass of the TSB, are therefore from the realm of sheer fantasy. The real mass was considerably less.

Yet, we seem to have digressed from facts to hypothetical constructions. Let's return to reality.

To solve the Tunguska problem we need, first and foremost, to determine the chemical composition of the TSB. So, what is now known about it? Sorting out the substances that have been discovered in the Tunguska soil and peat, we can compile the following list of 12 chemical elements whose concentration at Tunguska is unusually high:

1. ytterbium,
2. lanthanum,
3. lead,
4. silver,
5. manganese,
6. zinc,
7. barium,
8. titanium,
9. copper,
10. tantalum,
11. mercury and
12. gold.

An impressive set, isn't it? It looks rather exotic. Nevertheless, the first five elements from it – ytterbium, lanthanum, lead, silver, and manganese – not only demonstrate an increased concentration in the soil and peat but the zone of their increased concentration runs directly under the TSB's trajectory. Therefore, they could have been part of this space body. And as we've seen, the accelerated growth of Tunguska vegetation, especially pines, does also testify to a considerable contribution of rare earth elements (such as ytterbium and lanthanum) to the Tunguska site. In experiments only lanthanum and ytterbium (from the elements discovered at Tunguska) could stimulate the process of sprouting of pine seeds.

So how could a space body consisting of these elements explode? Or perhaps, we are dealing here with those components of the TSB substance which did *not* explode, and the space body consisted of two different parts – an "explosive" part and a "shell"? We can see that the complicated ("butterfly-like") outlines of the area of the leveled forest tell us that the blast wave acted unevenly, its power being very different in different directions. The strongest blasts hit the "butterfly's wings."[7] Obviously, an area of forest leveled by an even blast wave would have been shaped like a circle or, for the moving source of the blast wave, an ellipse (with some nuances, caused by peculiarities of the local terrain) – but definitely not a shape like a butterfly. If the magnitudes of the blast wave and ballistic shock wave had been comparable, one could have attempted to explain this strange shape by their interaction. But as we know, the ballistic shock wave was much weaker than the blast and therefore could not have influenced it in a significant way. Rather, the butterfly could have originated as a result of the explosion of something like a shaped charge – that is, a piece of explosive inside which a conical cavity is made and coated with a layer of metal. The blast wave destroys the cover within the hollow, starting from its top and giving enormous speed to particles of the metal. Naturally, the direction in which the blast wave of such an explosion acts most destructively coincides with the axis of symmetry of the hollow in the piece of explosive.

It was in 1959 at a conference in Moscow dedicated to the results of the first postwar academic expedition to Tunguska that the Soviet specialist in the physics of explosions – Academician Mikhail Sadovsky – said that judging from the forest destruction the source of the blast wave must have had a complicated shape.[8] The Academician had profound intuition. In those years nobody could have suspected that the outlines of the Tunguska area of the leveled forest would be as unusual as to resemble a butterfly. Subsequently, the conclusion about an intricate shape of this source of the explosion was mathematically justified by Siberian scientists Dmitry Demin and Victor Zhuravlev.

Well, let's agree that the TSB could incorporate, figuratively speaking, an "explosive" and, less figuratively speaking, a "shell." And inside the shell there were some hollows where explosions took place. But what can we say about *properties* of this "explosive"?

Attempting to explain the Tunguska explosion, authors of various hypotheses have used almost all known types of explosions: physical (impact, thermal, and dynamical, such as the swift fragmentation of the meteor body); chemical, including the vapor cloud explosion; and nuclear (fusion, fission, and antimatter annihilation). But the nuclear explosion differs very much from the chemical and physical – and not only by its magnitude. Having piled in one place 50 million tons of a powerful chemical explosive in bars and blown them up, we would not obtain all the effects that accompany the explosion of a 50-Mt thermonuclear charge. The point is that the nuclear explosion differs from all other types of explosion by its much greater concentration of energy. One cubic centimeter or one gram of a "nuclear explosive" produces *20 million times* more energy than an equivalent volume or mass of any other explosive and *100,000* more energy than is released when a meteorite collides with Earth's surface flying at a great cosmic velocity. (Let's recall, however, that there was at Tunguska no collision with Earth's surface.) Thus, according to the concentration of energy, all explosions may be separated into two groups: nuclear (having a high concentration of energy) and nonnuclear (having a low concentration of energy).[9] And what can we say about the concentration of energy of the Tunguska explosion?

