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The Ordovician biodiversification: Setting an agenda for marine life

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Abstract

Profound changes in the biodiversity and biocomplexity of marine life occurred during the early to mid-Ordovician through an interval of some 25 Myr. The planet's seascapes were changed forever with massive hikes in biodiversity, the installation of a benthos dominated by suspension feeders together with the introduction of many new megaguilds; increased bioturbation, biotic tiering above and below the sediment–water interface, the more widespread prevalence of hard substrates, in a calcite sea, and the development of new reef formers helped drive these changes. The strong and varied regional and taxonomic components of the global signal emphasize the extrinsic controls on the radiation. A model involving the cascading development of γ (inter-provincial), β (inter-community) and α (intra-community) diversity highlights the interplay between ecology, environment, geography and adaptive strategy during the event. Further deconstruction of the event into individual taxonomic and regional components together with the acquisition of more environmental and isotopic data are required to elucidate the causes of this marked and multifaceted biodiversification.

Keywords: Ordovician; Biodiversity; Palaeoecology; Palaeobiogeography

1. Background

During a protracted interval of some 25 Myr, during the mid to late Ordovician, the biological component of the planet's seafloors was irreversibly changed. A massive hike in biodiversity (Sepkoski, 1981) was matched by an increase in the biocomplexity of marine life (Droser and Sheehan, 1997). The Great Ordovician Biodiversification is one of the two most significant evolutionary events in the history of Palaeozoic life. By contrast, however, to the Cambrian explosion, which has been well documented in many books and symposia together with many hundreds of publications, there are relatively few major published studies on the Ordovician diversification; an exception is the recently published compilation by Webby et al. (2004a,b). The Cambrian explosion involved the origins of skeletalization and a range of new body plans together

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with the extinction of the soft-bodied Ediacara fauna and the appearance of the Bilateralia. The Ordovician diversification (Fig. 1), by contrast, generated few new higher taxa, for example phyla, but witnessed a staggering increase in biodiversity at the family, genus and species levels. This taxonomic radiation, which included members of the so-called 'Cambrian, Paleozoic and Modern' evolutionary biotas, set the agenda for much of subsequent marine life on the planet against a background of sustained greenhouse climates. Although many taxa counts are available through 45 million years of the Ordovician Period, there are relatively few studies of the ecological and environmental aspects of this diversification (Bottjer et al., 2001). Moreover the causes of the event, and its relationship to both intrinsic (biological) and extrinsic (environmental) factors, are far from clear.

In many ways the Ordovician Period was unique (Jaanusson, 1984). The period was thalassocratic with extensive, epicontinental seas, with virtually flat seabeds, and restricted land areas, many probably represented only by archipelagos. Magmatic and tectonic activity was intense with rapid plate movements and widespread volcanic activity. Island arcs and mountain belts provided sources for clastic sediment in competition with the carbonate belts associated with most of the continents. Biogeographical differentiation was extreme affecting plankton, nekton and benthos and climatic zonation, particularly in the southern hemisphere. Together conditions were ideal for both allopatric and sympatric speciation processes together with opportunities for canalization of ecological niches. Most significant was the diversification of skeletal organisms, including the brachiopods, bryozoans, cephalopods, conodonts, corals, crinoids, graptolites, ostracodes, stromatoporoids and trilobites.

Disassembly of the strong global signal into ecological, taxonomic and regional components has further emphasized the many facets of this complex event. Although the ecological and taxonomic amplitudes of the biodiversification may indeed be decoupled, there are important feedback loops in the process. The hike in biodiversity and marked change in biocomplexity significantly changed the planet's seafloors and provided a new agenda for much of subsequent marine life.

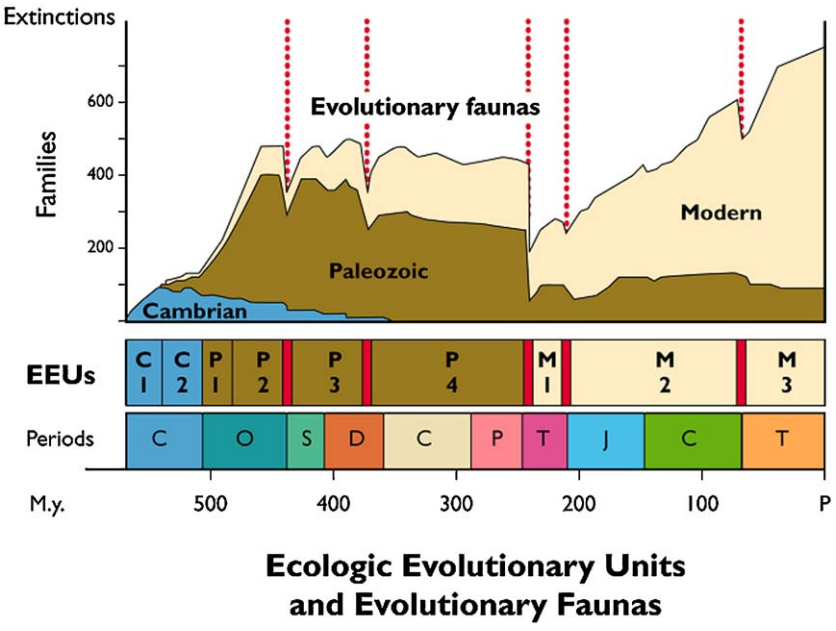

Fig. 1. Family diversity of skeletonized marine invertebrates during the Phanerozoic, together with Sepkoski's three, statistically based, marine evolutionary faunas; diagram includes Boucot's evolutionary ecologic units, modified by Sheehan, together with an indication of the five big extinction events (modified from Sheehan, 1996).