Estimation of the energy released in the igneous province of Deccan as a result of an asteroid impact to the Gulf of Mexico at the K-Pg boundary

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According to one hypothesis [1], the impact of a ten-kilometer body to the Gulf of Mexico (Chicxulub crater) is not the main cause of mass extinction at the K-Pg boundary. However, the impact can be considered as a trigger for increasing volcanic activity at the end of the main stage of eruptions in the igneous province of Deccan (India), which is about 13,000 km away from the Chicxulub crater. A seismic energy release in the mantle plume region is considered as the mechanism. According to [1], the bulk energy density should be about 0.1-1.0 J/m^3 for the excitation of volcanic processes in the igneous province. This energy range is justified by both observational data on volcanic eruptions initiated by earthquakes and the results of 3-D numerical modeling of seismic processes developing upon the impact of a ten-kilometer body.

To broaden our understanding of the energy balance in the area of propagation of seismic disturbances, we proposed a method for estimating the bulk energy density induced by sources of various magnitudes at different distances. This method includes a number of formulas compiled from various references. The input parameter is a magnitude, which directly depends on the seismic disturbance energy, i.e. we need to determine the conversion factor "k"of the kinetic energy of a cosmic body into seismic energy (seismic efficiency). According to recent laboratory studies and our theoretical studies, the average value of "k"is 0.001. Theoretical estimates are substantiated by numerical simulations of the propagation of ground shock waves, initiated both by the impacts of crater-forming cosmic bodies and by underground explosions. It was shown that the seismic efficiency obtained from the explosion tests, reduced by a factor of 3-5, can be used to estimate the seismic effect of crater-forming impacts of space bodies. For underground explosions, seismic efficiency is determined with a good accuracy and practically does not depend on the explosion energy. The seismic efficiency is (1-3)$\times$0.01 for underground explosions in granite. Given the composition of the soil, we estimated the average value of "k"as 0.001. Under this condition, the estimate of the bulk energy density, released as a result of the Chicxulub impact, gives values in a range of 0.1-1.0 J/m**3 at distances from 10,000 km to 15,000 km.

However, our analysis of the data used by Richards M.A. et al. (2015) shows that only for moderate magnitudes (less than 6) the energy density falls in the range of 0.1-1.0 J/m^3 on average. The energy density is, on average, an order of magnitude higher for magnitudes 7-8. If we use our estimate for magnitudes not exceeding 8, then all observational data fall in the range of 10-100 J/m^3. Neither estimates nor calculations predict such high values of energy density after the impact of a ten-kilometer body at distances exceeding 10,000 km from the impact point.

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References: [1] Richards M.A. et al. 2015. GSA Bulletin 127(11-12): 1507-1520.