Dr. Victor Zhuravlev has been studying this question in detail and for a long time and has examined the "Anfinogenov's butterfly," that is, the zone of complete destruction of the taiga. This is distinct from the larger Fast's butterfly having an area of 2,150 km^2. The area of the "Anfinogenov's butterfly" is "just" 500 km^2 – less than one-fourth of the latter. (Generally speaking, this is not so small an area. If the zone of complete destruction had looked like a circle, its diameter would have been as large as 25 km.)

It is from the area of the "Anfinogenov's butterfly" that one can calculate, using formulas from the theory of *nuclear* explosions, that the magnitude of the Tunguska explosion was in the range between 40 and 50 Mt. However, if one is using in one's calculations the equally exact formulas from the theory of *chemical* explosions, the magnitude of the Tunguska explosion turns out, strangely enough, much higher – up to 150 Mt. Why such a difference between the "nuclear" and "chemical" estimations? After all, when the Russian specialist in powerful explosions – Professor Ivan Pasechnik – used a calculation method that does not depend on the nature of the explosion (the analysis of Tunguska seismograms), he concluded that the "nuclear" figure was correct and the most probable magnitude of the explosion was 40–50 Mt.[10] The cause of the divergence lies in the essentially different levels of concentration of energy of these two types of explosion. So whatever the nature of the Tunguska explosion, its concentration of energy exceeded that of conventional explosions by about *10 million times*.

The doubts about the chemical or kinetic (impact) nature of the Tunguska explosion lie in the calculations of Alexey Zolotov when preparing his dissertation. Zolotov was reasoning from probably the most precise and informative data, namely the barographic records made in Russia and in Britain immediately after the Tugnuska explosion. Before World War II, when methods of analysis of barographic disturbances generated by powerful explosions were still underdeveloped, attempts of Francis Whipple and Igor Astapovich to use British and Russian barograms to determine the Tunguska explosion magnitude led to too low figures (maximum 50 kt, or about "four Hiroshimas"). But soon after the end of the war, the British meteorologist R. S. Scorer conducted the first professional examination of these data. And his result was 90 Mt.[11] Today 40–50 Mt is considered a more realistic figure, but the order of magnitude has remained the same. Thus, we should give Scorer his due – the more so that he had no idea about the area of the flattened forest and the number of leveled trees and therefore could not use this information in his calculations. Scorer's computations were based exclusively on the barographic data.

These barographs[12] did not record the sound waves that we hear but the so-called infrasonic acoustic waves, whose frequency is lower than we could hear. Sound waves fade very quickly in the atmosphere so that sound generated even by a very powerful thermonuclear explosion can be heard not farther than a few hundred kilometers from its epicenter. As distinct from this, infrasonic waves of such an explosion may encircle the globe several times, being recorded each time on the tapes of sensitive instruments. It was well understood as far back as 1963, when the partial Nuclear Test Ban Treaty was drawn up and signed, that characteristics of these waves might be measured at great distances. What is more, if we have barographs at several points we can determine the place and time of the explosion, as well as its magnitude. But initially, it remained unclear if it would be possible to differentiate nuclear explosions from other types of explosions – say, volcanic and conventional chemical explosions. Russian geophysicists, Professor Leonid Brekhovskikh and Professor Ivan Pasechnik, successfully solved this task, proving that "signatures" of nuclear and nonnuclear explosions on barograms are radically different.

The most evident difference between them lies in the shape of the line they trace out on the barogram. The barogram of an explosion having a low ("non-nuclear") concentration of energy looks like a wave whose size and period remain practically constant. However far the barograph is from the epicenter, its recorded timings will always be the same. If a record, made at a hundred kilometers from the epicenter, lasts 10 min, one can be sure that at a distance of 5,000 km it will also last 10 min. Yet, for an explosion with a high ("nuclear") concentration of energy the curve on the tape of a barograph will be absolutely different. We can see (see Figure 11.1) that with time both the amplitude and the period of this wave swiftly diminish. And, as distinct from a conventional explosion, the farther the barograph is located from the epicenter of the nuclear explosion, the longer will last the recording itself (from several minutes at a distance of several hundred kilometers to half an hour at several thousand kilometers).[13] It is thanks to these characteristics of air waves that specialists monitoring the observance of the Treaty of 1963 can say immediately, not waiting for information about nuclear contamination of the atmosphere, whether a powerful explosion detected by their instruments at a far-off island somewhere in the Pacific was nuclear or not.

