Distribution of the *Hirnantia* fauna and its meaning

By RONG JIA-YU

The geographic and stratigraphic distribution of the late Ashgill *Hirnantia* brachiopod fauna is here recorded and discussed based mainly on Chinese data. The *Hirnantia* fauna from the Kuanyinchiao Beds and their equivalents in southern China is approximately contemporaneous with the late Ordovician graptolite zones of *Dicera tograptus mirus*, *Paraorthograptus uniformis* and *Diplograptus bohemicus*. The *Hirnantia* faunal assemblage became extinct before the *Glyptograptus persculptus* Zone, although the fauna is undoubtedly diachronous. Ecologic communities of the *Hirnantia* fauna are discussed. The present data reveal that the distribution of the *Hirnantia* fauna might not be restricted to one hemisphere and its development was not necessarily controlled by a cold water environment. It probably extended into the temperate and even subtropical zones during the latest Ordovician. The ecologic distribution of the main elements of the *Hirnantia* fauna were much broader than previously thought.

Rong Jia-yu, Nanjing Institute of Geology and Palaeontology, Academia Sinica, Chi-Ming-Ssu, Nanjing, The People’s Republic of China.

The *Hirnantia* fauna is a geographically widespread and distinctive brachiopod fauna that occurs near the boundary between the Ordovician and Silurian systems. It seems to have appeared abundantly at the beginning of the Hirnantian (i.e. Late Ashgill), spread rapidly, and become extinct as a whole fauna beneath the *Glyptograptus persculptus* Zone. Temple (1965) introduced the term *Hirnantia* fauna for the brachiopod assemblage in the *Dalmanitina* Beds of the Holy Cross Mountains of S. Poland, the Ashgill Shales of N. England, and the Hirnant Beds of N. Wales. The common taxa in this fauna are *Hirnantia sagittifera* (M’Coy), *Dalmanella testudinaria* (Dalman), *Kinnella kielanae* (Temple), *Paromalomena polonica* (Temple), *Eostropheodonta himantensis* (M’Coy) and *Plectothyrella crassicosta* (Dalman) (*P. platystrophoides* Temple). The unusually distinctive *Hirnantia* fauna is commonly associated with the trilobites *Dalmanitina* (*Mucronaspis*), *Bron giartella* and *Leonaspis* (Kielan 1960). Since 1965 the *Hirnantia* fauna has been recognized from the following areas: Bohemia (Marek & Havlček 1967; Havlcek 1977), Västergötland, Sweden (Bergström 1968), Kildare, Ireland (Wright 1968), Keisley, England (Temple 1968), Maine, U.S.A. (Neuman 1968), Anti-Atlas, Morocco (Havlcek 1971; Destombes 1976), Carnic Alps, Austria (Schönlauß 1971; Jaeger et al. 1975), W. Libya (Havlcek & Massa 1973), Quebec, Canada (Lesperance 1974; Lesperance & Sheehan 1976, 1981), Southwest Wales (Cocks & Price 1975), Kazakhstan (Nikitin 1976), Southern China (Rong 1979), Kolyma (Oradovskaya & Sobolevskaya 1979), Anticosti Island, Canada (Cocks & Copper 1981), the Garth area, Wales (Williams & Wright 1981), and the Girvan District, Scotland (Lamont 1935; Harper 1981) (Fig. 1). The Burmese brachiopod assemblage described by Reed (1915), from the Northern Shan States, should also be considered as a representative of the *Hirnantia* fauna in southeastern Asia. Amsden (1971, 1974) compared the brachiopod fauna from the Noix Limestone (lower part of the Edgewood Group), with the *Hirnantia* fauna and noted that these two faunas had some genera in common and were probably of the same age. However, in general these two faunas have a different composition. There are many genera in the older Edgewood fauna, such as *Stegerhynchus*, *Brevilamnulella*, *Dolerorthis*, *Eospirigerina*, *Leptoskeldion*, *Thebesia*, *Orthostrophella*, "Homoeospira", *Dictyonella* and others, which are un-
known in the typical *Hirnantia* fauna, and conversely there are a number of genera in the *Hirnantia* fauna, for example, *Draborthis, Kinnella, Paromalomena, Leptaenopoma, Eostrophodonta, Plectothyrella, Hindella* and others, which are not present in the Edgewood fauna (Amsden 1974: 28). The older Edgewood fauna, therefore, seems significantly different from the *Hirnantia* fauna at both the generic and specific level.

