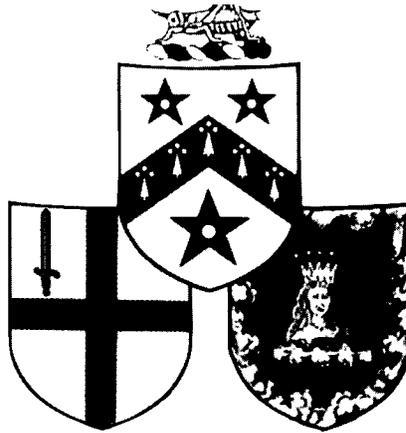


*G R E S H A M*  
*C O L L E G E*



**TUNGUSKA**

A Lecture by

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## Tunguska

At 5.32am on the morning of Tuesday June 30<sup>th</sup> 1908, although not a sound was heard, barometric pressure measuring devices at meteorological stations in Kensington, Westminster and Shepherds Bush recognised that an unexpected atmospheric shock wave had reached Britain. The same instruments, likewise others in Cambridge, Leighton Buzzard, Petersfield were activated again the next day as the disturbance which had passed right around the Earth was detected for a second time before dying out. Then strange things began to happen at night. Katherine Stephen of Huntingdon wrote to the Editor of the Times (printed July 2<sup>nd</sup>) about the Aurora Borealis being particularly brilliant and asking had anyone-else seen it. Astronomers already had; Mr E.W. Maunder and Mr H.P. Hollis of the Royal Observatory drew attention to the long lasting aurora on the morning of July 1<sup>st</sup> during a meeting of the British Astronomical Association (Times July 3<sup>rd</sup>). Golfer Holcombe Ingleby went further. A party of his chums had strolled across the Brancaster course in Norfolk, towards where they could look out north from the links across the sea. There they witnessed a salmon pink sunset of immense beauty lasting until 2.30am. Mr Ingleby related how he could still read a book in his chamber at 1.15am quite comfortably.

By July 4<sup>th</sup> a full scale scientific debate was raging and the Times was forced into evaluating the various explanations for a phenomena which had now been reported from as far away as Berlin. A group of scientists, notably Professor Fowler of Kensington, had been researching solar prominences, which they believed had magnetically coupled to the Earth disturbing the aurora. Their explanation looked a little thin when the sunset glows continued without any obvious geomagnetic signals. Consequently another theory began to develop. The Times recalled that wonderful sunsets were seen in Britain in the autumn of 1883 when Karakatoa had erupted in the Far East at the end of August. The column of smoke and dust rose 33 miles high before the volcano collapsed beneath the sea into a 600 foot crater. The resultant tidal wave had destroyed 300 towns and villages killing an estimated 30,000 people. As The Times remembered, the sunset glows had been explained as dust which had found its way in the northern hemisphere by way of a previously unknown air current. The problem however with all this speculation was that no one had reported a major volcanic event at any recent time.

Edwardian London went about its business blissfully unaware that it had just missed judgement day. Other news reports on Women's suffrage, the Olympic Games and the

iniquity of travelling at 15-20mph on a motor cycle took precedence. Had the event in question been 6hrs and 45minutes later, then Britain's capital would have been in about the right place to experience a detonation estimated to be about the equivalent of a 30 megaton nuclear bomb.

No one appreciated what happened that day. It would be 20 years before an intrepid scientist managed to persuade his authorities that an investigation for posterity was needed. What he found in the wastes of the Siberian forest in 1927 must have made his blood run cold even without the help of subzero temperatures. Taken to the region by an Evenki nomad, one of the few men who had personal experience of the disaster, Leonid Kulik became the first westerner to see the devastation of 800 square miles of conifers which to all intents and purposes looked like a cornfield hit by a hurricane.

In 1908 Siberia was a wilderness; its not much better now, then it was even worse. Used for centuries as a place of no return of anyone who challenged the regime, the taiga had no use except to the few peasant hunters who herded reindeer and trapped for skins. But on the morning of June 30<sup>th</sup> passengers on the newly opened Trans-Siberian railway were jolted out of their seats by the engine violently coming to rest. Those who were already awake might have seen the fireball which passed across them and heard the explosion which convinced the driver one or more of his carriages had derailed. These terrified travellers, pioneers to open up a new territory, however were 350 miles away from the real scene of the action. If the railway had run through the trading post of Vanavara, still 30 miles from an act of nature at its most terrifying, then those travelling to new opportunities in the east would almost certainly have turned around and headed straight back to Moscow.