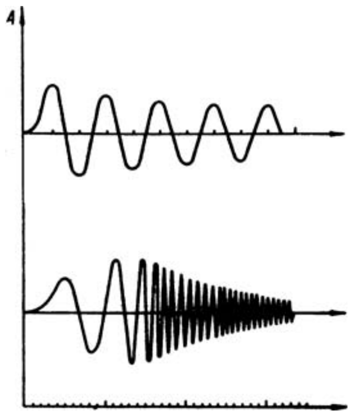

FIGURE 11.1. Here are idealized barograms of a nuclear explosion (bottom) and a nonnuclear explosion (top) compared. One can see that they are dissimilar (*Source*: Zolotov, A.V. *The Problem of the Tunguska Catastrophe of 1908*. Minsk: Nauka i Tekhnika, 1969, p. 150.).

Let's look at Figure 11.2, where barograms of a powerful chemical explosion are represented and a nuclear explosion with magnitude of several megatons that was carried out at a US testing

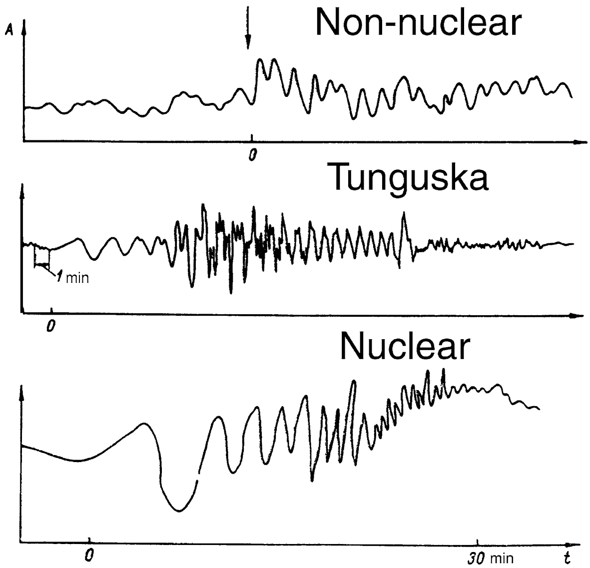

FIGURE 11.2. Comparison of real barograms of a nuclear, non-nuclear and Tunguska explosions. The Tunguska barogram does resemble the nuclear one, being very different from the non-nuclear barogram (*Source*: Zolotov, A.V. *The Problem of the Tunguska Catastrophe of 1908*. Minsk: Nauka i Tekhnika, 1969, p. 150.).

ground on Marshall Islands in 1954. A third curve is a record of air waves from the Tunguska explosion. The recording was made in 1908 in London (South Kensington). One can see that the "Tunguska" curve is very similar to the "nuclear" one, bearing at the same time no resemblance to the "chemical" curve. As for the periods during which the Tunguska barograms were recorded, in Kirensk (at a distance of 490 km from the epicenter) it was some 3 min; in Pavlovsk (3,740 km) 20 min; and in London (5,740 km) 35 min. If the concentration of energy of the Tunguska explosion had been much lower than the "nuclear," the durations of these records would have been equal. So, after comparing these curves and figures, Alexey Zolotov did have the right to say: "The explosion of the Tunguska space body had a very high concentration of energy in a small volume."[14] Somewhat later, he even took a risk to estimate the mass of this "high-concentrated explosive" that had to react in the Tunguska explosion. His final figure was just about half a ton.

Thus, information from the barograms has made it possible to establish – empirically and not referring to any hypothesis – a very important characteristic of the "TSB explosive" – its high concentration of energy. In turn, this fact confirms the conclusion about the complex structure of the TSB. It should have consisted of an "explosive" and a "shell" around this explosive; otherwise, its whole mass would have been too low to leave in the flattened forest even that weak trace of the ballistic shock wave that it did leave.

