# THE BEACH BEDS OF CASTLETON, DERBYSHIRE, AND THEIR RELATIONSHIP WITH THE APRON-REEF LIMESTONES.

by

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## Summary

The time of deposition of the Castleton Beach Beds is considered, in this paper, to be that of the Upper $B_2$ - Lower $P_{1a}$ sub-zones (Lower Carboniferous), as opposed to their assignment by Stevenson and Gaunt (1971) to Upper $D_2$ - Lower $P_2$. The Beach Beds are shown to be unconformable on the lower apron-reef at Cow Low and Long Cliff and to pass laterally into the limestones of the upper apron-reef on Treak Cliff. It is believed that the unconformity and deposition of the Beach Beds resulted from a vertical uplift at the outer rim of the lower reef during the Bowlandian Earth Movements.

## Introduction

The district around Castleton and Bradwell in north Derbyshire has for many years aroused the interest of geologists. Among the different aspects of the geology investigated, the age and nature of the Beach Beds and their relationship with the surrounding deposits has formed a small, though important, part.

The eroded shell beds near Castleton, first described by Barnes and Holroyd (1896, 1897), were attributed by these authors to a shore-line to the north, a view supported by Parkinson (1947, pp. 108-9, 115, 118, 121). In a later paper, Parkinson (1953, p. 260) considered the shore-line to lie to the south and west, where it formed the base of the concave slope of the apron-reef during a brief uplift in Upper $D_1$ time.

Sadler (1964) described in detail the Beach Beds and associated deposits and listed a large fauna, including the important diagnostic forms, *Striatifera striata* (Fischer), *Davidsonia septosa* (Phillips), and *Goniatites hudsoni* (Bisat). The age of the beds was given as approximately mid - $D_1$.

Sadler's hypothesis, that the Beach Beds originated from a Viséan submarine channel on the site of the present Winnats, was discussed fully (Parkinson 1955, pp. 170-172) and rejected, for nearly all the Beach Bed fossils were reef forms, mostly of species recorded from Treak Cliff, whereas the alleged channel was formed behind the reef complex in the shelf limestones, which hereabouts are poorly fossiliferous. Sadler's interpretation was not favoured in Stevenson and Gaunt (1971 p. 35). In their memoir, the Beach Beds were assigned to the higher part of the $D_2$ and the lower part of the $P_2$ zones, the sediment being deposited after the $P_1$ apron-reefs. As shown later in this paper, their upper limit is considered to be no higher than lower $P_{1a}$, and contemporaneous with the $B_2$ - $P_{1a}$ apron-reefs. (Table 1).

In Stevenson and Gaunt (1971), the Beach Beds are described, with the reef limestones, under the heading *Marginal Province*. This usage of the term 'Province' is not followed here, it being restricted to the commonly accepted regional context, for example, South-west Province, Central Province etc..

Mercian Geologist, Vol, 5, No. 2, 1974. pp. 105-113, text-fig. 1.

TABLE 1

| Series | Stage | Goniatite Zones | | Position of Beach Beds | Coral - Brachiopod Zones |
|---|---|---|---|---|---|
| Namurian (Millstone Grit) | Pendleian $E_1$ (lowest of seven stages) | *Cravenoceras malhamense* | $E_{1c}$ | | |
| | | *Eumophoceras pseudobilingue* | $E_{1b}$ | | |
| | | *Cravenoceras leion* | $E_{1a}$ | | |
| Upper Viséan | Upper Bollandian $P_2$ | *Lyrogoniatites georgiensis* | $P_{2c}$ | | |
| | | *Neoglyphioceras subcirculare* | $P_{2b}$ | | |
| | | *Mesoglyphioceras granosum* | $P_{2a}$ | Beach Beds Stevenson & Gaunt 1971 | $D_2$ |
| | Lower Bollandian $P_1$ | *Goniatites koboldi* | $P_{1d}$ | | |
| | | *Goniatites sphaericostratus* | $P_{1c}$ | | |
| | | *Goniatites falcatus* | $P_{1b}$ | | |
| | | *Goniatites crenistria* | $P_{1a}$ | | |
| | | *Beyrichoceras delicatum* | Lower $P_{1a}$ | Beach Beds Parkinson | |
| Middle Viséan | Cracoeian $B_1$ - $B_2$ | | Upper $B_2$ | | |
| | | *Beyrichoceras submicronatum* | Lower $B_2$ | | $D_1$ |
| | | *Merocanites henslowi* | Upper $B_1$ | | $S_2$ |
| | | *Bollandoceras hodderense* | Lower $B_1$ | | |

Table 1 lists the goniatite zones referred to in the Viséan and Namurian sequences and includes the approximately equivalent coral brachiopod zones. The age of the Beach Beds, as interpreted by Stevenson and Gaunt (1971) and the author, is indicated.