The story of the Trans-Siberian travellers was the information that brought Leonid Kulik on his first visit to Siberia in 1921. Kulik was in his mid-thirties and a scientist at the Mineralogical Museum of St Petersburg. He had fought against the Germans in the first world war and survived the terrors of the revolution to be charged by the Academy of Sciences of the emergent soviet state to catalogue occurrences of meteorite falls. He arrived in Filimonovo Junction in mid-September thirteen years after the Tunguska catastrophe. He had with him an old scrap of newspaper provided by a man called Sevyatsky who had found it pasted onto the back of a calendar. The news report actually said that the driver of the train and the passengers had found a meteorite which was of course untrue, but it was sufficient reason for Kulik's visit.

Late September in Siberia is hardly the time for a westerner to be setting off into the field so Kulik contented himself searching other local newspapers for confirmation of the report he already had, interviewing local settlers and nomadic tribesman whose memories of explosions in 1908 were all too vivid. When Kulik went home he already believed there had been a major meteorite fall and left behind him 2500 copies of a questionnaire to get more information. Over the next six years reports trickled back to St Petersburg from a number of geologists exploring the Siberian wastes. Several referred to Ilya Potapovich's brother, a man struck deaf and dumb by an explosion which flattened his cabin and the forest for miles around. Piecing together all the data suggested that the noise of the detonation had been heard over 380,000 square miles.

By 1927, Kulik managed to convince his superiors that all the stories pointed to a meteorite impact, a big meteorite impact. Cannily he warned that the object or objects which had fallen would likely be weathering away and soon would be lost. As a result he was given permission to return to the Tunguska region with an assistant. It was late February and Siberia was still in winter's grip, it took Kulik over a month using horse drawn sledges to struggle 300 or so miles from the railway to the trading station of Vanavara, where at last he located Ilya Potapovich who agreed to act as a guide for the last 30 miles. But the snow drifts were still too deep to allow the journey which had to be postponed until April 13<sup>th</sup>. When Kulik finally stood on the top of Khladmi ridge he scribbled in his diary:

"I really cannot take in the whole majestic picture. A hilly almost mountainous region stretches away tens of miles towards the northern horizon. From our observation point no forest can be seen for everything has been devastated and burned. One has an uncanny feeling when one sees twenty to thirty inch giant trees snapped across like twigs, and their tops hurled many yards away."

Kulik was itching to go on but the superstitious Potapovich had come as far as he would go. Reluctantly Kulik returned to Vanavara to find a more adventurous guide. By May 30<sup>th</sup> he and his helper Gyulikh had journeyed to a marshy basin known to the locals as the Southern Swamp. Here they found what they believed was the epicentre of the explosion – the place where the fallen trees lay like the spokes of a wheel appearing to point back to a focus. Everywhere were numerous swampy hollows each of which Kulik believed must contain massive meteorite fragments. The scientist / explorer had found what he came for but his

party had already strayed beyond the limit allowed by their provisions. Without further investigation they retraced their steps directly to Vanavara taking nine days to get there, ravenously hungry and exhausted.

Back in St Petersburg in December 1927, Kulik told his bosses he had walked in the cauldron of hell. Since the event that had caused it had occurred in the Soviet Union they were duty bound to study it. Elsewhere in the world, having heard of Kulik's findings, Harvey Nininger the American Meteorite pioneer, was trying to raise money in scientific circles to stage a U.S. investigation. He failed and wrote "It is a sad comment on the mental alertness of the scientific world that there has been no adequate effort put forth to collect the great fund of information which awaits any well equipped expedition into these parts".

But this time Kulik's superiors were quick to respond to his request for support so he was back the next season with a team including a film cameraman. The latter was on hand to record what could have been Kulik's untimely end; when one of the boats they used to travel along the river Chambe capsized hurling the group leader overboard it was sometime before his head broke the water's surface still incongruously wearing his trade mark steel-rimmed spectacles. In view of the tribulations of his journey Kulik did not arrive until late June and was able to do little except lay the foundations for the next year, building a cabin on stilts to protect his researchers from marauding wolves and bears.

His preparations made, Kulik arrived back on February 23<sup>rd</sup> 1929 with a large party and a plan to stay as long as it took. He was equipped with a drill and brought civil engineers and other experts to excavate and study the depressions in the peat. The work proceeded despite the arctic conditions which saw the temperature drop to  $-50^{\circ}\text{C}$  ( $-58^{\circ}\text{F}$ ). Kulik's prime target was a large crater like structure in the south swamp and a forty yard trench was dug to drain away the water before all the peat was removed. Despite this Herculean effort what they found must have completely dismayed them – right in the middle was the stump of a large tree clearly of greater than 20 years of age. There was absolutely no possibility they were looking at an impact crater.