On the other hand, having agreed not only with the very great magnitude of the Tunguska explosion but also with a high concentration of its energy, which hints at the high temperature of the fiery ball, we find ourselves facing a new problem: how would it be possible to explain the herringbone pattern that exists, as we know, in the *western* part of the leveled forest area? This pattern testifies that a fairly massive body flew westward *after* the explosion. But for an explosion with a near to nuclear concentration of energy, according to the barographic data, the TSB's survival looks incredible. In fact, no material body could have survived this hellfire. If something did in fact pull through, this means there were *two* space bodies, one of which had exploded and another that continued flying to the west. (This idea about two bodies, by the way, follows from the existence of two compact groups of eyewitnesses – the southern and eastern ones – as well as from two axes of symmetry of the butterfly-like area of the leveled forest, determined by Wilhelm Fast.)

Now, we have outlined 25 components of an interdisciplinary model of the Tunguska phenomenon – from the low velocity of the TSB's motion and its peculiar chemical composition to a high concentration of energy in the Tunguska explosion and its directional character – using for this conclusion the 10 Tunguska traces, records of barographs and seismometers, plus the eyewitness testimonies. So which of these parameters of the Tunguska phenomenon are more reliable and which are less reliable? The most reliable parameters are, naturally enough, those that have been reflected in *several* traces. However strange it may seem, these are those features of the phenomenon that look very unusual from the viewpoint of traditional cometary and asteroidal hypotheses – for a start, the presence of ionizing radiation. There are four traces pointing at this: the local geomagnetic storm, genetic mutations, anomalies of thermoluminescence, and radiation peaks in the trees that had withered before 1945. Also, such an unexpected fact as the participation of *two* space bodies in the Tunguska event may be derived from three traces: two separate groups of eyewitnesses – in the south and in the east, two axes of symmetry of "Fast's butterfly," and the observation by shaman Aksenov of a flying body after the explosion.

And so, having at our disposal all these data, let us look at what can be concluded. Beginning on the evening of June 27, 1908, some space body was orbiting Earth, and by its motion disturbing the geomagnetic field. These magnetic disturbances were recorded in the German city of Kiel by Professor L. Weber. Also, in the same days in some places of western Europe, observers reported atmospheric optical anomalies. Soon after midnight GMT on June 30, 1908, just while the Weber effect was being recorded for the last time, two space bodies, flying at a relatively low speed, entered the atmosphere of our planet. They passed over central Siberia, moving toward the Great Hollow, the slopes of their trajectories not exceeding 15°. One of these bodies – let's call it TSB-A – flew from the south to the north, and the second – TSB-B – from the east-southeast to the west-northwest (see Figure 11.3).

The "southern" TSB-A flew over the Angara River not far from the village of Kezhma, flying more or less in a straight course (at least, we have no information about any maneuvers performed by it). The "eastern" TSB-B first traversed the upper reaches of the Lena River near the village of Mironovo and then the upper reaches of the Lower Tunguska River over the village of Preobrazhenka, flying in an arc. Having approached the Great Hollow and flying at several dozens of kilometers to the north from Vanavara, both the bodies changed direction. The TSB-A turned to the west-northwest and the TSB-B almost to the west. At an altitude of 6–8 km, there occurred an explosion annihilating the TSB-A, leveling 30 million trees, burning by a light flash an area of more than 200 km^2, and producing a forest fire. The explosion had been uneven and very powerful – comparable in its magnitude with the explosion of the "Tsar-bomb" that was tested on the Soviet nuclear testing ground Novaya Zemlya in 1961.

The TSB-A exploded due to an inner energy, not due to kinetic energy, its concentration exceeding considerably the level that is possible for conventional explosives and approaching that of a

