TUNGUSKA GENETIC ANOMALY AND ELECTROPHONIC METEORS

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One of great mysteries of the Tunguska event is its genetic impact. Some genetic anomalies were reported in the plants, insects and people of the Tunguska region. Remarkably, the increased rate of biological mutations was found not only within the epicenter area, but also along the trajectory of the Tunguska Space Body (TSB). At that no traces of radioactivity were found, which could be reliably associated with the Tunguska event. The main hypotheses about the nature of the TSB, a stony asteroid, a comet nucleus or a carbonaceous chondrite, readily explain the absence of radioactivity but give no clues how to deal with the genetic anomaly. A choice between these hypotheses, as far as the genetic anomaly is concerned, is like to the choice between "blue devil, green devil and speckled devil", to quote late Academician N.V. Vasilyev. However, if another mysterious phenomenon, electrophonic meteors, is evoked, the origin of the Tunguska genetic anomaly becomes less obscure.

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1. Introduction

Tunguska — the scent of mystery and adventure, all over the ninety five years. Many theories to what happened many years ago in remote region of the Sleeping Land — this is the meaning of the Tartar word Siberia (Gallant 2002). And none of them can explain all the facts. Not very surprising — the systematic research had begun with significant delay and the facts found are indeed perplexing (Vasilyev 1998, Bronshten 2000a, Zolotov 1969, Zhuravlev and Zigel 1998, Ol'khovatov 2003). What is really surprising is that this at first glance purely scientific problem raised so much interest. It seems the irrational roots of this phenomenon are not always recognized and appreciated. We are tempted to give some thought to this side of the Tunguska problem before we embark on the more conventional scientific track.

The truth is that both the public interest in the Tunguska catastrophe and its scientific exploration were spurred by Kazantsev's (Kazantsev 1946) fantastic suggestion that a nuclear-powered alien spacecraft catastrophe caused the Tunguska event (Plekhanov 2000, Baxter and Atkins 1977). Another truth is that the scientific community is rather reluctant about alien spacecrafts and other UFOs unlike their wordly fellows. But doing so the scientific community misses one important point: the birth and rise of the modern age UFO myths as well as their apparent impact on the popular culture are awesome phenomena begging for scientific explanation. To our knowledge, Jung (Jung 1959) was the first to realize scientific importance behind seemingly absurd UFO accounts.

According to Jung these accounts are just a projection of the inner psychic state of modern man into the heavens and represent his longing for wholeness and unity in this divided, hostile and alien new world. Therefore an important message behind of such UFO myths is that they signal an increasing psychological stress in the society, changes of the archetypes, or psychic dominants, and possibly indicate the end of an era in history and the beginning of a new one (Fraim 1998).

In this respect the mythological impact of the Tunguska explosion on the native Evenk people, representatives of the different culture, is of great interest. Therefore it is not surprising that Floyd Favel, one of Canada's most acclaimed playwrights and theater directors, decided to develop his next play, The Sleeping Land, on the base of great spiritual significance of the Tunguska event for the Evenk people (Gordon and Monkman 1997). He has really a good story for the play. It starts "with the battle between two Tunguska Evenk clans. Over the years, their feud escalated, both clans using their powerful shamans to curse to the other, with evil spirits, misfortune and disease. The hostility between them grew until one shaman called upon the Agdy to destroy the hated enemy forever. These fearsome iron birds fly above the earth in huge clouds, flapping their terrible wings to cause thunder, flashing lightening from their fiery eyes. On that sunny morning in June, the sky became black as a never ending legion of the fearsome birds swooped low over the unfortunate Shanyagir clan. Their devastating blasts of fire blew the Shanyagir's tents up into the air over the tree tops. The clan's belongings were destroyed, two hundred and fifty of their reindeer vanished without a trace, the ancient forest was flattened in every direction, and those who still could, fled in panic. To this day, the Evenk believe that only the Agdy can live in the area where explosion took place. Only a few will risk visiting. And none will live there" (Gordon and Monkman 1997).

Although the cultures are different, this Evenk myth has some resemblance with the Sodom and Gomorrah Biblical story of miraculous destruction of these cities by the raining down of fire from heaven. One can even think that this ancient myth was also born due to real cosmic event (Clube and Napier 1982). In Koran, the holy book of Islam, one finds a similar story (Wynn and Shoemaker 1998) "about an idolatrous king named Aad who scoffed at a prophet of God. For his impiety, the city of Ubar and all its inhabitants were destroyed by a dark cloud brought on the wings of a great wind." This last story has an unexpected and adventurous continuation. In 1932 an eccentric British explorer John Philby (Monroe 1998), obsessed by the idea to find Ubar, made an arduous trip into the Empty Quarter of southern Saudi Arabia, which is one of the most inaccessible and formidable deserts of our planet (Wynn and Shoemaker 1997). He really found something interesting, the place he dubbed Wabar — fortunate misspelling because it was not the Lost City of Koran, but the place of the fierce meteorite impact (Wynn and Shoemaker 1997, 1998). The real Ubar city was allegedly found much later and this is another breathtaking adventure (Clapp 1999). Radar images from the Landsat and SPOT remote sensing satellites, which uncovered old caravan routes, played the crucial role in this discovery (El-Baz 1997). Evidence indicates that Ubar was not destroyed from heaven, instead it fell into sinkhole created by the underground limestone cavern collapse. But the Wabar meteorite was certainly capable to destroy Ubar or any other ancient city, because the 12 kilotons blast was comparable to the Hiroshima bomb (Wynn and Shoemaker 1998). The Tunguska explosion was thousand times more powerful, capable to destroy any modern city. Therefore we come to the conclusion that the unconscious fears of modern man about hazards from the outer space are not completely groundless, although not aliens but minor space bodies cause the peril. It is clear that to reliable estimate this danger it would be helpful to understand the nature of the Tunguska Space Body (TSB). And this is the point we embark on the more conventional scientific track, as promised.

There are two main hypotheses on this track about the nature of the TSB: cometary (Shapley 1930, Zotkin 1969, Kresak 1978, Fesenkov 1966) and asteroidal (Kulik 1940, Fesenkov 1949, Sekanina 1983, Chyba *et al.* 1993). Unfortunately for the science the proponents of these two hypotheses practically ignored each other for a long time (Farinella *et al.* 2001) assuming the question was settled down once for all by their own solution — an interesting example of the Planck's principle (Hull *et al.* 1978), according to which "a new scientific truth does not triumph because its supporters enlighten its opponents, but because its opponents eventually die, and a new generation grows up that is familiar with it." There is still no consensus among scientists about the choice between a comet and an asteroid. Some recent research supports the asteroidal origin of the TSB (Foschini 1999, Farinella *et al.* 2001) while Bronshten (2000b) advocates the cometary hypothesis indicating that despite an extensive and scrupulous search no stony fragments of alleged asteroid were found. He gives arguments that neither fireball radiation nor air friction can eliminate completely such fragments from the stony asteroid.

But there are facts which are hard to reconcile with either of these hypotheses (Vasilyev 2000, Ol'khovatov 2003). Below we discuss genetic impact of the Tunguska event, which is one of such facts.

2. Biological consequences of the Tunguska event

Ecological consequences of the Tunguska event have been comprehensively discussed by Vasilyev (Vasilyev 1999, 2000). They constitute another conundrum of this intricate phenomenon. There were two main types of effects observed. The first type includes accelerated growth of young and survived trees on a vast territory, as well as quick revival of the taiga after the explosion. The second type of effects is related to the genetic impact of the Tunguska explosion.