## Review of the evidence of $P_2$ age

Although the Beach Beds lie on the frontal slope of the $B_2$ apron-reef, it is argued, in Stevenson and Gaunt (1971), that their contemporaneous deposition with that reef is not proved because strata of Beach Beds type occur within the Eyam ($P_2$) Limestones of the Castleton Borehole. These limestones are shown in places (e.g., Bradwell) to have an unconformable base, and this is inferred for the base of the Beach Beds.

In the Castleton Borehole, the rocks attributed to the Beach Beds are reached at a depth of 139 ft. 3 in. and continue to the base at 203 ft. 6 in. It is not clear from the borehole log where the base of the $P_2$ zone should be placed, but the presence of *Nemistium edmondsi* associated with *Lithostrotion portlocki* at 167 ft. 9 in. suggests, according to the authors, "a position high in the $D_2$ shelf succession, perhaps near the $P_1$-$P_2$ boundary of the basin". The beds beneath this zonal boundary, therefore, are below the base of $P_2$ and are equivalent to the Upper Monsal Dale Beds, placed in the High $D_2$ zone.

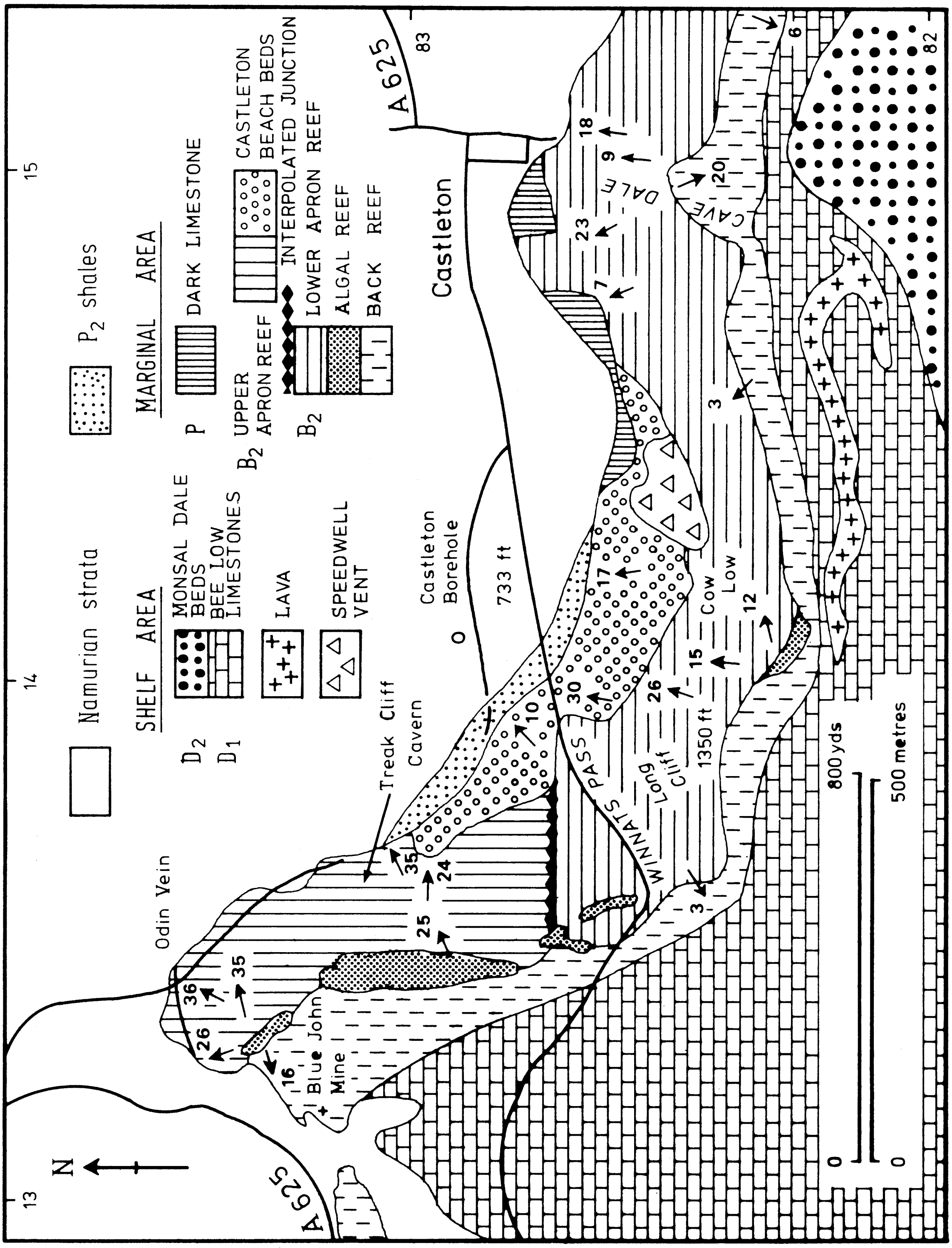
## The Beach Beds at outcrop.