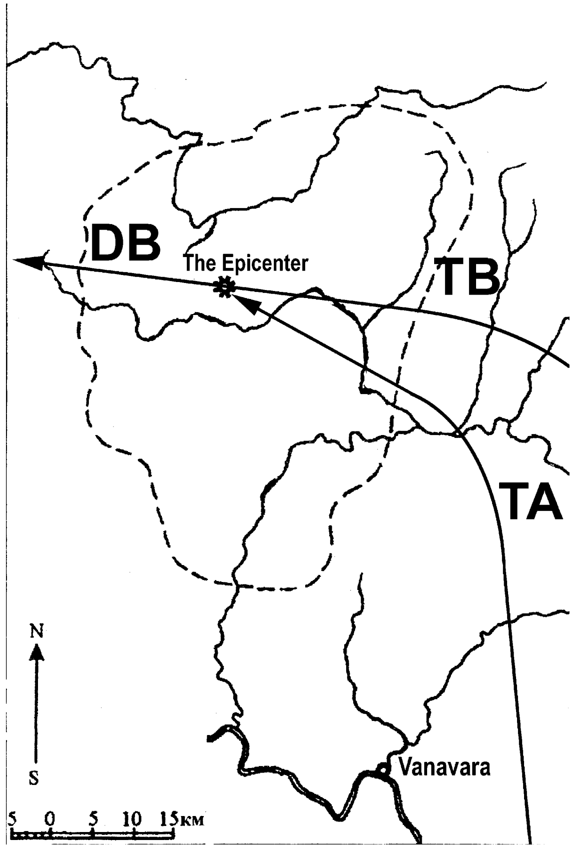

FIGURE 11.3. Directions of approach of the first (TA) and the second (TB) Tunguska space bodies to the epicenter; the trajectory of departure of the surviving body (DB).

nuclear explosion. But, most probably, only approaching but not reaching that level, as evidenced by the fact that separate pieces of the TSB-A were still exploding during a couple of minutes at lesser altitudes and with considerably less power. It is quite obvious that a nuclear charge would not have left any pieces after its explosion. The fiery ball, formed during this explosion, rose to the upper atmosphere, where its ionizing radiation induced a magnetic disturbance in the ionosphere. It developed into a local geomagnetic storm lasting about five hours. Products of the explosion (which contained, judging from the data of the Mount Wilson Observatory, some peculiar aerosol of ultramicroscopic particles suspended in the air) got into the atmosphere and gave rise to an abrupt jump in intensity of anomalous atmospheric phenomena over western Europe and European Russia.

Immediately before the explosion, the TSB-A was flying relatively slow (at a velocity not exceeding a couple of kilometers per second), its diameter being about 50 m. It appears that the structure of the TSB-A was far from uniform, due to which the blast wave acted most strongly in two directions – to the south-southeast and east-northeast, forming the butterfly-like shape of the area of the leveled forest. Only a very small share of its mass (some five thousandth of a percent) had reacted in the explosion, its whole mass being not more than 10,000 tons. The lack of a long tail of burning substance behind this body, when it was moving through the atmosphere, indicates that it did not lose any noticeable mass due to ablation – that is, the loss of surface material through evaporation caused by friction with the atmosphere. The TSB-A had a fairly low average density, but sufficiently high mechanical strength. And the paleomagnetic anomaly, discovered in the Great Hollow, testifies that it was also a source of a powerful magnetic field.

The TSB-B continued its flight westward – possibly gaining altitude (otherwise it would have fallen not far from the epicenter and flattened the taiga even more). Nothing concrete is known about its physical parameters (dimensions, mass, velocity at this stage of flight), but since the "herringbone" trace left by it in the western part of the area of the leveled forest was weaker than a similar structure left by the TSB-A in the eastern part of this area, its mass and/or velocity must have been less than those of TSB-A. For good reason, we know absolutely nothing about its chemical composition. But as for the chemical composition of the TSB-A, the main 12 elements of which it could consist were listed earlier – from ytterbium to gold.

Just 15 min after the Tunguska explosion, the Weber effect stopped and it never returned. Probably, the space body that had been producing it left near-Earth space (whether "upward" or "downward").

It is worth noting that the above description of the Tunguska phenomenon does not pretend to be exhaustively complete or absolutely accurate. Quite possibly it lacks some important details (just because these had not impressed themselves in the Tunguska forest, soil, and peat, or on the bands of seismographs and barographs) or that some characteristics have been represented imperfectly. But this model has one very important advantage over all other "theoretical" pictures of the Tunguska event: it has been built on the real empirical facts, any hypothetical consideration having been ignored. Certainly, the proposed picture is open to change and criticism. But it would be desirable to have these changes and this criticism also based on facts and not on preferred theories.

One must admit with some regret that the reconstructed image of the Tunguska phenomenon does not offer a definite answer to the question "what was it?" What is more, none of the hypotheses considered in the previous chapter – even the hypothesis by Henrik Nikolsky and his colleagues about the "orbital comet" – fits this image sufficiently well. In particular, the high concentration of energy of the Tunguska explosion contradicts the hypothesis of the vapor cloud explosion. And an ordinary comet or a stony asteroid seems to be out of the question.