Already participants of Kulik's first expeditions made some observations about forest recovery in the catastrophe area. In various years the impressions were different (Vasilyev 1999): in 1929–1930 the taiga seemed depressed in this area, while in 1953 no signs of growth deceleration were seen in comparison with neighboring regions. The first systematic pilot study of growth of the tree vegetation in the catastrophe region was performed during 1958 expedition (Vasilyev 1999). Anomalously large tree ring widths up to 9 mm were found in young specimens which were germinated after the catastrophe, while the average width of the growth rings before the catastrophe was only 0.2–1.0 mm. Besides the young trees, the accelerated growth was observed also for the survived old trees.

Stimulated by these first findings, a large scale study of the forest recovery in the Tunguska area was performed in series of following expeditions after 1960. In 1968 expedition, for example, morphometric data for more than six thousand pine specimens were collected. This vast material establishes the reality of the accelerated growth without any doubt (Vasilyev 1999). More recent study of Longo and Serra (Longo and Serra 1995) confirms this spectacular phenomenon and indicates that the growth has weakened only recently for trees of the respectable age of more than 150 years.

The cause of the anomalous growth remains controversial. The most natural and simple explanation, suggested already in sixties (Vasilyev 1999), assumes that the explosion led to the improved environmental conditions due to ash fertilization and decreased competition for light and minerals because of the increased distance between trees. Longo and Serra (Longo and Serra 1995) found an interesting correlation between the anomalous tree growth and the dimensions of the growth rings before the catastrophe. The growth acceleration was more prominent for trees that grew more slowly before the catastrophe. But their conclusion that this finding seems to favour the above described simple hypothesis should be considered as too premature in light of Vasilyev's (1999, 2000) more detailed and broad perspective analysis of the problem.

According to Vasilyev (1999), an averaging influence of the Tunguska event on the final tree dimensions is just a manifestation of the Wilder's Law of initial values (Wilder 1953), which states that the higher the initial level of some physiological function, the smaller the response of the living organism to function-raising agents and the greater the response to function-depressing agents, irrespective to the stimuli nature. Naturally, the change of the environmental conditions played a significant role in the taiga recovery. But there are some features of the accelerated growth phenomenon which are hard to explain solely on the grounds of this obvious factor.

The areas where the accelerated growth is observed have different shapes for the young, after-catastrophe trees and for the old ones that have somehow survived the catastrophe (Vasilyev 1999). For the young trees the effect is maximal within the epicenter area. But the region where the accelerated growth is observed differs significantly both from the area of the forest fall and from the area affected by forest fire. This interesting fact hints that the change in the environmental conditions due to the forest devastation is not the leading factor of the accelerated growth in this case. Instead, one can suggest that the leading role was played by proximity of the ancient volcano and the resulting contamination of the soil by volcanic material (Vasilyev 1999). An interesting fact is that the Tunguska epicenter almost exactly coincides with the muzzle of a Triassic volcano. Therefore, if the quick growth of the young trees in the Tunguska area is indeed related to the soil enrichment by some rare earth and other elements of volcanic origin, it is not surprising that the effect is maximal in the epicenter area, where the volcano muzzle is also situated. What is surprising was found by observing later generation trees. It turned out that the younger the trees, the higher the concentration of the accelerated growth effect towards the projection of the TSB trajectory (Vasilyev and Batishcheva 1979, Vasilyev 1999). Therefore there should be one more factor, directly related to the TSB and possibly of mutagenic nature.

For the old survived trees the effect of the accelerated growth is more scattered and patchy character. One can find such trees in the forest fall area, as well as outside of it. Again, the effect is more prominent in regions nearby to the TSB trajectory. Besides, the contours of the areas, where the effect is observed have oval shapes stretched along the direction of the TSB trajectory (Emelyanov *et al.* 1979, Vasilyev 1999). It is also interesting that there are regions, as for example in the area between Kichmu and Moleshko rivers, with considerable forest fall but without any signs of the accelerated growth among survived trees (Vasilyev 1999). Moreover, the effect of the accelerated growth does not reach its maximum in the investigated area. Instead its extrapolated maximum is expected far away from the epicenter, at some 20-25 km distance (Emelyanov *et al.* 1979, Vasilyev 1999). One has an impression that the flight of the TSB was accompanied by some unknown agent capable to induce remote ecological and maybe even genetic changes.

Genetic consequences of the Tunguska event is the most controversial subject. In sixties some experiments were performed in Novosibirsk to find genetic effects of ionizing radiation on pines. Among various changes, the most prominent effect was an increased occurrence of 3-needle cluster pines, while usually the pine used in experiments had 2-needle clusters. Stimulated by this finding, G.F. Plekhanov organized special expeditions to study young pines in the catastrophe area. It turned out that the frequency of 3-needle cluster trees was really increased in the epicenter area, having the maximum near the Mount Chirvinskii — the special point where the TSB trajectory "pierces" the Earth's surface and where the effect of accelerated growth also reaches its maximum for after-catastrophe trees (Vasilyev 1999). However, as was found later, it is rather common that 3-needle cluster pines occur with high frequency in areas with intense forest recovery (after forest fires, for example), when pines have large linear increments. Therefore, unfortunately, this interesting phenomenon can not be undoubtedly associated with the primary factors of the Tunguska explosion and might be a secondary effect.

In seventies V.A. Dragavtsev elaborated a special algorithm to separate genotypic and phenotypic variations. Tunguska pine trees linear increments were processed with this algorithm. It was found that the genotypic dispersion has sharply increased in the Tunguska trees. The effect is prominent, has a patchy character and concentrates toward the epicenter area, as well as toward of the TSB trajectory projection (Vasilyev 1999, 2000, 1998). At maximums the genotypic dispersion shows about 12-fold increment (Vasilyev 2000). One of the maximums coincides again with the Mount Chirvinskii, another — with the calculated center of the light flash (Vasilyev 1999).

No indications of increased mutageneses was found in the area, however, in later study of pine isozyme systems polymorphysm by electrophoresis method. Unfortunately only 11 trees were studied from different locations and the results were averaged because of sample smallness. Therefore, although this result does not strengthen Dragavtsev's findings, it is inconclusive to reject them either (Vasilyev 1999).

Some population-genetic studies were performed in the catastrophe area by using a pea Vicia cracca. All studied phenogenetic characteristics were found considerably higher in the epicenter area than in the reference point near the Vanavara settlement (at about 70 km from the epicenter). At that two special points with maximal effect were clearly seen in the data. Remarkably, one of them is again the Mount Chirvinskii and the another one (the Chugrim canyon) is only at 1–1.5 km distance from the light flash center (Vasilyev 1999).

The same researchers studied fluctuating asymmetry of birch leaves in the broader region. It is believed that the fluctuating asymmetry arises as a result of stress the organism experiences during its development and is a good measure of its ability to compensate for stress. It was found that the asymmetry is significantly increased not only in the epicenter area but also in remote regions not affected by the Tunguska explosion (Vasilyev 1999). This is not surprising because the climatic conditions are severe in the Siberian taiga and recent studies indicate that fluctuating asymmetry in leaves of birch seems to be a robust indicator of ambient climatic stress (Hagen and Ims 2003). Interestingly, in the epicenter area one of the sites where the highest asymmetry is observed is noted Mount Chirvinski (Vasilyev 1999).