In lithology the Beach Bed strata in the Castleton Borehole are similar to those seen at outcrop, but the faunas are quite distinct. At least three species in Dr. Sadler's list are not known above lower $P_1$ and no diagnostic upper $P_1$-$P_2$ forms are named. The presence of *Striatifera striata* is significant. This species first appears at, or maybe just below, the base of $P_{1a}$ and is apparently not known above low $P_{1b}$. Its association at the same horizon in the Beach Beds with the characteristic $D_1$ species *Davidsonina septosa* Sadler, 1964, p.361) suggests that the summit of the $D_1$ zone is higher than the base of $P_{1a}$. Stevenson and Gaunt (1971, Table 1, p.8) place the top of the $D_1$ zone slightly higher than the bottom of the $P_1$ zone.

The field relations are consistent with the fossil evidence, as can be seen by combining the information from the sketch map (Stevenson and Gaunt, 1971, Plate XI, no contours) with the contoured $2\frac{1}{2}$ inches to one mile Geological Survey map of Edale and Castleton. Text-fig.1 of the present paper is based largely on Plate XI. The boundary lines are unaltered, but an additional boundary is drawn between Lower and Upper $B_2$ sub-zones. The sketch map shows that, on the western side of the outcrop, $P_2$ shales apparently follow the Beach Beds, which dip north-east, whilst on the eastern side the Beach Beds dip north beneath dark limestones of $P_1$-$P_2$ age. If the Beach Beds do, in fact, post-date the dark limestones, then the tectonics are much more complex than is indicated on the Geological Survey maps.

Consideration of slope and dip suggests that the well-known goniatite pocket at Cow Low Nick is older than the beds at the top of the slope of Cow Low and, if this is true, the pocket is lower than the high $B_2$ apron-reef at the foot of Treak Cliff. Further, as will be shown, the goniatite assemblages support this view.

In the memoir (Stevenson and Gaunt 1971) the $B_2$ apron-reef is described and mapped as a single unit and it is stated (p.141) that the available information is inadequate to sustain a subdivision of $B_2$ based on goniatites, as had been suggested by Hudson and Cotton (1945, p.301). I agree that more work is needed on the goniatite sequence; nevertheless, there is evidence, (Parkinson 1974), not only around Castleton but from widely separated area of the Central Province, of a mid-$B_2$ (middle $D_1$) break (Bowlandian earth movements) in the sequence, above which new goniatite species appear. Stevenson and Gaunt (1971, p. 34), while considering that a non-sequence cannot be firmly established, admit evidence of a break in the right position near Blue John Mine and invoke intra-$B_2$ earth movements "to account for the off-setting of the reef-belt and production of a knoll-like mass of reef-limestones at Middle Hill".




Text-fig. 1. Geology west of Castleton.

By examining the outcrop of the Beach Beds on text-fig.1, it can be seen that, at their north-western extremity, they pass laterally into fore-reef strata near Treak Cliff Cavern. Since the beds in the cavern have yielded *Posidonia becheri* Bronn (Ford, 1952, p. 352), a $P_1$ form which first appears in higher $B_2$, the reef beds in contact with the Beach Beds are unlikely to be appreciably lower than the top of the $B_2$ zone. The varying lithology of the Beach Beds contrasts sharply with that of the reef limestones; this is a consequence of a change in facies, the reef limestones passing laterally into the deposits of Beach Bed type.