Hence, the Tunguska mystery has once again demonstrated the high level of its intricacy. This does not mean, of course, that none of the existing hypotheses can be improved to convincingly explain this picture. But one should not put the cart before the horse and ignore facts just because they contradict this or that theory. The ultimate objective of science is scientific truth, however stiltedly or banally it might sound. And this objective can be reached only if the scientist is constantly comparing results of his or her abstract thinking with empirical facts. Even if it will be needed to add complexity to an existing theoretical scheme or to build a principally new theoretical scheme to account for the event that occurred in central Siberia in the summer of 1908 – well, such things have happened in the history of science. After all, we are very lucky that the set of Tunguska data, accumulated by several generations of researchers, is very detailed and informative.

It only remains to understand the meaning of these facts, details, and figures. As Albert Einstein used to say, "God may be subtle, but He isn't plain mean." Similarly, the Tunguska phenomenon is by no means trying to mislead us, but a considerable level of subtlety in it can also be noticed. It is therefore necessary for scientists to display an equally high level of ingenuity – and then the peculiar, enigmatic, and sometimes challenging facts will turn out obvious elements of a well-balanced picture.

Notes and References

1. If we accept that the TSB started to emit light at an altitude of 150 km (which may be considered as overstating for usual meteors, but admissible), then at a distance of 1,000 km from the epicenter it could be seen if the slope of its trajectory did not exceed 5°. But taking into account various additional factors (such as the radius of the field of vision of the eyewitnesses), this figure should be somewhat increased.
2. See Dmitriev, A. N., and Zhuravlev, V. K. *The Tunguska Phenomenon of 1908 as a Kind of Cosmic Connections Between the Sun and the Earth.* Novosibirsk: IGIG SO AN SSSR, 1984, p. 34 (in Russian).
3. For lovers of exact figures: the Tunguska space body exploded at 0 h 13 min 35 s GMT ± 5 s. See Pasechnik, I. P. Refinement of the moment of explosion of the Tunguska meteorite from the seismic data. – *Cosmic Matter and the Earth*. Novosibirsk: Nauka, 1986, p. 66 (in Russian).
4. Recently, there appeared a different estimation – a few megatons. We will consider this figure in the final chapter of the book.
5. See Demin, D. V., and Simonov, S. A. New results of processing the catalog of Tunguska leveled trees. – *Tungussky Vestnik*, 1996, No. 3 (in Russian); Demin, D. V. On some peculiarities of the energy-generating zone of the Tunguska phenomenon of 1908. – *RIAP Bulletin*, 2000, Vol. 6, No. 1; 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).
6. Suslov, I. M. Questioning witnesses in 1926 about the Tunguska catastrophe. – *RIAP Bulletin*, 2006, Vol. 10, No. 2, pp. 18–19.
7. Which also testifies that the blast wave could not originate due to the swift fragmentation of the space body – otherwise we would have seen the maximal destructions in a forward direction. See Kuvshinnikov, V. M. On some peculiarities of the Tunguska area of leveled forest. – *The Tunguska Phenomenon: Multifariousness of the Problem*. Novosibirsk: Agros, 2008, p. 161 (in Russian).
8. See Tsikulin, M. A. Shock waves generated by the atmospheric motion of large meteorite bodies. Moscow: Nauka, 1968, p. 5 (in Russian).
9. Around 4.2×10^{10} and 8.4×10^{17} ergs per gram, accordingly.

10. Pasechnik, I. P. Estimation of parameters of the Tunguska meteorite explosion from seismic and microbarographic data. – *Cosmic Matter on the Earth*. Novosibirsk: Nauka, 1976 (in Russian).
11. See Scorer, R. S. The dispersion of a pressure pulse in the atmosphere. – *Proceedings of the Royal Society of London*. Series A, Mathematical and Physical Sciences, 1950, Vol. 201, No. 1064.
12. Strictly speaking, *micro*barographs, which can measure and record very small changes in atmospheric pressure.
13. For details see Pasechnik, I. P. Science has proved that nuclear explosions can be detected anyplace. – *Priroda*, 1962, No 7 (in Russian).
14. Zolotov, A. V. On energy concentration of the explosion of the Tunguska space body. – *Zhurnal Tekhnicheskoy Fiziki*, 1967, Vol. XXXVII, No. 11, p. 2094 (in Russian).