In 1969 morphometric peculiarities of ants Formica fusca were searched in the epicenter area by inspecting 47 anthills. No noticeable differences were found at several locations, but ants from the Mount Chirvinskii and from the Chugrim canyon were significantly different (Vasilyev 1999). Unfortunately no reference studies were performed outside the epicenter area. Analogous studies were continued in 1974–1975 by using ants Formica exsecta. No peculiarities were found in ants inhabited in the central and peripheral parts of the catastrophe area (Vasilyev 1999).

A very interesting genetic mutation, possibly related to the Tunguska event, was discovered by Rychkov (Rychkov 2000). Rhesus negative persons among the Mongoloid inhabitants of Siberia are exceptionally rare. During 1959 field studies, Rychkov discovered an Evenk woman lacking the Rh-D antigen. Genetic examinations of her family enabled to conclude that a very rare mutation of the Rh-D gene happened in 1912. This mutation may have affected the women's parents, who in 1908 lived at some 100 km distance from the epicenter and were eyewitnesses of the Tunguska explosion. The women remembered her parents' impressions of the event: a very bright flash, a clap of thunder, a droning sound, and a burning wind (Rychkov 2000).

All these facts indicate that the Tunguska event had left a very peculiar ecological and genetic traces. The hard question, however, is to separate the primary and secondary factors leading to the observed phenomena, which may have complex origins. A recurrent appearance of the TSB trajectory and some special points related to it in the above given stories suggests nevertheless that the flight and explosion of the TSB was accompanied by some unknown stress factor. A great challenge for the conventional Tunguska theories is when to find and explain the nature of this factor. We think that such a factor might be electromagnetic radiation. Interestingly, a powerful electromagnetic radiation is suspected to accompany electrophonic meteors — an interesting class of enigmatic meteoritic events.

3. Electrophonic meteors and Tunguska bolide

The history of the electrophonic meteors research presents another good example of the Planck's principle in action. In 1719 eminent astronomer Edmund Halley collected eyewitnesses accounts on a huge meteor fireball seen over much of England. He was perplexed by the fact that many reports declared the bolide was hissing as if it had been very near from the observer. Being aware that the sounds can not be transmitted so quickly over distances in excess of 100 km, he dismissed the effect as purely psychological, as "the effect of pure fantasy". This conclusion and Halley's authority hindered any progress in the field for two and a half centuries (Keay 1997).

At present eyewitnesses accounts on the unusual sounds which accompany some rare meteoritic events are quite numerous (Vinković *et al.* 2002, Keay 1994a) and almost no more doubts are left about reality of the effect. Electrophonic sounds can be divided into two classes according to their duration. About 10% of the observed events have short duration, about one second, and are of burster type. They produce sharp sounds which are reported as "clicks" and "pops". Other electrophonic events are of the long duration sustained type and the corresponding sounds are described as being "rushing" or "crackling" (Keay 1992a, Kaznev 1994). Interestingly, similar "clicks" have been reported to be heard by soldiers during nuclear explosions and it is assumed that they are caused by an intense burst of very low frequency (VLF) electromagnetic radiation, which is peaked at 12 khz (Johler and Monganstern 1965, Keay 1997).

The mechanism of how VLF radiation can be generated by a meteoroid was proposed by Keay (Keay 1980). It is suggested that the geomagnetic field becomes trapped and "twisted" in the turbulent wake of a meteoroid. Afterwords the plasma cools and the strain energy of the field is released as VLF electromagnetic radiation. The theory was further elaborated by Bronshten (Bronshten 1983) who showed that as much as megawatt VLF power can be easily generated by bright enough bolids.

Extra low frequency (ELF) and VLF electromagnetic fields can be generated also by other possible mechanisms. For example, explosive disruption of a large meteoroid will generate electromagnetic pulses similar to what happens in nuclear explosions. An electrostatic mechanism of perturbing geoelectric field, operating for bolids with steep trajectories, was considered by Ivanov and Medvedev (Ivanov and Medvedev 1965). Beech and Foschini developed a space charge model for electrophonic bursters (Beech and Foschini 1999, 2001). They suggest that during meteoroid catastrophic breakup a shock wave is produced which propagates in the plasma around the meteoroid and leads to a significant space charge due to different mobility of ions and electrons. In this case no significant VLF signal is generated, instead we have a brief transient in the geoelectric field.

Suitable transducer is required to transform the VLF energy into audible form and this is that makes the electrophonic meteor observation such a rare and capricious phenomenon (Keay 1997). From a group of even closely placed observers one or two may hear the sounds and the others do not. In a series of experiments Keay and Ostwald demonstrated (Keay and Ostwald 1991, Keay 1997) that for audible frequency electric fields various common objects can serve as a transducer. For example, volunteers were able to detect as low as 160 volts peak-to-peak variations of the electric field at 4 kHz frequency, with their hair or eyeglass frames acting as a transducer.

Therefore at last we have a clever and scientifically sound explanation of these mysterious sounds which baffled scholars for centuries. But any theory needs experimental confirmation. Unfortunately instrumentally recorded electrophonic meteor data are very scarce due to extreme rareness of the phenomenon: by an optimistic prediction a person which would spend every night outdoors may expect to hear an electrophonic sound once in a lifetime (Keay and Ceplecha 1994b, Keay 1997).

In 1993 Beech, Brown and Jones (Beech, Brown and Jones 1995) detected 1–10 kHz broad band VLF transient concomitant to the fireball from the Perseid meteor. However no electrophonic sounds were reported. Still earlier a meteor VLF signal was detected by Japanese observers (Keay 1992b). Garaj *et al.* (Garaj *et al.* 1999), as well as Price and Blum (Price and Blum 1998) reported detection of the ELF/VLF radiation associated with the Leonid meteor storm. A very interesting observation was made during reentry of the Russian communications satellite Molniya 1–67 (Verveer *et al.* 2000). An observer reported an electrophonic sound near the end path of the satellite, which produced a large orange fireball during its entry in the atmosphere. At the same time several geophysical stations in Australia detected a distinct ELF (about 1 Hz) magnetic pulse. Unfortunately no instrumentation was available to detect electromagnetic radiation above 10 Hz to check Keay–Bronshten's theory. Interestingly, ELF electromagnetic transients may effect the human brain directly and therefore may require lower energy levels to produce electrophonic effects (Verveer *et al.* 2000). These sparse experimental data are clearly insufficient to draw definite conclusions about the physics of the radio emissions from meteors (Andreić and Vinković 1999). On the other hand, the existing theoretical models are also too simplified to be able to give a detailed description of the phenomenon (Bronshten 1991).

A remarkable benchmark in the research of electrophonic meteors was the first instrumental detection of electrophonic sounds during the 1998 Leonid meteor shower (Zgrablić *et al.* 2002). Ironically Leonid meteors are least suitable devices for production of the VLF radiation via the Keay–Bronshten mechanism which demands the Reynolds number in the meteor plasma flow to exceed 10^6. In the case of Leonids, which are mostly dust grains, this leads to unreasonably large initial size $D_0 > 3$ m and mass ~ 3000 kg (Zgrablić *et al.* 2002). Nevertheless two clear electrophonic signals were instrumentally recorded during the expedition. The first originated from the meteor at the altitude of ~ 110 km. The second — at altitude of 85–115 km. In both cases the sounds preceded the meteors' light maximum. These features are hard to explain also in other models suggested for electrophonic bursters. No ELF/VLF signal was detected in these two events. But the receiver apparatus was insensitive for frequencies below 500 Hz, while the frequency range of the observed electrophonic sounds was 37–44 Hz. If one assumes that these sounds originated from the transduction of the ELF/VLF transient, the observed sound intensities will imply unreasonably high ELF/VLF radiation power, impossible to explain by any theoretical mechanism starting from meteor alone (Zgrablić *et al.* 2002). Therefore this remarkable observations show that the existing theories are at least incomplete and the electrophonic meteor mystery remains still largely unsolved.

