N89-21409

COLLISIONS WITH ICE-VOLATILE OBJECTS: GEOLOGICAL IMPLICATIONS; P. Wilde, M. S. Quinby-Hunt, and Berry, W. B. N., *Marine Sciences Group, University of California, Berkeley, California 94720*

The collision of the Earth with extra-terrestrial ice-volatile bodies is proposed as a mechanism to produce rapid changes in the geologic record. These bodies would be analogs of the "ice" satellites found for the Jovian planets[1,2] and suspected for comets and certain low density bodies in the Asteroid belt. Five generic end-members are postulated: (I) water ice; (II) dry ice: carbon-carbon dioxide rich, (III) oceanic {chloride} ice; (IV) sulfur-rich; (V) ammonia hydrate-rich ice; and (VI) clathrate: methane-rich ice. Due to the volatile nature of these bodies, evidence for their impact with the Earth would be subtle and probably best reflected geochemically or in the fossil record[3]. Actual boloids impacting the Earth may have a variable composition generally some admixture with water ice. However for discussion purposes, only the effects of a "dominant" component will be treated. The general geological effects of such collisions, as a function of the "dominant" component would be (1) rapid sea level rise unrelated to deglaciation [type I; (2) decreased oceanic pH and rapid climatic warming or deglaciation [type II]; (3) increased paleosalinities [type III]; (4) increased acid rain [type IV]; (5) increased oceanic pH and rapid carbonate deposition [type V]; and (6) rapid climatic warming or deglaciation. The extent of all effects would depend on the size of the boloid and to the extent of evaporation as it passes through the atmosphere.

The effects of a collision of type I boloid would be a rapid sea level rise unrelated to deglaciation. Fluctuations of sea level that cannot be explained as glaciation/deglaciation events are observed in the Cretaceous. The earth in Cretaceous time is generally considered to have been ice free.[4]

Type II boloids would introduce massive amounts of CO_2 to the atmosphere, enhancing the greenhouse affect and causing a climatic warming resulting in deglaciation. The oceanic pH would decrease. The low pH might inhibit the use of carbonate causing decreased production of calcareous tests, as is seen at the end of the Cretaceous. At the K-T boundary event, the rudistid bivalves and ammonites became extinct; large massive reef corals were greatly reduced, as were the calcareous nannofossils.[5-7]

The impact of a Type III chloride-rich boloid would initially increase the levels of HCl in the atmosphere. The resulting acidic rain would dramatically lower the pH of rain, fresh and sea waters. Such an input could result in mineral dissolution, potentially increasing the salinity of the bodies of water affected. Following such dissolution, massive amounts of evaporates could be formed, due to precipitation of the insoluble sulfates of the cations dissolved by the HCl. Such evaporites appear in the Permo-Triassic and throughout the rock record.[8] Similarly, a Type IV boloid, which would raise the concentration of sulfates and sulfites in the ocean, could cause deposition of evaporites due to precipitation of sulfates.[9]

In addition, either a Type III or Type IV boloid could lower the pH of rain, fresh and marine waters to an extent determined by the size of the boloid and the buffer capacity of each body of water. This could result in massive loss in diversity in land plants.[10,11] The impact of altered pH in marine waters would depend on the extent of change due to the impact and the variation in pH the species have already adapted to. Thus estuarine species may have adapted to large variations in pH, and could survive or even thrive after an impact. Marine species may not be effected, due to the large buffer capacity of the ocean which may prevent any large variation in pH. However, a sufficiently large influx of acid could locally overwhelm the buffer system. If organisms have adapted to relatively constant pH, a relatively small change in pH could be inhibiting.

The impact of an ammonia-rich boloid (Type V) would cause increased concentrations of ammonia in the atmosphere or in waters, resulting in increased pH in rain and marine waters depending on the size of the boloid and the buffering capacity of the body of water. As for a sulfur-rich boloid, the impact of such pH and concentration changes, would depend upon the pre-adaptation and sensitivity of the organisms involved. Because ammonia is a nutrient species, organisms adapted to variations in pH would be highly competitive relative to those used to waters with restricted pH variability. The effects of such a collision might be observed as losses in species diversity among some types of organisms and a concomitant increase in those species to whom increased nutrient concentrations are advantageous.[3]

REFERENCES

1. Stevenson, R. J. (1987) An evolutionary framework for the Jovian and Saturnian satellites. *Earth, Moon and the Planets*, 39, 225-236

2. Wilde, P. (1987) Primordial origin of the oceanic Rubey volatiles as a consequence of accretion of ice-sulfur planetesmals. *EOS*, 68(44), 1337.

3. Berry, W. B. N., Wilde, P. and Quinby-Hunt, M. S. (1988) Late Wenlock (Middle Silurian) Bio-Events: caused by volatile boloid impact/s?. Abstract, this volume.

4. Schlanger, S.O. (1986) High frequency sea-level fluctuations in Cretaceous time: An emerging geophysical problem, *Mesozoic and Cenozoic Oceans*, Geodynamics 15, 61-64.

5. Perch-Nielsen, K. (1988) Uppermost Maastrichtian and lowermost Danian calcareous nannofossil assemblages. *Abstracts: Third International Conference on Global Bioevents: Abrupt Changes in the Global Biota*. International Palaeontological Association (IPA), International Geological Correlation Programme (IGCP; Project 216), University of Colorado, Boulder, CO, p.29

6. Wiedmann, J. (1986) Macro-invertebrates and the Cretaceous-Tertiary boundary. *Global Bio-Events*, Lecture Notes in Earth Sciences 8, O.H. Walliser, ed., Springer-Verlag, Berlin, pp. 397-409.

7. Johnson, C.C. and Kauffman, E.G. (1988) Extinction patterns in Cretaceous reef. *Abstracts: Third International Conference on Global Bioevents: Abrupt Changes in the Global Biota*. International Palaeontological Association (IPA), International Geological Correlation Programme (IGCP; Project 216), University of Colorado, Boulder, CO, p.21.

8. Borchert, H. (1965) Principles of oceanic salt deposition and metamorphorphism, in: *Chemical Oceanography*, J.P. Riley and G. Skirrow, eds., 2, Academic, New York, pp.205-276.

9. Railsback, L.B. and Anderson, T.F (1987) Control of Triassic seawater chemistry and temperature on the evolution of post-Paleozoic aragonite-secreting fauna, *Geology*, 15, 1002-1005.

10. Johnson A.H. and T.G. Siccama (1983) Acid deposition and forest decline, *Environ. Sci. Tech.*, 17, 294.

11. National Research Council, Committee on Atmosphere Transport (1983) Atmospheric transport and chemical transformation in acid precipitation, in *Acid Deposition: Atmospheric Processes in Eastern North America,* National Academy Press, Washington, DC.