**Hirnantia** fauna in China

Recent discovery of the widespread occurrence of the *Hirnantia* fauna in China (Rong 1979) has considerably expanded the geographical distribution of this fauna. During the last two decades, large collections of the *Hirnantia* fauna, usually associated with the trilobites *Dalmanitina, Platycoryphe* and *Leonaspis*, have been made from a great number of places in China (Fig. 2). In northern China no representatives of the fauna are as yet known.

The *Hirnantia* fauna is well developed in the upper Yangtze Basin, including north-eastern Yunnan, Sichuan, southern Shaanxi, northern Guizhou, and western Hubei. Lu (1959) named the strata bearing the fauna in these regions the Kuanyinchiao beds, which are intercalated between the Wufeng and Lungmachi Formations. They include shelly and graptolitic facies, and consist mainly of marls, mudstones, and argillaceous limestones, usually 0.2–1 m thick. Zhang & Sheng (1958) reported the following taxa from these beds in Tongzi, northern Guizhou: *Hebertella aff. occidentalis* (Hall), *Rafinesquina cf. alternata* (Emmonds), *Platystrophia lynx* (Eichwald) and *Orthis* sp. The specimens collected by Zhang & Sheng from these beds at the same localities have been reidentified by the author as follows: *Hirnantia sagittifera* (M'Coy), *Aphanomena cf. ultrix* Marek & Havlíček, *Plectothyrella crassicosta* (Dalman) and *Dalmanella testudinaria* (Dalman), as well as

---

**Fig. 1. Global distribution of the Hirnantia fauna.**
Fig. 2. Occurrences of the Hirnantia fauna in China.

*Kinella kielanae* (Temple) and *Hindella crassa incipiens* (Williams). This is a typical (or strict) *Himantia* fauna which has been known from a great number of localities not only in northern Guizhou and southern Sichuan, but also in north-eastern Yunnan, northern Sichuan, southern Shaanxi and western Hubei (Rong 1979). A strongly diversified *Himantia* fauna has been found in Shuanghe, Changning in south-western Sichuan and Huanghuachang, Yichang in western Hubei by Mu and others during their field work in 1972 (Mu *et al*. 1978; Chang 1982). The Kuanyinchiao Beds yield the following taxa: "Paracranioptes" sp. nov., *Philhedra* sp., *Philhedrella* sp., *Acanthocrania* sp. nov., *Comatopoma* sp., *Toxorthis* sp. nov., *Dalmanella testudinaria* (Dalman), *Horderleyella inexpectata* (Temple), *Trucizetina* sp., *Hirnantia sagittifera* (M'Coy), *Kinella kielanae* (Temple), *Draborthis caelebs* Marek & Havlicek, *Cliftonia cf. oxoplecioides* Wright, *Aegiromena ultima* Marek & Havlicek, *Paromalomena polonica* (Temple), *Leptanopoma trifidum* Marek & Havlicek, *Aphanomena ultrix* Marek & Havlicek, *Coolinia* sp., *Dorytreta* sp. nov., *Plectothyrella crassicosta* (Dalman), and *Hindella crassa incipiens* (Williams). The composition of this fauna is quite similar to those of Bohemia (Marek & Havlicek 1967), northern England (Temple 1968) and Västergötland (Bergström 1968). In the Upper Yangtze Basin, a highly diverse *Himantia* fauna has also been recorded from Qiaoting, Nanjiang in northern Sichuan, Wanjiaowan and Tangya, Yichang in western Hubei and Sanlangpu, Xixiang in southern Shaanxi (Rong 1979).

In the Lower Yangtze Basin, in the provinces of Jiangxi and Anhui, the strata containing the *Himantia* fauna lie between the Kaochiapien and Wufeng formations. The fauna compri-
ses only three brachiopod taxa, viz. abundant Paromalomena polonica (Temple), fairly common Aegiromena ultima Marek & Havlicek, and very rare Coolinia ? sp. They are associated with Dalmanitina and Platycoryphe.

