Trigger effect of an asteroidal impact at the Permian-Triassic boundary

Svetsov V.V., Shuvalov V.V.

Institute of geospheres dynamics of Russian academy of sciences, Moscow, Russia

e-mail: svettsov07@rambler.ru

The causes of all mass extinctions are not precisely clarified and remain the subject of controversy. Severe extinction can occur when the biosphere under prolonged stress is subjected to strong short-term effects [1]. Many researchers believe that the impact of an asteroid with a diameter of 10-20 km is the main cause of the Cretaceous-Paleogene mass extinction event. It has been suggested that similar impacts could have caused other extinction events. For the largest Permian-Triassic mass extinction, the corresponding impact crater has been found, the 40 km Araguainha crater in Brazil, which has been dated to 254.7 ± 2.5 million years ago, overlapping with estimates for the Permian-Triassic boundary [2]. The estimated diameter of an asteroid at the Araguainha impact is about 3 km, which is insufficient for a direct cause of the global mass extinction. However, the impact can trigger other kill mechanisms. The impact of an asteroid with a diameter of 3 km and a speed of 20 km/s causes an earthquake of magnitude 9.5-10 [3]. Studies of the Paraná Basin, a large cratonic sedimentary basin comprising the Araguainha crater, show the evidence of the impactogenic earthquake caused by the Araguainha impact. Widespread occurrence of seismites is constrained to a stratigraphic horizon occupying the uppermost 10-100 m of the Passa Dois Group (Permian sedimentary rocks). And the lateral extent of soft-sediment deformations occurs within a radius of about 1000 km from the Araguainha impact site. The earthquake was accompanied by a large tsunami wave loaded with both washed off sediments and impact ejecta [4]. Much of the local rock was oil shale. It was suggested that the passage of this wave could cause rapid changes in lithostatic pressure for the oil shales (60-200 m below the paleosurface) contributing to the release of trapped methane from the organic-rich rock [5]. The estimates [5] give that around 1600 gigatonnes of methane were released into the atmosphere at that time, which would have significant climatic consequences. We have assessed another trigger mechanism of the impact - fires initiated by radiation from the impact plume. Numerical simulations of the impact of a 3-km-diameter asteroid with calculations of the radiation fluxes on the ground [6] show that ignition of easily combustible materials, such as dry grass, can be started within a radius of 2000 km from the impact site. The burning of volatile components from oil shale can aggravate the situation, leading to an increase in the amount of carbon dioxide in the atmosphere.

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