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Global cooling and mass extinction driven by a dark cloud encounter

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We found a broad positive anomaly in iridium across over ∼5 m in a pelagic deep sea sediment core sample, in addition to a spike in iridium at the K-Pg boundary related to the Chicxulub asteroid impact. Any mixtures of materials on the surface of the Earth cannot explain the broad iridium component. On the other hand, we found that an encounter of the solar system with a giant molecular cloud can explain the component, if the molecular cloud has a size of ∼100 pc and the central density of ∼2000 protons/cc.

Kataoka *et al*. (2013; 2014) pointed that the encounter with a dark cloud may drive an environmental catastrophe to lead a mass extinction. The solid particles from the dark cloud accreted onto the Earth and stayed for several months or years in the stratosphere: Since their sunshield effect is as large as -9.3 W m^{-2}, it can be a cause of a global climate cooling in the last 8 Myr of Cretaceous period, which is suggested by the variations of stable isotope ratios in oxygen (Barrera & Savin, 1999; Li & Keller, 1999; 1998; Barrera & Huber, 1990) and strontium (Barrera & Savin, 1999; Ingram, 1995; Sugarman *et al*., 1995). The resultant extensions of the continental ice sheet cause a regression of the sea level, too. The global cooling seems to be associated with the decrease in the diversity of fossils, which eventually lead to the mass extinction at the K-Pg boundary.

The mass extinction at K-Pg boundary is widely thought to be caused by an impact of an asteroid (Alvarez *et al*., 1980; Schulte *et al*., 2010) at 65.5 Ma. However, a complete extinction of the total family by just one asteroid impact seems rather difficult because of the following two reasons. (1) A severe environment turn-over would finish few years after impact, the solid particles and sulphate launched by the asteroid impact is settled down for only few months (troposphere) to few years (stratosphere) and negative radiative forcing become negligible after a few years from the impact. (2) There were similar impacts without environmental catastrophe on the Earth, for example, Woodleigh, Chesapeak and Popigai craters. However, there are no evidences of association for mass extinction. It is difficult to explain why only Chicxlub impact leads mass extinction but the other three comparable impacts did not.

It is worth noting that the encounter with the dark cloud can perturb the orbit of asteroids and comets by its gravitational potential may cause asteroid impact or comet shower. The asteroid impact at K-Pg, therefore, may be one of the consequences of the dark cloud encounter.

We conclude that the cause of the climate cooling at the End-Cretaceous was driven by an encounter with a giant molecular cloud, with such an encounter and related perturbation in global climate a more plausible explanation for the mass extinction than a single impact event, Chicxulub.

Keywords: Nebula Winter, dark cloud encounter, Space Climate, End-Cretaceous, K-Pg boundary, mass extinction