DELIVERY OF MATERIAL FROM A TRANS-NEPTUNIAN REGION TO THE EARTH. S.I. Ipatov[1] and A.A. Mardon[2], [1]Institute of Applied Mathematics, Miusskaya sq. 4, Moscow 125047, Russia; ipatov@keldysh.ru. [2]Antarctic Institute of Canada, PO Box 1223, MPO, Edmonton, Alberta, T5J-2M4, Canada; mardon@freenet.edmonton.ab.ca.

Introduction: Some meteorites can be cometary fragments. It is considered by many scientists that the Tunguska event was caused by the explosion of an icy debris of a comet. Active and extinct periodic comets may account altogether for about 20% of the production of terrestrial impact craters larger than 20 km in diameter. Most of Jupiter-family comets came from the trans-Neptunian (Edgeworth-Kuiper) belt. Duncan *et al*. [1] obtained that about 10-20% of trans-Neptunian objects (TNOs) with a semimajor axis $a<50$ AU left the belt during last 4 Gyr and about 1/3 of Neptune-crossing objects reach Jupiter's orbit during their lifetimes.

Objects leaving the trans-Neptunian belt. To our estimates [2], the gravitational interactions of TNOs can also play a role in their migration inside the Solar system, and during last 4 Gyr several percents of TNOs could change their semimajor axes by more than 1 AU due to the close encounters with other TNOs. Even small variations in orbital elements of TNOs caused by their mutual gravitational influence and collisions can cause large variations in orbital elements due to the gravitational influence of planets [3].

Migration of former trans-Neptunian objects to the Earth's orbit. It is considered that there are about 10^{10} TNOs with diameter $d>1$ km and $a<50$ AU. Besides the results obtained in [1], in our estimates of migration of former TNOs inside the Solar system we used the computer investigations results of orbital evolution of Jupiter-crossing objects. It was obtained in [4] that the mean time interval, during which an object crosses Jupiter's orbit during its lifetime, is about 0.2 Myr, the portion of Jupiter-crossers that reach the orbit of the Earth during their lifetimes is equal to 0.2, and the mean time, during which a Jupiter-crossing object crosses the Earth's orbit, is about 5000 yr. We showed [5] that the number of the present Jupiter-crossers with $d>1$ km, which came from the trans-Neptunian belt, is equal to 30,000 and there are about 170 former TNOs with $d>1$ km, which cross both the orbits of Earth and Jupiter, i.e., about 20% of all Earth-crossing objects (ECOs) with $d>1$ km. The number of former Jupiter-crossers that move inside Jupiter's orbit in Encke-type orbits can be of the same order (or even more) than the number of objects that cross both the orbits of Jupiter and Earth. Asher *et al.* [6] showed that the rate at which objects may be decoupled from Jupiter and attain orbits like NEOs is increased by a factor of four or five, producing ~20% of the observed NEO population, if nongravitational forces are included in integrations as impulsive effects.

Collisions of near-Earth objects with the Earth. The mean value of a characteristic time elapsed up to a collision of an ECO with the Earth equals to 100 Myr [7]. Considering that the number of all ECOs with diameter $d>1$ km is equal to 750, we have about 7.5 collisions per Myr. The number of all 100-m ECOs is estimated to be about 70,000-160,000, so such objects collide the Earth on average ones in 600-1400 yr. Tunguska-size objects ($d>70$ m) collide the Earth once in several hundreds (~500) years. The portion of NEOs colliding with the Earth from Jupiter-crossing orbits is smaller than their portion among all ECOs, because the characteristic time elapsed up to a collision with the Earth for a Jupiter-crossing body is larger by a factor of several than that for a typical Apollo object.

Earth Impact Threat. The source of the Earth impacting bodies means that different deflection mechanisms need to be used. This is whether the cometary body has greater percentage of volatiles than objects that are from the inner Solar system. Different deflections due to the composition might mean different nuclear detonation mechanisms might be used. The detection of bolides is a more accurate source for the infalling characteristics of objects than meteorites. Even those recovered from the Antarctic. Comets might also be a valuable source of water and other volatiles in the inner Solar system. Small objects in the inner Solar system that were either formed there or were from the outer Solar system would have likely have lost their volatiles. The Tunguska object if it were to hit a location that has population would cause major loss of life and damage to property. Testing needs to be done to test the efficacy of nuclear deflection technologies on rocky ECOs and former TNOs. Their is likely a difference in the technologies that would need to be used to deflect an Earth impacting body.

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