Warming and cooling in the Phanerozoic: gigantism of marine bivalves and its end

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The biodiversity change in the Phanerozoic likely reflected the long-term temperature change on the Earth's surface. The overall diversity tends to increase during warm periods, and decline during the colds, thus cooling appears more critical than warming in maintaining biodiversity. Cooling has a profound impact particularly to low latitude areas with high diveristy. During a cooling period, biota in high- and mid-latitudes can migrate to low-latitudes, whereas tropical fauna have nowhere warmer to evacuate and thus become extinct. Global warming may cause the opposite, but the damage is samller because of lower diversity and smaller areas of high latitudes.

The intermittent rise and fall of bivalve gigantism in the Phanerozoic may have been tuned by the long-term history of global warming/cooling. The gigantism in bivalves has a long history since the middle Paleozoic. Giant bivalves appeared intermittently at least 5 times in the Phanerozoic, i.e. 1) the Silurian-Devonian megalodonts, 2) Permian Alatoconchidae, 3) Late Triassic to Early Jurassic megalodonts/lithiotids, 4) Late Jurassic to Cretaceous rudists/inoceramids, and 5) Miocene-modern tridacnids. Most of these aberrant bivalves occurred in shallow marine environments of low latitude domains or under extremely warm climates. This suggests that the gigantism represents a common style of adaptation to warm-water (probably tropical) shallow marine environments for bivalves, and that bivalves attained extraordinary size likely through symbiosis. Most of them including the oldest likely have performed photosymbiosis, whereas some (e.g., lithiotids and inoceramids) may have deployed different (non-photosymbiotic) strategies, such as chemosymbiosis like modern Calyptogena. The rise of photosymbiotic giant bivalve likely occurred during the warming periods. Algal-bivalve symbiosis was established several times in history.

The bivalve gigantism specialized for the tropic domain appears fragile, because their survival is highly dependent upon the stability of warm environments. Although the symbiosis between bivalves and photosynthetic bacteria/algae started in the Early Silurian, it is noteworthy that none of gigantic bivalve lineages lasted for a considerably long time, longer than two geologic periods (more than a hundred million years). The intermittent rise and decline of the photosymbiotic giant bivalves in the Phanerozoic may have been controlled by the long-term change in global climate. Megalodonts appear like the champion of long lineage; however, their total range in fact consists of 2 distinct acmes, i.e., one in the Siluro-Devonian and the other in the Late Triassic-Early Jurassic, that are separated by a remarkably long interval of decline/disappearance in the Late Paleozoic. This interval includes the Gondwana glacial period. As observed in the extinction case of Permian Alatoconchidae during the Kamura cooling event, cooling, even in a short duration, appears a crucial cause for terminating gigantism. The disappearance of megalodonts at the end of the Early Jurassic and that of rudists at the end of Cretaceous may have been likewise related to short-term cooling/eutrophication possibly associated with the Toarcian event and K-T boundary event, respectively.

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