Zgrablić *et al.* (Zgrablić *et al.* 2002) suggested that the Leonids acquire large enough space charge and can trigger an yet unidentified geophysical phenomenon upon entering the E-layer of ionosphere at ~ 110 km. It is assumed that such phenomena in its turn will generate a powerful EM radiation burst. Note that this possibility was advocated by Ol'khovatov (Ol'khovatov 1993) much earlier.

But Keay–Bronshten mechanism is expected to operate well for slow and bright bolids (brighter than the full Moon), which penetrate deep into the atmosphere. The Tunguska meteorite was clearly of this type. Therefore we can not exclude that its flight was accompanied by a powerful ELF/VLF radiation. Are there any eyewitness accounts which support the electrophonic nature of the Tunguska bolide?

Already in 1949 Krinov (Krinov 1949) draw his attention to the strange circumstance that many independent observers described sounds which preceded the appearance of the bolide. He notes that similar phenomena were reported many times by spectators of electrophonic meteors. But there was a significant difference: in the Tunguska bolide case the sounds were extraordinary strong, more like to powerful strikes than to the feeble electrophonic cracks and rustles. Krinov notes further that this difference might be a consequence of the exceptional magnitude of the Tunguska event. However more likely to him appears the explanation that all these reports were purely psychological in nature, that the observers have a unconscious tendency to change the succession of light and sound effects, or unify them in time by neglecting the time lag due to low velocity of the sound. Here is one such witness account (Krinov 1949) from K.A. Kokorin, resident of Kezhma village:

"... at hours 8–9 in the morning, not later, the sky was completely clear, without any clouds. I entered the bath (in the yard) and just succeeded in taking my shirt out when suddenly heard sounds, resembling a cannonade. At once I run out in the yard, which had an opened perspective towards the south-west and west. The sounds still continued at that time, and I saw in the south-west direction, at an altitude about the half between the zenith and the horizon, a flying red sphere with rainbow stripes at its sides and behind it. The sphere remained flying for some 3–4 seconds and then disappeared in the north-east direction. The sounds were heard all the time the sphere flew, but they ceased at once as the sphere disappeared behind the forest."

Krinov's reaction to this report is very characteristic for the history of the electrophonic sounds research. He considers it clearly impossible the sounds to precede the bolide flight and concludes that Kokorin just forget the right succession of the events because of remoteness of the event, as the inquiry took place in 1930. Of course, in this particular case Krinov might be right, but the fact that similar assertions can be found in many other witness accounts forces us to believe just the opposite.

E.E. Sarychev, inquired in 1921 (Vasilyev *et al.* 1981) remembers: "I was a leather master. In summer (near the spring) at about 8 AM tanners and I washed wool on the bank of Kana river, when suddenly a noise emerged, as from wings of a frightened bird, in the direction from south to east, towards Anzyr village, and a wave went upward the river like ripples. After this a piercing strike followed, and then dull other strikes, as if from the underground thunder. The strike was so powerful that one of workers, Egor Stepanovich Vlasov (who died now), fell into the water. With the emergence of noise, a radiance appeared in the air, of spherical shape, the size of half Moon and with a bluish tinge, quickly flying in the direction from Filimonov to Irkutsk. Behind the radiance a trail was being left in the form of sky-bluish stripe, stretching along almost all the track and gradually decaying from the end point. The radiance disappeared behind the mountain without any explosion. I can't notice how long it lasted, but it appeared only very briefly. The weather was absolutely clear and there was the still around."

Ya.S. Kudrin, who was a nine years old child at that time, gives the following description of the sounds heard (Vasilyev *et al.* 1981): "The sound was like a thunder, it ceased after the bolide flight. The sound was not very strong, just like ordinary thunder. The sound was moving together with the object toward the north. The sound was heard before the object became visible and it stopped as the object disappeared."

I.K. Stupin was also 8–10 years old boy in 1908 and also remembers that the appearance of the sound preceded the appearance of the object. According to him the sound was cavernous and of low tone. At that he did not notice any air wave or vibration of the Earth (Vasilyev *et al.* 1981).

The eyewitness report from V.I. Yarygin is also interesting in this respect (Konenkin 1967): "In 1908 I lived in village Oloncovo, at some 35 km from the town Kirensk upstream to Lena river. At that day we rode horses in a field. At first we heard a loud roar, so that the horses had stopped. We saw a blackness on the sky, behind of this blackness there were blazing tails and then a fog of the black color. The sun vanished and darkness came down. From this blackness a flame of fire darted from south to north."

One can easily find witness reports where the character of sounds resembles very close the electrophonic ones. For example E.K. Gimmer describes the sounds from the meteorite as of sizzling type, as if a red-hot iron was put into water (Vasilyev *et al.* 1981). S.D. Permyakov remembers that there was no roar when the bolide fled above him, instead he heard some noise and boom (Konenkin 1967).

Note that the electrophonic nature of the Tunguska bolide was argued earlier by Khazanovitch (Khazanovitch 2001), who gives some other examples of eyewitness accounts to support this suggestion. Even more earlier Vasilyev (Vasilyev 1992) had discussed an unsolved conundrum that thunderlike sounds were heard not only during and after the bolide flight, but also before it. He dismissed the psychological explanation of this strange fact by subjective errors, as the peculiarity had been reported by too many independent observers, some of them being at several tens of kilometers from the bolide-trajectory projection, and therefore the sounds heard by them can not be caused by the ballistic wave. He came to the conclusion that the only real explanation could be achieved by suggesting a link with powerful electromagnetic phenomena, induced by the bolide.

It is interesting that a terrific roar of presumably electrophonic nature was reported by eyewitnesses to accompany overhead passing of a Tunguska-like bolide in the British Guyana in 1935 (Steel 1996). Other known evidence of electromagnetic disturbances from bolids indirectly supports a possibility that the similar phenomena is not excluded also in the Tunguska event case. The most recent one is related to the Vitim meteorite which fell in Siberia 25th September 2002. The witness report from G.K. Kaurtsev, a Mama airport employee, clearly indicates that a strong alternate electromagnetic field was induced by the bolide during its flight which led to the induction phenomenon and to the appearance of St. Elmo's fires (Yazev *et al.* 2003):

"At night there was no electricity, the settlement was disconnected. I woken up and saw a flash in the street. The switched off filament lamps of the chandelier lighted dimly, to half their normal intensity. After 15–20 seconds an underground boom came. Next morning I went to the dispatcher office of the airport. Security guards Semenova Vera Ivanovna and Berezan Lydia Nikolaevna have told the following story. They were on the beat and have seen that "bulbs were burning" on the wooden poles of the fence surrounding the airport's meteorological station. They were scared very much. Fires glowed during 1–2 seconds on the perimeter of the protection fence. The height of the wooden poles is approximately 1.5 meters."

Note that the Mama settlement was at several tens of kilometers distance from the bolide's flight path. Besides, the scale of the Vitim event is incomparable with the scale of the Tunguska explosion: the latter was by about three orders of magnitude more energetic. Therefore it seems very plausible that the Tunguska bolide flight might be accompanied by very strong alternate electromagnetic fields. The next question is whether these fields could lead to the observed ecological and genetic consequences.

