

THE PALAEOECOLOGY OF THE GONIATITE BED AT COWLOW NICK, CASTLETON, DERBYSHIRE

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ABSTRACT. The Cowlow Nick Goniatite Bed is shown to be an accumulation of randomly oriented, hollow, or spar-filled goniatite shells of several species in a matrix of calcilutite. Of very limited dimensions, the bed is surrounded by algal limestones of the fore-reef facies of Upper B₂ age (Lower Carboniferous). Suggestions as to the mode of accumulation are discussed and it is concluded that the bed represents a specialized drifted assemblage of floating shells which were washed gently into an inactive surge channel or submarine cave. Some comparable occurrences elsewhere in Derbyshire are noted.

THE small bed of limestone crowded with goniatites occurring in Cowlow Nick, west of Castleton in Derbyshire (Nat. Grid Ref. SK/142824) is well-known to workers on the Carboniferous Limestone. It was first recorded by Bisat (1934) who described species found there by G. B. Alexander. Subsequently it was included in the Castleton Limestones (of reef facies) by Shirley and Horsfield (1940) who included these in the B₂ sub-zone, resting unconformably against 'cliffs' of the massif-facies D zone limestones. Parkinson (1947) agreed in placing the Cowlow Nick beds in the B₂ sub-zone, but thought that this reef facies was equivalent in age to the massif-facies limestones to the south which are of D₁ age. Both Hudson and Cotton (1945) and Parkinson (1947) discussed further subdivision of the B₂ sub-zone, but as there is some discrepancy between the results of these authors and with the indications of the fauna listed herein, there seems to be some revision needed.

None of the above workers discussed the palaeoecology of the Goniatite Bed except as a very broad interpretation of all the pockets of fossils in the reef limestones as drifted assemblages. Wolfenden (1958) described the palaeoecology of the whole reef complex of B₂/D₁ age by analysing the distribution of the various elements of the fauna in terms of fore-reef, reef, back-reef, and shelf biotopes. The existence of a basinal biotope was noted, but not analysed. Goniatites were noted as being almost confined to the fore-reef facies (and basin by inference). Wolfenden challenged the drifted-assemblage concept of Hudson and Cotton (1945) and said that as the goniatites occurred throughout the fore-reef in all sizes and were well preserved, and were not often transported out of that biotope, they were probably preserved where they lived—a life assemblage. Wolfenden, however, did not discuss the Cowlow Nick Goniatite Bed nor did he mention localized accumulation of goniatites to the almost total exclusion of other members of the biota.

It is the purpose of this short communication to analyse the composition of the fauna in the Cowlow Nick Goniatite Bed, to examine its relationship with surrounding deposits and to attempt to draw conclusions about the mode of accumulation.

THE FAUNA

The material collected by Alexander and described by Bisat (1934) included: *Beyrichoceras submicronotum* Bisat, *B. vesciculiferum* (de Koninck), *Goniatites maximus* Bisat, [Palaentology, Vol. 8, Part 1, 1965, pp. 186–91, pl. 20.]

Dimorphoceras gilbertsoni (Phillips), *Sagittoceras acutum* Hind (= *discus* Roemer), *Pronorites cyclolobus* (Phillips), *Prolecanites discoides* Foord and Crick.

Shirley and Horsfield (1940), Hudson and Cotton (1945), and Parkinson (1947) failed to add to this, though other species were found in the Castleton Limestones at the nearby localities of Cavedale and Treak Cliff. Wolfenden's list (1958) noted facies distribution, but not individual localities.

Further collecting by the writer and by Dr. J. R. L. Allen has yielded: *B. rectangularum* Bisat, *G. cf. hudsoni* Bisat, *P. serpentinus* Phillips, *P. cf. P. discoides* Foord and Crick, ? *Discitoceras sp.*, 'Orthoceras' spp.

A sample of the bed was broken up and the following abundances of the various species were noted:

<i>B. submicronotum</i>	29
<i>B. vesciculiferum</i>	2
<i>B. rectangularum</i>	8
<i>G. maximus</i>	29
<i>G. cf. hudsoni</i>	1
<i>D. gilbertsoni</i>	1
<i>P. serpentinus</i>	1
<i>P. cf. P. discoides</i>	3
'Orthoceras' spp.	6
? <i>Discitoceras sp.</i>	1
Total	81

Other samples produced much the same proportions, showing a slight preponderance of *Beyrichoceras spp.* over *Goniatites spp.* Owing to the difficulties of extraction of the goniatites in an undamaged condition (particularly of young forms) no reliable size frequency distributions could be recorded. However, both polished and thin sections show all sizes to be present, although adults are predominant with only a few young. The sizes of the adults in the different species groups differ considerably. In the *Beyrichoceratids* the diameters range from 15 mm. to 20 mm. whilst in the *Goniatites spp.* the range is from 18 mm. to 25 mm. *Orthoceratids* are scattered throughout and vary up to 100 mm. in length and 20 mm. diameter.

