What is so special about the Ordovician?

By VALDAR JAANUSSON

Some of the most distinctive features of the Ordovician Period appear to have been (1) an extreme thalassocratic distribution of the land and sea, with associated extensive development of epicontinental carbonate sediments, (2) profound changes in the composition of skeleton-bearing faunas during the Period because of the appearance or diversification of numerous major taxonomic groups, and (3) a pronounced biogeographical differentiation. The Ordovician south pole had an ice cap whereas in the northern polar area no ice cap was developed. The important change in the biogeographical pattern from the Ordovician to the Silurian might have been associated with the disappearance of the southern ice cap.

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The purpose of this paper is to outline those general aspects that make the study of Ordovician fossils and rocks both challenging and rewarding. Emphasis is placed on features which may be said to be particularly distinctive to the Peroid as a whole.

The Ordovician Period was pronouncedly thalassocratic, in the sense that epicontinental seas had a greater extent than in almost any other period and land areas were relatively small, being represented on most cratons by archipelagos rather than continents. The cratonic land areas were mostly of low relief, the rivers had gentle gradients and low energy of transport. The resulting low supply of terrigenous material to the epicontinental seas facilitated widespread deposition of carbonate sediments, mostly on a sea floor that was almost perfectly flat. It is difficult to find modern counterparts for these conditions, and this in turn renders it difficult to understand some of the depositional processes.

Movements along several plate boundaries gave rise to mountain belts, many as island arcs. Erosion of both these uplifted areas and cratonic land areas adjacent to the Ordovician south pole appears to have been the principal producer of terrigenous sediment. The widespread volcanic activity associated with the plate movements was more intense than during almost any other geological period (see, e.g., Stillman in this volume).

The composition of the skeleton-bearing benthic fauna and flora changed markedly during Ordovician times. In this respect, the Ordovician is one of the most interesting periods in the history of marine faunas. A number of major taxonomic groups appeared or became common and diverse for the first time. The list of such groups is long, but the most important are stromatoporoids, various corals, pelecypods, cephalopods, cystoids, crinoids, echinoids, ostracodes with a calcitic exoskeleton, and bryozoans. Representatives of these groups are either absent or very rare in the Cambrian. Among planktic groups graptoloids appeared and euconodonts became common and diverse.

The successive appearance of new major groups affected the composition of skeleton-bearing benthic associations, so that to a large extent the quantitatively dominant organisms in the later part of the Ordovician belong to taxonomic groups that had either not evolved or were very rare in the earliest part of the Period. The change in the composition of the skeleton-bearing associations is even more accentuated if one takes into account the successive appearance of new taxa at superfamily or order level within major groups that were already common in the Cambrian. Examples are the enteletacean, plectambonitacean, strophom-

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enacean, rhynchonellacean, and atrypoid articulate brachiopods, and trinucleid trilobites. Soon after their appearance these became common to dominant constituents in many assemblages. In the Lower Ordovician, organic reefs are rare, mainly because the principal skeleton-bearing groups which formed the frame in later Ordovician non-algal reefs had not yet acquired the ability, or lacked the selection-induced necessity, to secrete skeletons.

Concomitantly with the successive appearance of the new groups, a biotic organisation of the benthic epifauna developed that characterises many of the subsequent Palaeozoic epifaunas but differs in several respects from the organisation of modern counterparts. The presence of many forms with an ambitopic (attached in juvenile stages, recumbent as adults) or recumbent mode of life make the distinction between soft-bottom and hard-bottom epifaunas less sharp than on the modern sea floor (Jaanusson *in* Jaanusson *et al.* 1979: 272). In modern benthic faunas, sedentary organisms lying free on the substrate are rare, and for this reason a community itself does not produce patches of hard-bottom to the same extent as in the Palaeozoic.

The Ordovician Period was also characterized by an extreme biogeographical differentiation of marine faunas (for a recent summary, see Jaanusson 1979), more extensive than during most other periods. This affected both benthic and planktic faunas, but the degree of differentiation in the planktic graptoloids and conodonts is far weaker than in the benthic faunas. In modern seas the primary factor regulating the distribution of faunal provinces is temperature (see Ekman 1953). According to palaeomagnetic data, the Ordovician north pole was situated somewhere in the present north-western Pacific ocean, apparently far away from any continental plates (for recent, somewhat conflicting reconstructions of Ordovician geography see Scotese *et al.* 1979; Smith 1981; Smith *et al.* 1981; Spjeldnæs 1981). This implies that there was no northern ice cap, because water in the polar region had free exchange with the vast thermal reservoir of the oceans. This in turn suggests that climatic zones of the Ordovician northern hemisphere were probably poorly defined. On the other hand, the Ordovician south pole was most probably situated on a continent, possibly in north-western or western Africa. An ice cap was present, and southern climatic zones were well defined. An important event at the end of the Ordovician Period was an extensive glaciation in areas close to the south pole (Beuf *et al.* 1971; Allen 1975), which obviously had important eustatic effects. One of the main reasons for the strong Ordovician biogeographical differentiation appears to have been the pronounced climatic zonation in the southern hemisphere, coupled with restriction of communication between various epicontinental seas.

The pronounced biogeographical differentiation in the Ordovician contrasts sharply with the almost cosmopolitan distribution pattern of the succeeding Llandovery faunas. In fact, the change in the degree of biogeographical differentation at the Ordovician-Silurian boundary appears to be one of the most remarkable events in the history of marine faunas. The reason for this change is not clear. The late Ordovician glaciation itself has been suggested as playing a decisive role in the change of biogeographical pattern (Sheehan 1973, 1975), but the far more extensive Pleistocene glaciations do not appear to have produced effects of a comparable magnitude on marine faunas. A strong reduction or disappearance of the southern polar ice cap at that time would have produced a sufficient effect, particularly if the location of the pole had shifted from a continent to an ocean. However, the latter possibility is not supported at present by reconstructions of Silurian geography. A model for Silurian climate without polar ice caps has also been suggested by Spjeldnæs (1981).

We are still far from understanding Ordovician biogeographical relationships, partly because it is difficult to distinguish between what in the known spatial distribution of faunas is due to ecological factors and what is due to geographical factors. Another reason is that we still lack reliable palaeomagnetic data on the approximative latitudinal position of many Ordovician plates, and in several cases it is not clear what constituted an individual plate.

The pronounced biogeographical differentiation of faunas is also one of the main reasons why it is difficult to correlate and classify Ordovician deposits, not only on an intercontinental scale but even between adjacent regions. With regard to stratigraphical classification, the Ordovician is perhaps the most confused of all periods. The problems of correlation have not been made easier by the fairly recent observations (Jaanusson 1976) that changes in benthic and planktic faunas are often not contemporaneous. Changes in both graptoloid and conodont faunas occur at levels at which no conspicuous change can be detected in local benthic faunas and, likewise, major changes in benthic faunas take place at levels where no corresponding change can be proved in graptolite faunas. The factors that influenced the change in planktic faunas were mostly different from those that affected local benthic faunas.

Many problems remain as a basis for future research on Ordovician rocks and fossils. Some pertinent fields in which our knowledge is particularly unsatisfactory, such as the paucity of reliable palaeomagnetic data, are mentioned above. A solid taxonomic framework is a necessary foundation for stratigraphical, ecological and even palaeogeographical conclusions, and much taxonomic work remains to be done. Large faunas await description or revision, and I would like to emphasise the importance of more extensive studies of calcareous algae. My particular wish for future research is that sedimentologists and palaeontologists should work more closely together and individual workers should combine lithological and faunal studies as a mean of presenting more coordinated interpretations of Ordovician patterns and processes.

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