4. Biological effects of ELF/VLF electromagnetic radiation

It is not excluded that one should apply to a magical herb mugwort (Artemisia Vulgaris), the foremost sacred plant among Anglo-Saxon tribes, to resolve the enigma of the Tunguska genetic impact. It is said that mugwort can invoke prophetic dreams if used in a dream pillow (Cunningham 1985). So a solution of the riddle could be dreamed up in this way. But jokes aside, what is really magical about mugwort, it is the suspected ability of Artemisia Vulgaris to use Earth's magnetic field for adaptation purposes. Mugwort is not the only plant with such ability. For example, compass-plant (Silphium Laciniatum) uses the same adaptation strategy, which is even more pronounced in this case. Its deeply cut basal leaves are placed vertically and they align themselves in a north-south direction. This allows them to avoid excessive heat of the overhead midday sun and so minimize the moisture loss, but nevertheless have a maximum exposure to the morning and evening sun.

Some animals, including fish, amphibians, reptiles, birds and mammals, are also using geomagnetic field for orientation (Wiltschko and Wiltschko 1995). The sensory basis of magnetoreception is not completely clear yet. Two types of magnetoreception mechanisms are suspected in vertebrates. The evidence for a light-dependent, photoreceptor-based mechanism is reviewed by Deutschlander *et al.* (Deutschlander *et al.* 1999) along with the proposed biophysical models. It is supposed, for example, that magnetic field can alter the population of excited states of photosensitive molecules, like rhodopsin, which might lead to chemical effects. But some experiments have shown that light is not necessary for magnetoreception (Wiltschko and Wiltschko 1995). Therefore a mechanism for a direct sensing of the magnetic field should also exist. This mechanism possibly is based on chains of single-domain crystals of magnetite in a receptor cell (Walker *et al.* 2002). As the chain rotates in the magnetic field, it will open some mechanically gated ion channels in the cell membrane by pulling on the microtubule-like strands which connect the channels to the chain.

Above given examples indicate that Earth-strength magnetic fields can affect biological systems. Moreover, this interaction provides evolutionary important tools for adaptation. Therefore one can expect that the magnetic sense in the biological systems is as perfect as any other known sensory systems and has evolved down to the thermal noise limit in sensitivity (Kirschvink *et al.* 2001).

Thus it is not surprising that various biological effects of the low frequency nonionizing electromagnetic radiation have been found, although the underlying mechanisms responsible for these effects are still not completely understood (Marino and Becker 1977, Binhi and Savin 2001, Becker and Marino 1982, Binhi 2002). The potentially hazardous effects of the ELF electromagnetic fields were especially scrutinized during last decades, because the power frequencies of most nations are in the ELF range. Let us mention some most impressive facts from Marino and Becker's review (Marino and Becker 1977).

Even relatively brief exposures to high intensity ELF electric fields were shown to be fatal to mice, Drosophila and bees. For example, above 500 v/cm, bees sting each other to death. And 30–500 v/cm at 50 Hz is sufficient to change metabolic rate and motor activity.

ELF electric field exposure affects central nervous system. For example, a significant increase in hypothalamic activity was recorded from the microelectrodes implanted in anesthetized rats during the 1 h exposure period to the inhomogeneous electric field of 0.4 v/cm maximum at 640 Hz. Some in vitro studies indicate effects on the calcium release and biochemical function. For example, 1.55 v/cm electric field at 60 Hz caused complete loss of biochemical function in brain mitochondria after 40 min exposure.

Exposure to the ELF electric or magnetic field produces a physiological stress response. For example, rats exhibited depressed body weights, decreased levels of brain choline acetyltransferase activity, and elevated levels of liver tryptophan pyrrolase after 30–40 days exposure to 0.005–1.0 v/cm electric field at 45 Hz.

It was found that an asymmetrically pulsed magnetic field repeating at 65 Hz with a peak value of several G accelerates the healing of a bone fracture in dogs. Some studies indicated a slight enhancement of growth in plants near high-voltage transmission lines. The growth rate of beens was significantly (about 40%) effected by 64 days exposure to 0.1 v/cm electric field at 45 Hz, when the been seeds were planted in soil. But no significant effect was observed when the soil was replaced with a nutrient solution.

Of course, possible genetic effects of VLF/ELF radiation are most interesting in the context of our goals. Some early work suggested that weak electric and magnetic fields produced genetic aberrations in Drosophila, however these observations were not confirmed by subsequent experiments (Marino and Becker 1977). Epidemiological evidence of possible carcinogenic effects of electromagnetic field exposure is reviewed by Heath (Heath 1996) and Davydov *et al.* (Davydov *et al.* 2003). It seems this field is subject to continuous controversy. Some studies suggest that exposure to power frequency electromagnetic fields may lead to increased risks of cancer, especially for leukemia and brain cancer. But other epidemiological studies did not reveal any increased risk. For example, eight of the eleven studies conducted in 1991–1995 found statistically significant elevation of risk for leukemia. And four of the eight investigations that studied brain cancer also found some increase in risk (Heath 1996). Nevertheless Heath considers the overall evidence as "weak, inconsistent, and inconclusive".

For energetic reasons, VLF/ELF radiation of not thermal intensity can not damage DNA or other cellular macromolecules directly. On this basis, the possibility that such weak electromagnetic fields can induce any biological effects was even denied for a long time (Binhi and Savin 2001), until a plethora of experimental evidence proved that "Nature's imagination is richer than ours" (Dyson 1996). Let us mention one such recent experiment of Tokalov *et al.* (Tokalov *et al.* 2003).

Cells have very effective emergency programs to cope adverse environmental conditions. Remarkably, cellular stress response is rather uniform irrespective to the stress factor nature. Some cellular functions that are not essential for survival, for example cell division, are temporarily suspended. Besides special kind of genes, the so called heat shock proteins (HSP), will be activated. Their major function is the proper refolding of the damaged proteins. Heat shock proteins, notably the HSP70, were first discovered while investigating cellular responses to a heat shock, hence the name. Tokalov *et al.* (Tokalov *et al.* 2003) studied effects of three different stressors on the induction of several heat shock proteins and on the cell division dynamics. The stress was produced by 200 keV X-ray irradiation, by exposure to a weak ELF electromagnetic field (50 Hz, $60 \pm 0.2\ \mu$T), or by a thermal shock (41° C for 30 min).

The pattern of induction of the most prominent members of the heat shock multigene family was found similar for all three stressors and HSP70 was the most strongly induced gene. But no effect on cell division was detected in the case of ELF electromagnetic field exposure, in contrast with other two stressors. Interestingly, when combined with the heat shock, ELF electromagnetic field shows cell protective effect: the number of proliferating cells strongly increases in comparison with the case when only the heat shock stress is present. One might think that this protection property is related to the induction of HSP70 genes by the electromagnetic field which helps to cope the thermal stress. But no protective effect was found when ELF electromagnetic field exposure was combined with ionizing X-ray irradiation. The reason of this difference is unknown, as are the molecular targets of ELF electromagnetic field. It was suggested that electromagnetic fields can act directly on DNA by influencing electron transfer within the DNA double helix (Goodman and Blank 2002).