A Hirnantia fauna has most recently been found in western Yunnan and northern Xizang (northern Tibet). A good sample from the uppermost unit of the Ordovician rocks near the Mangjiu reservoir in Luxi, western Yunnan has been collected by Sun Dong-li and his colleagues during their field work in 1981. The unit yields a shelly fauna with Hirnantia sagittifera (M'Coy), Cliftonia sp., Paromalomena polonica (Temple), Aphanomena cf. ultrix Marek & Havlicek, Coolinia cf. dalmani Bergström, Plectothyrella crassicosta (Dalman) and Hindella crassa incipiens (Williams) associated with Dalmanitina. The first occurrence of the typical Hirnantia fauna in northern Xizang (northern Tibet) has been reported by Ni et al. (1981) from the upper part of the Xainza Formation in Xainza. It contains Hirnantia, Kinnella, Cliftonia, Paromalomena, Aphanomena, and Hindella, but the identifications are at present only at the generic level.

Stratigraphic distribution of the Hirnantia fauna

The time of both the appearance and extinction of the Hirnantia fauna in China is apparently not the same at all localities, although it is always within the Late Ashgill (= Hirnantian). Mu (1974) distinguished six graptolite zones in the Wufeng Formation, in ascending order, the zones of Pleurograptus lui (W₁), Dicellograptus szechuanensis (W₂), Tangyagraptus typicus (W₃), Diceratograptus mirus (W₄), Paraorthograptus uniformis (W₅), and Diplograptus bohemicus (W₆). The relationship of these zones to the base and top of the beds with the Hirnantia fauna is as follows (Fig. 3):

1) In Ganxi, Yanhe in north-eastern Guizhou, the Kuanyinchiao Beds with the Hirnantia fauna lie between the D. bohemicus (W₆) and T. typicus (W₃) zones (Mu In Lu & Mu 1980).
2) In Honghuayuan, Tongzi in northern Guizhou, the beds yielding the Hirnantia fauna occur beneath the D. bohemicus (W₆) Zone and above the D. mirus (W₄) Zone (Zhang et al. 1964).

<table>
<thead>
<tr>
<th>Graptolitic zones</th>
<th>Huanghuachang</th>
<th>Qiaotong</th>
<th>Fenxiang</th>
<th>Shanyang</th>
<th>Tongzi</th>
<th>Ganxi</th>
</tr>
</thead>
<tbody>
<tr>
<td>Llandoverian</td>
<td>Akidograptus acuminatus</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Glyptograptus pessulatus</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ashgillian</td>
<td>Diplograptus bohemicus</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Paraorthograptus uniformis</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Diceratograptus mirus</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Tangyagraptus typicus</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Dicellograptus szechuanensis</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Fig. 3. Different levels of the Hirnantia fauna in south-western China.
3) In Fenxiang, Yichang in western Hubei, the Kuanyinichiao Beds lie between the D. bohemicus (W₆) and P. uniformis (W₅) zones (Mu en-zhi, pers. comm.).

4) In both Huanghuachang, Yichang in western Hubei and Shuanghe, Changning in southwestern Sichuan, the beds containing the Himantia-Dalmanitina fauna occur between the G. persculptus (L₁) and D. bohemicus (W₆) zones (Mu et al. 1978).

Thus, the Himantia fauna in China is basically contemporaneous with the D. mirus (W₄), P. uniformis (W₅), and D. bohemicus (W₆) zones, although the Himantia fauna-bearing beds may also be within or above the D. bohemicus (W₆) Zone. It always occurs beneath the Glyptograptus persculptus (L₁) Zone which, in turn, is followed by the "Akidograptus" acuminatus (L₂) Zone.

It is also worth mentioning that in Shahe, Baoshan (Western Yunnan) Diplograptus bohemicus (Marek) occurs in association with Climacograptus extraordinarius (Sobolevskaya) and Diplograptus cf. orientalis Mu et al., in a grey black silty shale (Ni et al. 1982). This indicates that the D. bohemicus Zone may be correlated with the C. extraordinarius Zone. The latter zone has been reported from Scotland (Rickards 1979), Kazakhstan and Kolyma Basin (Koren’ et al. 1979). Thus, the Ordovician and Silurian boundary could be placed at the level where the Himantia fauna disappears in the shelly facies and at the level between G. persculptus and D. bohemicus (or C. extraordinarius) zones in the graptolitic facies (Fig. 4).