The Goniatic Bed has only a few other macrofossils, except for a small lens of young brachiopods near the roof. This is seen only for about 30 cm. in length and up to 10 cm. thick, and is composed of young *Dielasma hastata*, all much the same size, about 7-8 mm. in length. A few productids are scattered through the bed, and also a few gastropods, some of which show traces of original colouring. The microfossils present are bryozoan fragments, and very occasional young brachiopods, foraminifera, and ostracods.

STRATIGRAPHICAL RELATIONSHIPS

The Cowlow Nick Goniatic Bed reaches a maximum of nearly 1 metre thickness in the mouth of an old lead-vein working, now partly collapsed. As far as can be judged from the irregular bedding it has a dip of some 15° NE. which is rather less than the hill slope and considerably less than the dips in the neighbouring outcrops of reef-complex

limestones, which range between 20° and 40° within a few hundred metres. As a result of these relationships, the Goniatile Bed disappears into the hillside on the up-dip side, whilst down dip its base is lost by the steep hill-slope. Along the strike exposures are discontinuous and the bed is lost beneath the turf only 3 m. to either side of the lead vein. The vein is, however, oblique to the strike and in the north-west wall the bed appears to wedge out in both directions, with about 3·5 m. between the extremities. The nearest exposures in all directions are calcite-mudstones of the reef-complex frequently showing algal banding, and with pockets of reef-brachiopods. Lenses of crinoidal debris appear lower down the hill slope.

Thus the detailed stratigraphical relationships of the bed are obscure, but in the general sense it may be said that it occurs in steeply dipping reef-complex limestones, which by projection south-eastwards of Wolfenden's (1958) mapping in the Winnats Pass are within the fore-reef facies, close to the reef wall.

Fortunately within the lead-vein opening parts of the roof and floor of the bed are visible, though only for a short distance laterally. The roof is composed of calcite-mudstone with algal banding. Immediately beneath this is the lens of young brachiopods in a matrix of calcite-mudstone. A metre below is the floor of the Goniatile Bed, which is composed of either a fragmental limestone with small crinoid ossicles, shell-fragments and calcite-mudstone fragments or of calcite-mudstone with algal banding. These are seen only for a length of about 0·5 m. and to a similar depth below the goniatile bed, and within this grain-size is variable up to about 8 mm.

PETROGRAPHY

The goniatites in the Cowlow Nick bed are of varied sizes as discussed above. They are randomly oriented in a fine-grained calcite-mudstone matrix. The shells are almost undamaged and the ornament is not worn. Body chambers can be seen in sections, but can rarely be extracted undamaged. No evidence of size sorting has been obtained.

Diagenetic alterations obscure much of the detail and the following features have been observed: (a) frequent veinlets of calcite and occasional fluorite cutting both goniatites and matrix; (b) patches of calcite spar, some with carbonaceous impurities, sometimes surrounded by algal reef 'tufa'; (c) fine calcite crystalline mosaic in the matrix obscuring details of original depositional textures; (d) recrystallization of parts of the shells to form either coarse calcite spar or fine crystal mosaic, and (e) scarce authigenic quartz crystals and patches of limonite staining. In places brecciation appears to be associated with the mineral vein.

The goniatile shells are mostly filled with coarse calcite spar. A few are still hollow or with only some chambers hollow and lined with calcite crystals. In a few cases there are crystals of fluorite or blebs of bitumen in either the spar filling or in the hollow shells. Some shells, which appear to be broken on a polished section, are seen in thin section

EXPLANATION OF PLATE 20

Polished vertical section of the Cowlow Nick Goniatile Bed. Approximately twice natural size. The section shows the random orientation of goniatile shells of various sizes in a calcilutite matrix. Both primarily damaged and diagenetically recrystallized shells are present. Cavity fillings of calcite, fluorite, and carbonaceous matter are also present.

to pass into the fine crystal mosaic of the matrix. No evidence has been found of original sedimentary filling of the shells other than in body chambers.

