epicentre was located. If was necessary to penetrate thick underbrush, follow rivers, and improvise rafts.

The general direction of the epicentre actually was not hard to determine. The explosion apparently was radial in its action and the tops of fallen trees were all pointing outwards from the impact area like the spokes of a wheel. They approached the region from the southeast where the first signs of broken trees were seen 37 miles from ground zero. The radial nature of the explosion was evident even at this distance, and it was subsequently verified over the southern and eastern limits. No information was available regarding the northern and western limits.

By the time they came to within 19 to 22 miles of the impact area, there were no longer any trees left standing except in isolated, sheltered places.

In the central area, they found a shallow depression with a radius of about one mile where the ground was compressed and pushed aside. This depressed region contained about 200 shallow craters with steep sides. The majority were filled with mud and some had raised centres, similar to some lunar craters. The diameters ranged from 1 to 50 yards.

The few trees left standing in this region were calcined and stripped of their bark and branches. The entire central area appeared to have been scorched by intensely hot gases. Even after the 19-year interim, a continuous scorching was visible on mosses, bushes and trees as far out as 6 to 10 miles from the centre. This area, which once was a rich forest, was barren and lifeless.

It was estimated that 80 million trees were knocked down or uprooted.

Eye-witness accounts were obtained by Kulik and others from natives who lived along the rivers Angara and Lena, and in the surrounding cities such as Bratsk, Enisseisk, Shamansk and Irkutsk.

The following account, told to Kulik by a native Tungu, gives an indication of the heat intensities involved. Apparently ground zero was used as a pasture for a herd of some 1500 reindeer by one of the wealthier Tungus. A few wooden sheds, which were used for warehouses were also in the area. When the natives returned following the explosions, they found the storehouses ruined, everything having been burned or melted. Only charred carcasses were found and the majority of the herd was never seen again, dead or alive.

Another interesting account is given by Kulik in the words of a native who saw the meteoroid from Vanovara, which is about 18 miles from ground zero:

> "About eight o'clock in the morning, I had been sitting on the porch with my face to the north, and at this moment in the northwest direction appeared a kind of fire which produced such a heat that I could not stand it. This overheated miracle I guess had a size of at least a mile. But the fire did not last long, I had only time to lift up my eyes and it disappeared. Then it became dark, and then followed an explosion which threw me down on the porch about 6 ft. or more. I heard a sound as if all houses would tremble and move away. Many windows were broken, a large strip of ground was torn away and at the warehouse an iron bolt was broken."

Physical Data

The energy of the explosion was expended by several different physical processes. By comparing the observed phenomena at the time of the explosion with known data it is possible to estimate the energies and intensities involved.

Table V is based upon data accumulated by Astopavich and gives estimated values of the explosion energy or intensity.

Table V

Physical quantity	Reference data	Estimated value
Acoustic energy	Cracatoa explosion	10^{24} erg.
Ground shock	Earthquakes	10^{22}–10^{23} erg.
Wind intensity	Hurricanes	10^{20} erg. sec.$^{-1}$
Uprooted Trees	Strength of materials	$4{\cdot}4 \times 10^{23}$ erg.
Light intensity	Sunlight	2×10^{19}–10^{24} erg. sec.$^{-1}$

The initial energy required to realize the above values plus the energy expended in digging out craters and heating the ground might well add up to 10^{22} ergs or more, although Astopavich estimates energies of the order of 10^{20}–10^{21} ergs. If the actual energy is placed between 10^{21} and 10^{22} ergs, then the solid curves in Fig. 3

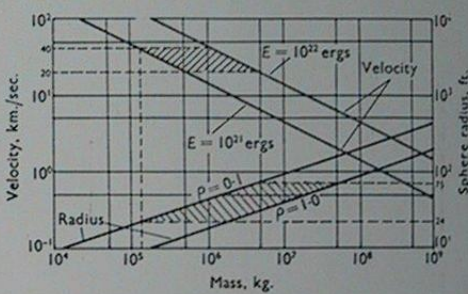

Fig. 3. Relation of the velocity of the Siberian cometoid to the expected mass and size. The energy is assumed to lie between 10^{21} and 10^{22} ergs and the density between 0·1 and 1·0 g./cm.^{3} Russian estimates of speed vary between 20 and 40 km./sec. The corresponding mass is of the order 10^5–10^7 kg. or about 110–11,000 short tons. Depending on the unknown density, the radius of the object must lie between 25 and 100 ft.

relate the mass to the impact velocity, or to an equivalent impact velocity since the entity apparently exploded before impact. This is evident from the numerous craters that were produced.

The trajectory was directed from south to north and had a slope towards the horizon of not more than 18°–24°. The azimuth of the trajectory as seen from the place of fall, was between 164° and 206° N. and the height over the horizon was 4°–24°. This corresponds to a patch on the celestial sphere in the constellation of Cetus. The radiant was not far south of the ecliptic.