Within the last decade or so, a mixture of Ordovician shelly fossils with so-called earliest Silurian graptolites have been reported from a few localities in various parts of the world (Rukavishnikova et al. 1968; Mikhailova 1970; Nikitin 1972, 1976; Lécèrè 1974; Jaeger et al. 1975; Koren’ et al. 1979; Apollonov et al. 1980). Some workers have suggested that the Ordovician-Silurian boundary should be placed at the base of the "Akidograptus" acuminatus (L₂) Zone. However, Glyptograptus ? persculptus forma A or B (Koren’ et al. In Apollonov et al. 1980), known in the association with the Himantia-Dalmanitina fauna of the Chu-Ili Monotants, Kazakhstan, is probably not G. persculptus (Salter) (Mu & Ni, in press). The G. ? persculptus Zone of Koren’ et al. has been considered in China to correspond to the D. bohemicus (W₆) or C. extraordinarius Zone, rather than to the G. persculptus (L₁) Zone (Lin, pers. comm. 1981; Mu & Ni 1982). In the Portage River area, near Percé, Quebec, Lesperance (1974) reported the association of Dalmanitina, Cryptolithus and Brongniartella with the early Llandovery graptolite Climacograptus rectangularis medius. However, Rickards (In Cocks & Price 1975), on the other hand, considered the graptolite in question to be a Ordovician form and Ingham (1977) believes this shelly fauna to be older than the late Ashgill. It should also be noted that no Himantia fauna is present with these graptolites.

In Feistritzgraben of the Karawank Alps, southern Austria, Jaeger et al. (1975) reported the occurrence of G. cf. persculptus in a black slate which has been correlated with the Himantia fauna-bearing beds in the Cellon section, Carnic Alps. However, the shelly fauna associated with G. cf. persculptus contains neither a Dalmanitina nor Himantia fauna. The identification of G. cf. persculptus is in doubt. The above occurrences of these taxa are insufficient to correlate the G. persculptus Zone with the Himantia-Dalmanitina fauna.

Ecologic communities within the Himantia fauna of northern Guizhou and southern Sichuan

When Cocks (1972; 627) discussed the ecology of the Clarkeia shelly fauna of S. America, he postulated that the low-diversity Himantia-Dalmanitina fauna...
Hirnantia fauna represents a community filling an ecologic niche comparable to the Eocoeola and Crytothyrella communities (i.e. Benthic Assemblage 2 of Boucot 1975) of the early Silurian. Lepartance & Sheehan (1976: 720) considered that the term Hirnantia Community should be used instead of the “Hirnantia fauna”. The Hirnantia Community has been assigned to Benthic Assemblage 4 (possibly 5) by Sheehan (1979). The available data in southern China indicate, however, that the Hirnantia fauna may comprise more than one ecological community.

During the latest Ordovician, the southern margin of the Upper Yangtze Basin was located approximately in the Bijie-Zynyi-Songtiao region of northern Guizhou. There are seven localities yielding the Hirnantia fauna from Zunyi to Xijiang (Fig. 5). The sandy shale Kuanyinchiao Beds at Jianwan, Donggonsi, Zunyi immediately north of the Mid-Guizhou Late Ordovician Land area, have yielded a rich brachiopod assemblage along with the trilobite Dalmanitina. The assemblage is characterized by the abundant occurrence of "Whitfieldella" n.s.p., comprising 97% of the whole fauna, associated with a few specimens of Hindella crassa incipiens (Williams) and Coolinia sp. This is not a typical Hirnantia fauna, although H. crassa incipiens is one of the most common taxa in the Hirnantia fauna elsewhere. The assemblage may have lived in a very shallow water environment near the shore and probably is a representative of Benthic Assemblage 2. Northwards, the conditions are quite different. From Jiancaohe, Zunyi in northern Guizhou to Guanyinqiao, Xijiang in southern Sichuan, no "Whitfieldella" has been found from the mudstone or argillaceous limestone of the Kuanyinchiao Beds and Hirnantia sagittifera, Dalmanella testudinaria, Kinnella kielanae, Paromalomena polonica, Aphanomena ultrix, Cliftonia psittacina, Plectothyrella crassica costa as well as H. crassa incipiens are all common elements of the typical Hirnantia fauna (Fig. 6). It seems possible that these Hirnantia-bearing faunas may occupy a position equivalent to high Benthic Assemblage 3, although the relative frequencies of the genera vary. It is suggested that the sea floor bottom of the Upper Yangtze Basin in N. Guizhou appears to have been relatively even, and the depth of the basin there did not change appreciably.