The team were exhausted and despondent – three members left the expedition. In November 1929 supplies were becoming low so Kulik ordered his new deputy Evgeni Krinov back to Vanavara. With a colleague and a horse carrying a small quantity of material for despatch back to St Petersburg, Krinov had to wade through waist deep snow drifts. His experiences

described in the book "Giant Meteorites" tell how his leather leggings froze to him at temperatures of forty below zero. When the pair reached Vanavara, stopping only to ensure that supplies were despatched to the distressed team, Krinov and his companion were forced to journey for another six days to the trading station at Kezhma to get medical treatment for their frost bite. There Krinov remained in hospital until mid-February; he was lucky to lose only one of his toes.

The expedition having run out of money finally gave up after 20 months in the summer of 1930. Kulik was still however convinced that the meteorite debris would be found and returned on three more occasions. In 1938, convinced by this time that he must be looking for a single object in one giant crater, he had organised an aerial photographic investigation. It failed to find anything.

The development of an airstrip at Vanavara meant that Kulik was able to visit the region one last time in 1939. On June 22<sup>nd</sup> 1941 the Germans attacked the Soviet Union. Although Kulik was 58 years old he enlisted in a Dad's Army prepared to fight to the death to defend mother Russia. In the desperate bid to prevent the enemy reaching Moscow, Kulik was wounded and captured. He ended his days in a concentration camp on April 14<sup>th</sup> 1942 still puzzled by the cause of the biggest explosion in living memory.

Without a champion the story might end there. But nearly thirty years after they had been collected, the samples from the 1929 expedition (the ones Krinov, despite the rigours of the journey, had brought out of Tunguska) were finally studied. Within the cores of peat were found tiny spherules of silicate which had once been molten. Also present were grains of magnetite, the iron oxide mineral produced when meteorites ablate in the atmosphere. Similar materials are encountered in abundance in deep sea sediments and polar ice. It is usually argued that they are the terrestrial products of cometary dust. In recent times dust layers associated with ice of Tunguska age have been found in polar regions.

Despite articles having appeared in the peer reviewed scientific literature that Tunguska was the result of a matter / antimatter recombination, or an encounter with a black hole, the generally accepted theory is that on the morning of June 30<sup>th</sup> 1908 a small fragment of a comet exploded in the atmosphere over Siberia, one paper suggests it was part of Comet Encke. On the basis of the estimated density for cometary nuclei being mostly

unconsolidated snow and ice then perhaps the Tunguska object was around 70,000 tonnes in mass and travelling at 20 miles / second. None of its water could ever expect to be found.

It is not however out of the question that a meteorite was involved. We now know a great deal more about the dynamics of objects moving with cosmic velocity. Bodies below 10 metres and above 300 metres are able to survive the stresses and strains imposed by hitting the atmosphere at high velocity. Objects in between these limits are torn apart by the combination of apparently hitting a wall with a following vacuum. The heat, shock and pressure generated causes disintegration. If Tunguska was a solid object it might have been as big as 7 million tons. If its velocity was asteroidal rather than cometary then it was moving at 7 miles / second. Either way what ever it was never reached the surface of the Earth but exploded 5-10 miles above the ground.

Postscript: In 1994, Jason Newton and Sasha Verchovsky of the Planetary Sciences Research Institute joined a multinational field trip to the Tunguska region. They brought back a peat core containing a layer believed to be the impact horizon. The peat was subjected to demineralisation and oxidation with appropriate acids. In the residue, which was 0.6wt%C with a  $\delta^{13}\text{C}$  of -25‰, were a number of visible anhedral grains of up to a few microns in size. By definition only something as robust as diamond could survive the preparation procedure. Planetary Sciences Research Institute has argued that diamond is a fall-out product of cosmic scale explosions: It is encountered in the ejecta of a variety of >20km size impact craters and observed in the worldwide K/T boundary layer thought to have resulted from a 200km sized event, which marks the demise of the dinosaurs.

Although further work remains to be done, it seems that our evidence of Earth's vulnerability to giant impacts can be accumulated from analysing specimens like those for which Kulick and Krinov risked their lives.

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#### References:

- R.M. Hough, I Gilmour, J Newton, J.W. Arden and C.T. Pillinger (1995) *Meteorites* 30 521  
D.R. Norton (1994) *Rocks from Space*. Mountain Press Publishing Company, Montana  
J Sloneley (1977) *Tunguska, Cauldron of Hell*, Star Books  
E.L. Krinov (1966), *The Giant Meteorites*, Pergamon Press  
*Sky and Telescope*, January 1984, 18-22  
*Sky and Telescope*, June 1994, 38-43