The fine grained matrix appears to be largely due to diagenetic recrystallization, but in places traces of original textures remain, chiefly irregular algal banding.

PALAEOECOLOGY

From the above it may be surmised that the Goniatite Bed is an assemblage of several species of goniatites, of varying sizes, preserved virtually undamaged and randomly oriented in a lenticular bed of restricted dimensions in the reef-complex close to the probable position of the algal reef-wall. In many of its characters the Bed compares with the well-known reef-brachiopod beds of the reef-complex on Treak Cliff, &c. Three possible explanations may now be examined:

- A. The Goniatites were gregarious sessile benthonic animals, not, as usually supposed, free-swimmers, and they were preserved as a 'life-assemblage', possibly by some catastrophe.
- B. The Goniatites were, as usually supposed, free-swimming reef-grazers, which at times of storm, &c., retired to a sheltered hollow in the reef, where they were overwhelmed by a catastrophe.
- C. The Goniatites are an unusual drifted assemblage, for which some mechanism must be found to account for a concentration of floating shells in the midst of largely algal limestones.

The first of these is difficult to uphold as it is completely in contrast to most opinion of the habits of ammonoids. Also one would expect such sessile gregarious colonies to have been preserved much more frequently. The same species are found in shale facies elsewhere associated with planktonic and epi-planktonic faunas, and they are also found as scattered individuals in association with reef brachiopods elsewhere in the reef complex. Finally, gregarious sessile benthonic associations are usually formed of a single species.

The possibility B seems more likely at first as it does not require any unusual means for concentrating shells if they retired to this shelter of their own accord. However, one would again expect to find such occurrences more often. If the goniatites had retired to a sheltered hollow during some time of stress only to be trapped there by some catastrophe such as the collapse of flanking deposits, it would be expected that the shells would be crushed together, not dispersed at random through the Bed. Also such a sheltered hollow might be expected to be populated with a sessile fauna before being occupied by the goniatites.

The third possibility C, that of a special type of drifted assemblage, must now be examined, and a perusal of literature on modern reefs has given a suggestion. In the Bikini Atoll Reports, Emery and others (1954, part A pl. 51, and part C figs. 92 and 93) have shown diagrams of surge channels in the active reef edge, and they have described there the gradual closure and abandonment of such surge channels by algal growth over the top and outwards around the mouths of the channels, leaving submarine caves. It is thus possible that the Cowlow Nick Goniatite Bed represents a concentration of goniatite shells in a surge channel, in a Lower Carboniferous reef complex. The fact that

the shells are not usually broken indicates that it could not have been an active surge channel with the repeated pressure of heavy waves. Shells recently dead and floating at or near the sea surface could be washed into an inactive channel, which algal growth or fore-reef accumulation had left as a submarine cave. Only gentle currents would be required to wash in floating goniatites. Such inactive surge channels could be potential homes for sessile brachiopods, bryozoans, &c., but the exclusion of all but a few scattered individuals may be explained by supposing that the Cowlow channel was open for a relatively short time and that as fast as the shells were washed in they were enveloped in algal deposits and precipitated calcite mud, now both represented by the recrystallized calcilutite matrix. It is also possible that B above is partly correct and that this particular surge channel was used as a shelter by a few goniatites which devoured the incoming spat of any sessile organisms.

In suggesting that the Cowlow Nick Goniatite Bed is a concentrate of shells in an inactive surge channel, the concept of it being a drifted assemblage as suggested by Hudson and Cotton (1945) is maintained, with the addition of details of the mechanism.

COMPARATIVE EVIDENCE FROM OTHER LOCALITIES

Despite a search of the literature on cephalopods, no description of a comparable accumulation of cephalopod shells has been found. Nor has any comparable accumulation of modern *Nautilus* shells been recorded. Wolfenden (1958) mentioned 'pockets of goniatites' in Upper Dovedale but gave no localities or descriptions.

There are, however, some other comparable occurrences known to the writer in Derbyshire. A block of calcite mudstone containing fifteen *Goniatites maximus* group in about 2 kgm. of matrix was found loose in the old quarries above Treak Cliff Cavern (SK/135831), but no parent rock could be found and it may have been quarried away. High on the summit ridge of Treak Cliff a small pocket in the middle of an algal limestone mass (Wolfenden's upper reef wall) contained six goniatites in what must have been a hollow some 20 cm. across between adjacent algal domes—perhaps not a surge channel, but at least a temporary hollow in the reef surface. Near Brassington (SK/224545) a mass of calcite mudstone little more than a cubic metre has been found crowded with *Prolecanites* cf. *discoides* close to an algal limestone mass. Here again detailed relationships are obscured by a small mineral vein and by extensive dolomitization all round the outcrop, and the shells have been impossible to extract as most are still hollow.