It is also interesting to compare the composition of the brachiopod fauna along the line (see Fig. 5) from locality 1 (Yanzikou, Bijie
in north-western Guizhou), through 2 (Liangfengya, Tongzi in northern Guizhou) to 3 (Datianba, Xiushan in south-eastern Sichuan) and 4 (Ludiping, Songtao in north-eastern Guizhou). The line runs approximately parallel to the northern coast of the Mid-Guizhou Late Ordovician Land. The brachiopod assemblages from the Kuanynichiao Beds at these four localities represent a typical Hirnantia fauna and contain about 5–8 taxa (Fig. 7). It is Dalmanella testudinaria (Dalman) which is the most abundant taxon comprising about 66.7% (1), 34.3% (2), 38.95% (3), 48.7% (4) in the respective assemblages. The overall similarities in both diversity and composition between these assemblages might indicate that they have belonged to a single palaeoecologic community. All of them probably inhabited a normal shallow water environment and may occupy a high Benthic Assemblage 3 position. With respect to the dominance of Dalmanella, the Hirnantia

---

**Fig. 6.** Percentage of elements of the Hirnantia fauna in different localities from Jiadanwan to Guanyinqiao in northern Guizhou and southern Sichuan.

<table>
<thead>
<tr>
<th>LOCALITY</th>
<th>1 Yanzikou</th>
<th>2 Liangfengya</th>
<th>3 Datianba</th>
<th>4 Ludiping</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>NW. Guizhou</td>
<td>Tongzi</td>
<td>Xiushan</td>
<td>Songtao</td>
</tr>
<tr>
<td>Dalmanella</td>
<td>50%</td>
<td>30%</td>
<td>30%</td>
<td>30%</td>
</tr>
<tr>
<td>Hirnantia</td>
<td>30%</td>
<td>20%</td>
<td>48.7%</td>
<td>48.7%</td>
</tr>
<tr>
<td>Kimmella</td>
<td>30%</td>
<td>10%</td>
<td>0.8%</td>
<td>0.4%</td>
</tr>
<tr>
<td>Cliftonia</td>
<td>10%</td>
<td></td>
<td>0.8%</td>
<td></td>
</tr>
<tr>
<td>Aphanomena</td>
<td>30%</td>
<td>10%</td>
<td>0.2%</td>
<td></td>
</tr>
<tr>
<td>Plectothyrella</td>
<td>30%</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hindella (Cryptothyrella)</td>
<td>30%</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Fig. 7.** Percentage of the components of the Hirnantia fauna in Yanzikou, Liangfengya, Datianba and Ludiping.
fauna mentioned above is comparable to the Caradoc Dalmanella Community of the southern Brywyns in North Wales (Pickerill & Brenchley 1979). The latter has been also assigned to Benthic Assemblage 3.

In a northerly direction towards Shuanghe, at the locality Changning in south-western Sichuan, situated in the central part of the basin (Fig. 5), there occurs a strongly diversified Hirnantia fauna which consists of 21 taxa associated with Dalmanitina, Platycoryphe and Leonaspis. Here the Hirnantia fauna includes not only the common representatives of the typical Hirnantia fauna (such as Dalmanella, Hirnantia, Kinnella, Cliftonia, Paromalomena, Aphanomena, Plectothyrella and Hindella), but also such genera as Toxorthis, Comatopoma, Trucizetina, Borderleyella, Draborthis, Triplezia, Dorytreta, Sphenotreta, Philhedra, Philhedrella, Paracraniops, and Acanthocrania which are very rare or absent in the typical Hirnantia fauna. Within this fauna there are four very abundant genera: Hirnantia, Kinnella, Aphanomena and Paromalomena. However, Dalmanella, Plectothyrella and Hindella are rare, usually making up only 1–4% of the whole fauna, or absent.

It appears that this highly diversified Hirnantia fauna may have lived in a deeper water environment than that of the strict Hirnantia fauna and may occupy a position about that of low Benthic Assemblage 3.