The fact that weak electromagnetic fields can induce the stress proteins indicates that cells consider electromagnetic fields as potentially hazardous (Goodman and Blank 2002). This is surprising enough, because the magnitude of an effective magnetic stimulus is very small. Electromagnetic fields can induce the synthesis of HSP70 at an energy densities fourteen orders of magnitude lower than heat shock (Goodman and Blank 2002). Such extra sensitivity to the magnetic field must have good evolutionary grounds. Interesting thermo-protective effect of the ELF electromagnetic field exposure mentioned above, and the absence of any effects of weak electromagnetic fields on the cell proliferation, may indicate that cells are not really expecting any damage from the weak electromagnetic impulse, but instead they are using this impulse as some kind of early warning system to prepare for the really hazardous other stress factors which often follow the electromagnetic impulse. There is another aspect of this problem also: some recent findings in evolutionary biology suggest that heat shock proteins play important role in evolution.

HSP90 guides the folding process of signal transduction proteins which play a key role in developmental pathways. When HSP90 functions normally, a large amount of genetic variation, usually present in genotype, is masked and does not reveal itself in phenotype. However, under the stress Hsp90 is recruited to help chaperon a large number of other cellular proteins. Its normal role is impaired and it can no longer buffer variation. Therefore some mutations will become unmasked and individuals with abnormal phenotype will appear in the population. If a mutation proves to be beneficial in the new environmental conditions, the related traits will be preserved even after the HSP90 resumes its normal function. Therefore HSP90 acts as a capacitor of evolution. If environmental conditions are stable, the buffering role of HSP90 ensures the stability of phenotype despite increased accumulation of hidden mutations in genotype. When the environmental conditions suddenly change, as for example after the asteroid impact, which is believed to cause the dinosaur extinction 65 million years ago, this great potential of genetic variation is released in phenotype and the natural selection quickly finds the new forms of life with greater fitness. The Drosophila experiments of Rutherford and Lindquist (Rutherford and Lindquist 1998) demonstrated this beautiful mechanism, which may constitute the molecular basis of evolution.

Further studies have shown that the HSP70 and HSP60 protein families also buffer phenotypic variation (Rutherford 2003). As was mentioned above, experiments demonstrated that ELF electromagnetic fields can induce various heat shock proteins and in particular HSP70. Therefore we can speculate that ecological and genetic consequences of the Tunguska event are possibly not related to mutations which happened during the event, but are manifestations of the latent mutations, already present in the Tunguska biota, which were unmasked due to the stress response. ELF/VLF radiation from the Tunguska bolide might act as a stressor thereby explaining why the effect is concentrated towards the trajectory projection.

Note that direct mutagenic effect of the TSB flight and explosion is not also excluded. Because the Tunguska bolide was electrophonic bolide of the exceptional magnitude, very strong induced electric and magnetic fields are expected, and therefore they could induce significant Joule heating in biological tissues. One can even find a witness accounts which can be interpreted as supporting this supposition, for example P.P. Kosolapov's report (Krinov 1949):

"In June 1908, at about 8 in the morning I was in Vanavara settlement preparing myself for a hay harvest and I needed a nail. As I could not find it in the hut, I went out in the yard and began to drag out the nail by pliers from the window frame. Suddenly something as if burned my ears. Seizing them and thinking that the roof was under fire, I raised my head and asked to S.B. Semenov who was sitting on the porch of his house: "Did you see something?" — "How not to see, answered he, I also felt as if I was embraced with heat." After that I immediately went to the hut, but as I just entered it and wanted to sit down on the floor to start work, a heavy blow followed, soil began to drop from the ceiling, the door of the Russian stove was thrown out on the bed which stand in front of the stove and one window glass was broken. After that a sound like thunderclap appeared which receded in the north direction. When there was quiet again, I rushed out in the yard, but noticed nothing any more."

Krinov notes that the eyewitness did not mention any light phenomena and explains this by the fact that he was near the south wall of the hut and thus shielded from the north half of the sky were the explosion took place. Krinov further speculates that the heat sensation was caused by the bolide glow as it fled overhead towards the explosion point. In our opinion more realistic explanation is provided by the Joule heating due to extraordinary strong electromagnetic pulse.

Many survived trees in the epicenter area have characteristic damages as if originated from the lightning strikes. Therefore one can expect that the explosion was accompanied by thousands of lightning strikes (Ol'khovatov 2003). It was proposed long ago that strong electric fields associated with thunderstorms could accelerate electrons to relativistic energies and lead to X-ray radiation. But all past attempts to register such radiation from lightnings have produced inconclusive results. At last, recent rocket-triggered lightning experiments unambiguously demonstrated that lightnings are accompanied by short intense bursts of ionizing radiation (Dwyer *et al.* 2003).

The detector used in these experiments (a NaI(Tl) scintillation counter) cannot distinguish between X-rays, gamma-rays and energetic electrons. So the actual composition of the radiation burst is unknown, but the fact that the radiation was not significantly attenuated by the 0.32 cm aluminum window on the top of the detector ensures that the particle energies were much more than 10 keV. The form of the observed signal indicates that the signal was produced by multiple energetic particles. The bursts had typical durations of less than 100 microseconds and the total deposited energy was typically many tens of MeV per stroke. The energetic radiation seems to be associated with the dart leader phase of the lightning and precedes the return stroke by about 160 μs.

Similar observations were made earlier by Moore *et al.* (Moore *et al.* 2001), who observed energetic radiation from natural lightning. In this case the radiation burst was associated with much more slower stepped leader phase and preceded the onset of the return stroke current by several milliseconds.

As we see, at present one has solid experimental evidence that lightnings are sources of short bursts of ionizing radiation. Note that this experimental fact cannot be explained by the conventional theories of high-voltage breakdown at high pressures and therefore they need to be revisited (Krider 2003).

We do not know whether the TSB flight was also accompanied by ionizing radiation. This is not excluded as well because the strong electric fields associated with the alleged space charge separation could produce energetic enough runaway electrons. Even if present, this radiation maybe will be too attenuated before reaching the ground to produce significant biological effects. However, it seems very plausible that at least the explosion was accompanied by intense bursts of ionizing radiation from lightnings with possible biological consequences.

5. The riddle of the sands

We tried to argue in the previous sections that the genetic and ecological impact of the Tunguska event is possibly related to the powerful ELF/VLF electromagnetic radiation from the bolide and to the ionizing radiation due to lightnings which accompany the explosion. Note that ionizing radiation from the bolide and electromagnetic pulse as possible causes of genetic mutations were considered earlier by Andreev and Vasilyev (Trayner 1997) from different perspective. Turbulent wake behind the large enough bolide can produce required energetics of ELF/VLF radiation, for example by Keay–Bronshten mechanism. The TSB was indeed very large, with the estimated prior to explosion mass between 10^5 and 10^6 tonnes (Trayner 1997). The fact that no single milligram of this vast material was reliably identified in the epicenter region possibly tells against the asteroidal nature of the TSB (Bronshten 2000b). But cometary theory may also fail to explain the low altitude of the explosion, as well as some specific features of the forest devastation in the epicenter. These features indicate that besides the main explosion there were a number of lower altitude (maybe even right above the surface) less severe explosions (Vasilyev 1998). The most striking fact is that the impression of the ballistic wave on the forest seems to extend beyond the epicenter of the explosion, as if some part of the Tunguska object survived the huge explosion and continued its flight (Vasilyev 1998). Of course, it is a great enigma how an icy comet nucleus can lead to such strange effects. Maybe the key to this riddle is buried in the Libyan desert sands.