It seems from these few occurrences, and there are doubtless others not seen by the writer, that the conditions at Cowlow Nick were not unique, though they were apparently best developed there.

CONCLUSION

From the evidence of a variety of species and sizes, preserved undamaged in a restricted lenticular deposit in the midst of algal fore-reef limestones, it is concluded that the goniatites accumulated as a result of gentle current sorting and washing into a hollow such as an inactive surge channel or submarine cave.

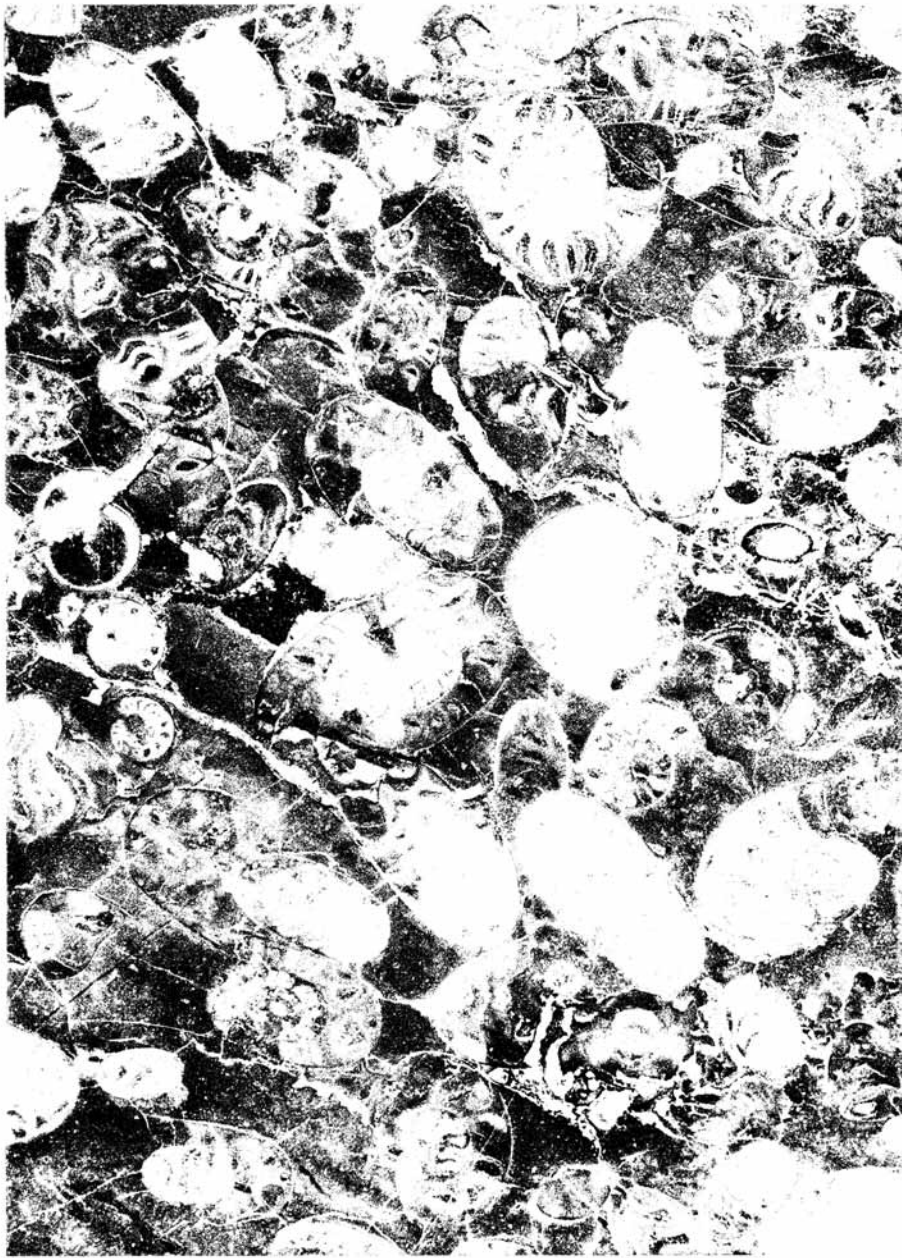
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