Evidently, the strict or typical low diversity Hirnantia fauna lived in more restricted conditions (compared to the highly diversified Hirnantia fauna) but also reached a wider distribution. It is possible that the Late Ordovician glaciation lowered sea levels (Sheehan 1973) and decreased broad shallow water environments during that time.

Climatic significance of the Hirnantia fauna

The occurrence of continental glaciation centered in North Africa during the Late Ordovician has been documented by Beuf et al. (1971), Bennacef et al. (1971), Fairbridge (1971), Berry & Boucot (1973) and others. Evidence of periglacial deposits has been obtained not only from Morocco, Mauritania, Mali, Chad, Ethiopia, Niger and Sierra-Leone, but also from South Africa, the Amazon Basin of Brazil, Argentina, Peru, Bolivia and southern Spain. Possible later Ordovician glacio-marine deposits also occur in the Armorican Massif (Normandy) of France (Dore & Legall 1972). Based on the discovery of a Hirnantia fauna in the Upper 2nd Bani Formation, a detrital deposit of glacial origin, in the central Anti-Atlas of Morocco (Havlíček 1971; Destombes 1971), it has been concluded that the maximum glaciation was reached at the end of the late Ashgill (Destombes 1976). Havlíček (1976) pointed out that the distinctive features of the Hirnantia fauna in the Kosov Beds were presumably a reflection of the very cool climate, whose influence can be traced all over the Mediterranean Province. Sheehan (1975) and Sheehan & Lèsperance (1978, 1979) postulated that the development of glaciers was accompanied by the expansion of a cold water fauna which originated in the high latitudinal Mediterranean Province. Thus they considered that the Hirnantia fauna was composed largely of Mediterranean Province genera and was part of a relatively cold water province. As Cocks & Price (1975) suggested, however, the extent to which the Hirnantia fauna is a direct reflection of cold water condition is as yet uncertain.

Recently, the distribution of the Hirnantia fauna has been shown to be much wider than previously assumed. In addition to Morocco and Libya, where both the Hirnantia fauna and Late Ordovician glacial deposits occur, this brachiopod fauna is known not only in Europe and North America, but also in vast regions of Asia including most of southern China (from Xizang (Tibet) on the west to Anhui on the east), Burma, Kazakhstan and Kolyma. In these regions no late Ordovician deposits of glacial origin have been encountered so far. It is evident that most of these regions were far from the occurrences of the late Ashgill continental glaciation. On palaeomagnetic evidence the Ordovician south pole was in northwest Africa (McElhinny & Luck 1970; Whittington & Hughes 1972). Regions with the Hirnantia fauna in Asia, northern Europe and North America were situated much closer to the palaeoequator than to the pole during that time. Southern China, Kazakhstan and Kolyma may have been within the temperate zone, or even subtropical zone, according to palaeomagnetic data or other evi-
idence (Morel & Irving 1978; Scotese et al. 1979; Seslavinsky 1979). It is also clear that the distribution of the Himantia fauna might not be restricted to one hemisphere. The fauna was apparently distributed far beyond the area of influence of the late Ordovician glaciation, into temperate and even subtropical climatic belts.

A much more diverse Himantia fauna than the typical one has been observed in Bohemia, Västergötland, Yunnan, Sichuan and Hu-bei. Here it is generally composed of 13 to 20 brachiopod taxa with a diversity greater than one would expect if it were a cold water fauna of the type described from the Malvinokaffric Realm in the Silurian and Devonian (Boucot et al. 1969; Boucot 1975). As yet no highly diversified Himantia fauna has been found in the cold water regions of North Africa and neighbouring areas.

A typical Himantia fauna comprising Dalmanella testudinaria, Aphanomena sp., Coolinia sp., Plectothyrella crassicosta, Dorytreta n. sp., and Hindella crassa incipiens, associated with Dalmanitina, has been found to occur in a 1.5 m thick argillaceous limestone in Yanzikou, Bijie in north-western Guizhou, south-western China (Rong 1979). It is associated with many solitary corals, such as Brachyelasma, Streptelasma, Grewingkia, Borealasma, Crassilasma, Siphonoplasma, Pycnactics, Paramplexoides, Singkiangolasma, Lambeophyllum, and Kenophyllum (Ho 1980). Rugose corals, in part the same genera, also occur in the Bohenshult fauna in Östergötland, Sweden, where there are also some elements of the Himantia fauna. A similar rugose coral fauna with some associated tabulates, such as Palaeofavosites, Schedoahylites and Propora, is known from an argillaceous limestone of the Kuanyinchiao beds in Leijiatun, Shiqian in north-eastern Guizhou (Yang Sheng-wu, pers. comm. 1982). The abundance of corals of southern China seems to cast doubt on the view that this Himantia fauna lived exclusively in a cold water regime.