In 1932 an incredibly clear, gem-like green-yellow glass chunks were discovered in the remote and inhospitable Libyan desert in western Egypt. Geologists dated the glass at 28.5 million years old and it is the purest natural silica glass ever found on Earth, with a silica content of 98%. About 1400 tonnes of this strange material are scattered in a strewn field between sand dunes of the Great Sand Sea (Wright 1999).

The origin of Libyan Desert Glass (LDG) is not completely clear. LDG seems to be chunks of layered tektite glass, the so called Muong Nong type of tektite (Müehle 1998). Tektites are “probably the most frustrating stones ever found on Earth.” (Faul 1966). The prevailing theory about their origin is that they are formed from the rocks melted in large meteorite impacts. But secrets of glass making in such impacts are still unknown and some scientists even refuse that such high quality glasses, as one has, for example, in the LDG case, could ever originate as a result of a fierce impact. The main argument against the terrestrial impact origin of tektites is the following (O’keefe 1994). Tektites are unusually free from the volatiles, like water and CO_2, which are always present in terrestrial rocks. Glassmakers need several hours to remove bubbles from the melted material to produce the high quality glass in industrial glass-making process. But the impact is very brief phenomenon, so there is not enough time to remove the volatiles.

O'keefe himself preferred lunar volcanism as an alternative explanation of tektite origin (Cameron and Lowrey 1975). In this approach tektites are considered as "Teardrops from the Moon", in perfect agreement with ancient legends (Kadorienne 1997). Very romantic theory of course, but it encounters even more severe difficulties (Taylor and Koeberl 1994). As a result the impact theory reigns at present.

But the glassmaker objection should be answered, and usually one refers to shock compression (Melosh 1998), the trick not used by glassmakers but expected in impact events. Due to shock compression at 100 Gpa, silicates almost instantaneously reach temperatures as high as 50000 °C (Melosh 1998). Of course, nothing even remotely similar to such extreme conditions ever happens in industrial glass production. Therefore the comparison is not justified.

In the case of the Libyan Desert Glass, however, no impact crater have been found. Therefore Wasson and Moore (Wasson and Moore 1998) suggested that an atmospheric Tunguska-like explosion, 10^4 times more powerful, was responsible for LDG formation. Tremendous explosion heated a 100km×100km portion of the entire atmosphere to temperatures high enough to melt small desert sand grains, which were elevated by generated turbulence. As a result a thin melt sheet of silicate was formed and a radiation background have kept it hot enough for some time to flow and produce Muong Nong type tektites after solidification. Maybe multiple impacts produced by a fragmented comet, like Shoemaker–Levy-9 crash with Jupiter, is needed to ensure the appropriate scale of the event (Wasson 1995).

But the question about the high quality glass making reappears in this scenario, because now there are no extreme pressures associated with the impact cratering, and therefore no extreme compressive heating. Besides, evidence for shock metamorphism was revealed in some sandstones from the LDG strewn field by microscopic analysis (Kleinmann *et al.* 2001). This indicates to an impact, not to an atmospheric explosion. But then where is the crater? The situation is further involved by the recent strontium and neodymium isotopic study of these very sandstones and of some LDG samples (Schaaf and Müller-Sohnius 2002). Isotopic evidence indicates the difference between the sandstones and LDG, therefore the former cannot properly be regarded as possible source materials for LDG (Schaaf and Müller-Sohnius 2002).

As we see, Libyan Desert Glass, much like to the Tunguska event, suggests very strange and peculiar impact. Maybe the required explanation should be also very unusual and queer, like an impact of the mirror space body. Surely you will have a lot of glass after such an impact, won't you?

More seriously, the mirror matter idea is completely sound and attractive scientific idea, which dates back to the Lee and Yang's (Lee and Yang 1956) seminal paper. This hypothetical form of matter is necessary to restore the symmetry between left and right. At the fundamental level the notions of left and right (left-handed and right-handed spinors) originate because the Lorentz group is locally identical to the SU(2)$\times$SU(2) group (see, for example, Silagadze 2002). Therefore one expects that the difference between these two factors of the Lorentz group, the difference between left and right, should be completely conventional and the Nature to be left-right symmetric. But **P** and **CP** discrete symmetries are broken by the weak interactions, so they can not be used to represent the symmetry between left and right, if we want a symmetric universe. One needs a new discrete symmetry **M**, instead of charge conjugation **C**, so that **MP** remains unbroken and interchanges left and right.

Lee and Yang (Lee and Yang 1956) supposed that this new symmetry can be arranged if for any ordinary particle the existence of the corresponding "mirror" particle is postulated. These new mirror particles are hard to detect because they are sterile (or almost sterile) to the ordinary gauge interactions. Instead they have their own set of mirror gauge particles, which we are blind to. The only guaranteed common interaction is the gravity (for a review and references on mirror matter idea see Foot 2001a, 2002, Silagadze 2001, 1997). Therefore big chunks of mirror matter can be detected by their gravitational influence. This means that in the solar system we do not have very much mirror matter, if any. But some amount is certainly allowed. Even a planetary or stellar mass distant companion to the sun is not excluded and represents a fascinating possibility (Foot and Silagadze 2001).

Mirror matter is a natural dark matter candidate. It may even happen that the mirror matter constitutes the dominant component of the dark matter (Berezhiani *et al.* 2001, Foot and Volkas 2003). We know that there is a lot of dark matter in our galaxy and even in the solar neighborhood its density can reach roughly 15% of the total mass density (Olling and Merrifield 2001). Therefore small asteroid size mirror objects occasionally colliding with the Earth is a possibility which can not be excluded.

What will happen during such collision depends on the details how the mirror matter interacts with the ordinary matter. If the predominant interaction is gravity, nothing interesting will happen, as the mirror asteroid will pass through the Earth unnoticed. But things will change if mirror and ordinary matters interact via sizable photon-mirror photon mixing (Foot 2001b, Foot and Yoon 2002). In this case mirror charged particles equire small ordinary electric charge, they lose their sterility with respect to the ordinary electromagnetic interactions and the mirror and ordinary nuclei will undergo

Rutherford scattering, causing the drag force upon entry of a mirror space body into the atmosphere.

In a number of detailed studies (Foot 2001b, Foot and Yoon 2002, Foot and Mitra 2002) the entry of a mirror body into the Earth's atmosphere was analyzed. The outcome depends on several factors, such as the magnitude of the photon-mirror photon mixing, the size of the mirror space body, its chemical composition and initial velocity. As concerned to the Tunguska problem, the most interesting conclusion was that a large ($R \sim 40$ m) chunk of mirror ice, impacting the Earth with initial velocity of about 12 km/s, will not be slowed down much by the drag force in the atmosphere, but it will melt at a hight 5-10 km. Once it melts, the atmospheric drag force will increase dramatically, due to the body's expected dispersion, causing the body to release its kinetic energy into the atmosphere. Therefore an atmospheric explosion is expected.

If the TSB was indeed a mirror asteroid or comet, as suggested by Foot (Foot 2001b), the absence of the ordinary fragments is nicely explained. Of course, mirror fragments are still expected, if the body had significant non-volatile component. Maybe these fragments are still buried at the impact site, but nobody bothers to dig them out.

