

Mass extinctions: hierarchy of causes and cosmoclimatological perspective

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This paper reviews possible causes proposed for the double-stepped extinction in regard of the current status of mass extinction studies. Causes of extinction can be grouped into four categories; from small to large scale, Category 1 to Category 4. Category 1 –direct kill mechanism, Category 2 –global environmental change, Category 3 –trigger on the planet’s surface, and Category 4 –ultimate cause. Among the Big-5 mass extinctions of the Phanerozoic, two events in the Paleozoic, i.e., the Hirnantian (Ordovician) and end-Guadalupian (Permian) events, show significant similarities in various aspects. Biological and non-biological aspects unique to these two distinct events include changes in biodiversity, isotope ratios (C, Sr etc.) of seawater, sea level, ocean redox state, episodic volcanism, and geomagnetism. In particular, the similar appearance of global cooling (Category 2) suggests the same cause and processes were likely responsible for the biodiversity drop. In addition to the most prevalent scenario of mantle plume-generated large igneous provinces (LIPs) (Category 3) for the end-Permian extinction, an emerging perspective of cosmoclimatology is introduced with respect to astrobiology. Galactic cosmic radiation (GCR) and solar/terrestrial responses in magnetism (Category 4) could have had a profound impact on Earth’s climate, in particular, on extensive cloud coverage (irradiance shutdown). Furthermore, the star-burst events detected in the Milky Way Galaxy apparently coincide in timing with the cooling-associated major extinctions of the Phanerozoic and also with the Proterozoic snowball Earth episode. As an ultimate cause (Category 4) for major extinction, the episodic increase in GCR flux from the source (dark clouds derived from star-burst) against the geomagnetic shield likely determined the major climate changes, particularly global cooling in the past. The study of mass extinctions on Earth is entering a new stage with a new astrobiological perspective.

Keywords: mass extinction, global cooling, GCR, extinction cause