Of special interest is the occurrence of the Himantia fauna in bioclastic, argillaceous limestones and bituminous limestone in many localities in south-western China (Rong 1979). The intimate association of the Himantia fauna with the upper part of the Chair of Kildare reef limestone at Kildare, Ireland and with oolitic limestones in the Hirnant beds at Aber Hirnant, North Wales is also known (Wright 1968). The presence of oolite indicates that the limestone was deposited in shallow water at an estimated water temperature of at least 25 to 27°C (Jaanusson 1973). Moreover, Bahaman-type sediments (Beales 1958; Bathurst 1971; Jaanusson 1973), such as peloids and ooids, occur in the Dalmantina Beds in Västergötland (Stårdberg 1980) together with the highly diversified Himantia fauna (Bergström 1968). Modern bahamitic sediments have been described by Newell et al. (1960) and Purdy (1963). Therefore, the author considers it more likely that the Himantia fauna did not necessarily live only in cold water. It probably extended into the temperate and even subtropical zones during the latest Ordovician, although these zones would have been influenced indirectly by the glacial events, accompanied by a significant eustatic lowering of sea-level (Sheehan 1973) and a cooling of the oceans (Jaanusson 1979).

The above discussion seems to suggest that the ecologic tolerances of the main elements of the Himantia fauna, such as Hirnantia, Kinellna, Paromalomena, Eostropheodonta and Plectothyrella, were much broader than previously implied. Other members of the fauna, such as Dalmanella, Aphanomena, Cliftonia, Leptaena and Leptaenopoma may have expanded to the regions near the equator associated with Dolerorthis, Brevilamnulella, Stegerhynchus, Eospirigerina and Dictyonella, which are almost absent in the typical Himantia fauna. Interestingly, an approximately contemporaneous Holorhynchus brachiopod fauna is located immediately to the north of the known limits of the Himantia fauna in Eurasia. It is possible that the Holorhynchus fauna lived in a warmer water environment than the Himantia fauna, although in central Sweden, the two are mixed (Jaanusson, pers. comm. 1978).

Acknowledgements

I am grateful to Prof. Mu En-zhi, who generously provided the graptolite data for correlation of the Himantia fauna in China and to Prof. V. Jaanusson who gave encouragement, corrected the manuscript and provided valuable comments. Prof. A. J. Boucot and Prof. P. Copper also critically read the manu-

109
script and suggested improvements. Mr H.-A.
Nakrem kindly redrew the text figures. Thanks
are due to Drs. Yang Sheng-wu and Gu Cheng-
dong for their kind help during the preparation
of the manuscript.

References

Amsden, T. W. 1971: Late Ordovician—early Silurian
brachiopods from the central United States. Mem.
Bur. Rech. geol. miner. 73, Colloque Ordovicien-

Amsden, T. W. 1974: Late Ordovician and early Si-
larian articulate brachiopods from Oklahoma,
southwestern Illinois and eastern Missouri. Ok-

Apollonov, M. K., Bandatelev, S. M. & Nikitin, I. F.
(eds.) 1980: The Ordovician—Silurian boundary
in Kazakhstan. 300 pp, 61 pls. Nauka Kazakh. SSR

Bassett, D. A., Whittington, H. B. & Williams, A.
1966: The stratigraphy of the Bala district, Me-

Bathurst, R. G. C. 1971: Carbonate sediments and

Beales, F. W. 1958: Ancient sediments of Bahaman
1880.

Bennacef, A., Beuf, S., Biju-Duval, B., DeCharpal,
O., Gariel, O. & Rognon, P. 1971: Examples of
cratic sedimentation: Lower Paleozoic of Alge-
rian Sahara. Amer. Assoc. Petrol. Geol. Bull. 55,
2225–2245.

Bergström, J. 1968: Upper Ordovician brachiopods
from Västergötland, Sweden. Geol. et Palaeontol.
2, 1–35.