Some other exotic meteoritic phenomena also appear less puzzling if one accepts that they were caused by mirror impactors (Foot and Yoon 2002). And not only on the Earth. Looking at asteroid Eros and at its impact craters, Foot and Mitra (2002) came to a strange conclusion that the small mirror space bodies in the solar system can actually outnumber the ordinary ones. The reasoning is the following (Foot and Mitra 2002). When a mirror space body collides with an asteroid, it will release its kinetic energy at or below the asteroid's surface, depending on its size, velocity and the magnitude of the photon-mirror photon mixing. For Small mirror bodies the energy is released too slowly and over too large a volume to expect any crater formation. Therefore a crater hiatus is expected at some critical crater size, if the craters are caused by mirror impactors. And this is exactly what is observed for Eros: a sharp decrease in rate was found for craters with diameter less than about 70 m.

Foot and Mitra (2002) was able to infer some estimation of the photon-mirror photon mixing magnitude from these observations. The result fits nicely in the range which is expected if the anomalous meteoritic phenomena, and the Tunguska event in particular, was indeed caused by the mirror matter space bodies. There are some other interesting experimental implications of the mirror matter which also involve the same range of the mixing parameter (for a review, see Foot 2003).

Eros reveals still another footprint of the mirror world. Puzzling flat-flaw crater "ponds" were unexpectedly discovered on its surface. The mirror impact theory provides a ready explanation (Foot and Mitra 2002): a large enough mirror space body while releasing its energy underground will melt surrounding rocks. If the photon-mirror photon parameter is negative, some extra heat is expected besides the kinetic energy. In this case mirror and ordinary atoms attract each other, so for the mirror matter chunk it is energetically favorable to be completely embedded within ordinary matter, releasing energy in the process (Foot and Yoon 2002).

Interestingly, an enigmatic flat-flaw crater can be found even on Earth. It is the nearly circular 38 km wide Richât structure in Mauritania, the western end of the Sahara desert. Nowadays this structure is no more considered as an impact structure, despite its uniqueness in the region, reported presence of coesite, and its round "bull's-eye" shape. The reason is flat-lying strata at the center of the structure with no signs of the disrupted and contorted beds, lack of evidence for the shock-metamorphic effects, and the suspicion that the reported coesite is in fact misidentified barite (Everett *et al.*, 1986). The Richât structure is believed to be a dome of endogenic origin sculpted by erosion. However why it is nearly circular remains a mystery.

Maybe Eros ponds hint the similar mirror matter explanation for this mysterious formation. Note that 50 km west-southwest of the Richât structure one finds similar but much smaller (of about 5 km diameter) formation — the Semsiyat dome. If the "soft" impact of the main mirror body created the Richât structure, one can thought that its large fragment may caused the Semsiyat dome.

One expects numerous lightnings during a mirror impact event, because the mirror space body will accumulate an ordinary electric charge while flying in the atmosphere. The charge builds up because the ionized air molecules can be trapped within the mirror body, while the much more mobile electrons will escape (Foot and Mitra 2002). Interestingly, there were some speculations that the coesite-bearing quartzite breccias of the Richât structure were produced by lightning strikes (Master and Karfunkel 2001). As already was mentioned above, there is an evidence that the Tunguska event was accompanied by thousands of lightning strikes. More recently, one can mention January 14, 1993 anomalous low altitude fireball event in Poland, a candidate for a mirror meteorite strike, with enormous electrical discharge at the impact site, which destroyed most of the electrical appliances in nearby houses (Foot and Yoon 2002).

There is something similar to the Libyan Desert Glass in south Australia, the so called Edeowie glass field (Haines *et al.* 2001). Unlike to the LDG, this enigmatic fused crustal material is quite clast-rich and inhomogeneous. The enigma in this case consists in the fact that no impact crater has been found nearby, despite clear evidence that some rocks were melted in situ. Haines *et al.* (Haines *et al.* 2001) concluded that lightning and impact-related phenomena are the only reasonable possibilities capable to produce the observed fusion. But in fact maybe there is one more reasonable alternative, a large mirror body hitting the ground at cosmic velocity (Foot and Mitra 2003), capable to provide both the impact and spatially and temporally confined intense lightnings.

6. Concluding remarks

We have mentioned some riddles in this article, such as the Tunguska genetic anomaly and electrophonic meteors, magnetoreception in biological systems and molecular basis of evolution, Libyan desert Glass and Edeowie glass field, flat-flaw Eros craters and the Richât structure, parity violation and the hypothetical mirror matter, and tried to argue that all these puzzles maybe are just different pieces of the same one big jigsaw puzzle. The picture that was assembled can be hardly considered as completely satisfactory, as in many cases we rely on hypothesis instead of firmly established scientific facts. Therefore we can not guarantee that the suggested picture is really the one created by the jigsaw puzzle author (the Nature). Nevertheless it seems to us interesting enough to offer to your attention.

As to the Tunguska genetic anomaly, we see the following picture as a reasonable explanation. The Tunguska bolide was of electrophonic nature. That means its flight was accompanied by a powerful ELF/VLF electromagnetic radiation. This radiation acted as a stress factor on the local biota and triggered subtle mechanisms to release the hidden genetic variations into the phenotype. Some direct mutagenic factors, related to the ionizing radiation associated with lightnings during the explosion, are also not excluded.

Interestingly, if the above given explanation is correct, the Tunguska genetic anomaly represents in miniature the action of the molecular basis of evolution. On much more grater scale, global catastrophic events, like the asteroid crash 65 million years ago which ended the dinosaur era, boost the evolution by the same mechanism. We are left to admire the Grand Design of Nature and try to survive its next evolutionary turn.

Therefore, finally let us return to outer space fears of sinful modern man. For a long time the ancient belief that the cosmos can influence mundane affairs was considered by scientists as a mere superstition. “Modern astronomers generally scoff at such superstitious beliefs, so it is somewhat ironic that science has in the past few decades uncovered compelling evidence for celestial interference in terrestrial matters” (Jewitt 2000). It is now widely accepted that near Earth objects larger than 1 km in diameter represent considerable hazard and in the past Earth witnessed a number of withering impacts, which maybe shaped the biological evolution. There are attempts to convince governments and society to fund ambitious projects to completely identify potentially threatening near Earth objects and develop adequate defense systems (Jewitt 2000).

But the Tunguska event and some other mysterious events of probably impact origin indicate the enigmatic type of soft impacts which do not leave any crater, as well as impactor fragments, despite their tremendous magnitude. In this article we mentioned one possible explanation that these impact events are caused by mirror space bodies. Of course, this explanation looks exotic, but in fact it is the only one falsifiable in near future.

For mirror matter explanation of anomalous impact events the crucial ingredient is the presence and magnitude of the photon-mirror photon mixing. And this can be experimentally tested! In fact the crucial experiment is already planned. This is ETH-Moscow positronium experiment (Badertscher *et al.* 2003, Foot 2003). The photon-mirror photon mixing leads to the orthopositronium-mirror orthopositronium oscillations. As a result in some tiny fraction of events the orthopositronium will decay into mirror photons and this will be detected as an event with missing energy. It is expected that the experiment will reach the needed sensitivity to prove or disprove the presence of the photon-mirror photon mixing of relevant magnitude (Badertscher *et al.* 2003, Foot 2003).

If the ETH-Moscow positronium experiment outcome turns out to be positive, it will mean bad news for fearful modern man, except the mirror matter theory proponents maybe. The peculiarities of the Eros craters, if really caused by mirror impactors, indicate significant population of small mirror bodies in the inner solar system. So the potential hazard for Earth is bigger than estimated. More importantly, it is very hard, if not impossible at all, to timely discover Earth approaching mirror space body and avert its impact. Therefore sinful modern man will be bound to face outer space hazards with eyes wide shut.

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