N89-21295

LATE WENLOCK (MIDDLE SILURIAN) BIO-EVENTS: CAUSED BY VOLATILE BOLOID IMPACT/S?; W. B. N. Berry, P. Wilde, and M. S. Quinby-Hunt, *Marine Sciences Group, University of California, Berkeley, California 94720*

Late Wenlockian (Late mid-Silurian) life is characterized by three significant changes or bioevents: (I) sudden development of massive carbonate reefs after a long interval of limited reef growth;[1,2] (II) sudden mass mortality among colonial zooplankton, graptolites;[3] (III) origination of land plants with vascular tissue (Cooksonia).[4] Both marine bioevents are short in duration and occur essentially simultaneously at the end of the Wenlock without any recorded major climatic change from the general global warm climate. Coeval marine level bottom shelf communities experienced moderate change. Certain new taxa of brachiopods appeared in the late Wenlock marine shelf fauna.[5] These included many ribbed, relatively thick-shelled pentameroids or certain eospiriferids. These organismal events took place in water oceanward from the shallow subtidal zone. The oldest vascular land plant material has been recovered from latest Wenlock strata in Ireland.[3] Ireland was within the tropics during the Silurian.[6]

These three disparate biologic events may be linked to sudden environmental change that could have resulted from sudden infusion of a massive amount of ammonia into the tropical ocean. Impact of a boloid or swarm of extraterrestrial bodies containing substantial quantities of a volatile (ammonia) component could provide such an infusion.[7,8] Major carbonate precipitation (formation), as seen in the reefs as well as, to a more limited extent, in certain brachiopods, would have been favored by increased pH resulting from addition of a massive quantity of ammonia into the upper ocean.[9,10] Initially, the elevated ammonia concentrations and increased pH could have been inhibiting to some marine species.[11] However, with time, ammonia concentrations would have been diluted near the point of impact, and, due to transport, increased over a broader region. At these concentrations, ammonia could act as a nutrient for marine photosynthesis, enhancing primary productivity.[12] Such enhancement could have led to increased food resources for coral polyps. Some graptolites, ocean plankton that lived in or near waters with low-oxygen content, may have been sensitive to increased pH or increased ammonia concentrations as the result of ammonia influx. Many modern marine zooplankton find small changes in pH and/or increases in ammonia concentration are inhibiting to toxic.[11]

Because of the buffer capacity of the ocean[13] and dilution effects, the pH would have returned soon to some point of equilibrium. When that happened, graptolites re-radiated, as indicated by the stratigraphic record.[4] Major proliferation of massive reefs ceased at the same time. Addition of ammonia as fertilizer to terrestrial environments in the tropics would have created optimum environmental conditions for development of land plants with vascular, nutrient-conductive tissue. Prior to ammonia bolide impact, appropriate terrestrial environments may not have had enough nitrogen compounds available to make development of vascular tissue viable. Cooksonia developed slightly later than the onset of massive coral reef development and mass mortality among the graptolites. Fertilization of terrestrial environments thus seemingly preceded development of vascular tissue by a short time interval. Although no direct evidence of impact of a volatile boloid may be found, the bioevent evidence is suggestive that such an impact in the oceans could have taken place. Indeed, in the case of an ammonia boloid, evidence, such as that of the Late Wenlockian bioevents may be the only available data for impact of such a boloid.

At such times as the Wenlock, which were non-glacial and during which warm climates were widespread; the major observable effects would have been from increase in pH. With the great buffer capacity of the ocean, the pH eventually would return to some new equilibrium value as demonstrated by the reradiation of the graptolites in the Late Silurian.[3]

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