Berry, W. B. N. & Boucot, A. J. 1973: Glacio-eustat-
ic control of Late Ordovician—Early Silurian
platform sedimentation and faunal changes.

Beuf, S., Biju-Duval, B., DeCharpal, O., Rognon,
Paleozoique inferieur au Sahara-sedimentation
et discontinuites, evolution structural d’un craton.
Inst. Franc. Petrol. -Sci. et Tech. du Petrol. 18,
1–464.

Boucot, A. J. 1975: Evolution and extinction rates

Boucot, A. J., Johnson, J. G. & Talent, J. A. 1969:
Early Devonian brachiopod zoogeography. Geol.

Ghang Mei-li 1982: Hirnantia fauna of the Uppermost
Ordovician in Yichang, Hubei. Acta Paleont. Si-
nica 20 (6), 557–566.

Science press, Beijing.

Cocks, L. R. M. 1972: The origin of the Silurian Clar-
kea shelly fauna of South America, and its exten-

Cocks, L. R. M., Brunton, C. H. C., Rowell, A. J. &
Rust, I. C. 1970: The first Lower Palaeozoic fau-
na proved from South Africa. J. Geol. Soc. Lond.
125, 583–603.

Cocks, L. R. M. & Copper, P. 1981: The Ordovician-
Silurian boundary at the eastern end of Anti-
1034.

Cocks, L. R. M. & Price, D. 1975: The biostratigra-
phy of the Upper Ordovician and Lower Silurian
of South-west Wed, with comments on the Hir-
nantia fauna. Palaeontology 18, 703–724.

Destombes, J. 1976: The Ordovician of the Moroc-
can Anti-Atlas. In Bassett, M. G. (ed.): The Ordo-
vician System: proceedings of a Palaeontological
Association Symposium, Birmingham, Sept. 1974,
411–416. University of Wales Press and National
Museum of Wales, Cardiff.

Dore, F. & Legall, J. 1972: Sedimentologie de la ’Til-
lite de Feuguerolles’ (Ordovicien supérieur de Nor-

Fairbridge, R. W. 1971: Upper Ordovician glaciation
82, 269–274.

Ge Zhi-zhou, Rong Jia-yu, Yang Xue-chang, Liu Geng-
wu, Ni Yu-nan, Dong De-yuan & Wu Hong-ji,
1979: The Silurian system in Southwest China. In 
The Carbonate Biostratigraphy of Southwest

Harper, D. A. T. 1981: The stratigraphy and faunas of
the Upper Ordovician High Mains Formation of the
Girvan district. Scott. J. Geol. 17, 247–255.

Havlíček, V. 1971: Brachiopodes de l’Ordovicien du

Havlíček, V. 1976: Evolution of Ordovician brachio-
pod communities in the Mediterranean Province. In 
Bassett, M. G. (ed.): The Ordovician System:
Proceedings of a Palaeontological Association
University of Wales Press and National Museum of
Wales, Cardiff.

Havlíček, V. 1977: Brachiopodes of the order Orthida
in Czechoslovakia. Rozpr. Ustr. ust. geol. 44, 1–
327.

Havlíček, V. & Massa, D. 1973: Brachiopodes de l’Or-
dovicien superieur de Libye occidentale. Imple-
ments stratigraphiques regionales. Geobios 6, 267–
290.

Ho Xin-yi. 1980: Tetracoral fauna of the Late Ordo-
vician Guanyinqiao Formation, Bijie, Guizhou Pro-

Ingham, J. K. 1977: The Upper Ordovician Trilobi-
tes from the Cautley and Dent districts of West-
moreland and Yorkshire. Palaeontogr. Soc. Mono-
gr. (3), 89–121.

Ingham, J. K. & Wright, A. D. 1970: A revised clas-

Jaanusson, V. 1973: Aspects of carbonate sedimenta-
tion in the Ordovician of Baltoscandia. Lethaia
6, 11–34.

Jaanusson, V. 1979: Ordovician. In Orbinson, A. &
Teichert, C. (eds.): Treatise on Invertebrate Paleon-
tology, Part A, Introduction + Biogeography and
Biostratigraphy, A136–A166. University of Kansas
Press.


Jour. Geol. 87, 217–277.