This deduction of the succession is consistent with the results of research conducted by Shaw (1970), on an unusual limestone deposit characterised by the abundance of the pectinid *Pseudamuseum ellipticum* (Phillips). This bed was examined by Shaw in various exposures in the apron-reef on the slope of Treak Cliff, notably in high $B_2$ strata above Treak Cliff Cavern and the limestone was also found in the Beach Bed outcrop north of the Winnats. The goniatite *Beyrichoceras rectangularum* Bisat was found "at many localities" and *Goniatites maximus* Bisat group was noted from the Beach Bed outcrop. Shaw suggested that, the *P. ellipticum* limestone lies beneath the Beach Beds, but he stated that the relationship could not be determined since the contact was not exposed.

Within the outcrop of the Beach Beds, Sadler (1964) recognised five types of detrital shelly limestone. She also noted that both fore-reef and basin-type limestones were locally interbedded with the Beach Beds. It is here suggested that the *P. ellipticum* bed north of the Winnats is a layer of reef limestone interbedded with the Beach Beds. Assuming that Shaw's correlation of the *P. ellipticum* exposures near the Winnats with those of Treak Cliff is correct - and he gives good reasons for this - it follows that, on the new interpretation of the succession, the Beach Beds are approximately synchronous with the upper apron-reef. It follows further that the *P. ellipticum* limestone is higher in horizon than the lower levels of the Beach Bed group, since its position in the apron-reef is a high one. This is in line with the view that the Beach Beds rest with unconformable overlap on the lower apron-reef.

## Depositional dips at Treak Cliff

Broadhurst and Simpson's work (1967) on infillings of shells and cavities in the apron-reef at Treak Cliff provides the first direct evidence of high depositional dips and indicates that the estimate of 20°, (Parkinson 1965, p.173), was too low. At one locality, the average inclination of the surface of numerous infillings indicated a depositional dip of 27°, whereas the observed present dip is 35°; at another locality, the observed dip of 30° is not appreciably higher than the estimated dip.

Broadhurst and Simpson's conclusions necessitate some small modification in the amount of the postulated uplift between the deposition of the lower and upper $B_2$ apron-reefs in the Beach Bed area of sedimentation. Parkinson (1965) assumed that the beach Beds lay on a surface not substantially inclined, so that the existing dip had a large tectonic component: Broadhurst and Simpson's (1967) research suggests that the tectonic component is less than was formerly thought. At Cow Low the present dip of the (lower) apron-reef is variable, with an average approximating to 25°. Down the dip slope here, the overlying Beach Beds are inclined at 17° north (Plate XI; text-fig.1). The map included in Parkinson (1965, fig. 1) shows a dip of 20° north; a dip of 20° is also shown on Sadler's (1964) map. Near the Winnats, the existing average dip of the reef of about 23° compares with approximately 18° for the Beach Beds. The figures suggest a tectonic component of the Beach Beds between 5° and 10° higher than that of the apron-reef.

In the same Parkinson paper (1965, p. 172), the thickness of the lower apron-reef in the southern face of the Winnats from the summit, as represented by the oolitic pebbly limestone at the top of the cliff Parkinson, (1947, Plate VIII) down to the lowest exposures in the gorge, was estimated at 350 ft. Down dip from the floor of the Winnats to the base of the Beach Beds, the estimated thickness was 250 ft., which indicates an overstep of the apron-reef of 100 ft., on the assumption that there is no diminution in thickness down the reef slope.

It seems reasonable to suppose that the uplift was a vertical movement, with its maximum expression along the outer margin of the apron-reef. The movement is presumed to have raised the rim of the 350 ft. thick apron by about 300 ft., the uplift diminishing towards the inner margin. The presence of the oolitic conglomerate at the inner margin suggests that the actual emergence of the reef was small.

Beach Bed sedimentation presumably started somewhat earlier than the initiation of the upper apron-reef, which coincided with the next downward movement of the sea floor. The upper apron, with the algal reefs (Wolfenden, 1958) at the inner margin, was laid down at an angle of about 30° on the eroded surface of the lower reef, which was inclined down dip at about 25° (Parkinson, 1965, fig. 2). The thickness apparently increased down the slope but probably never exceeded some 70 or 80 feet.

## Goniatites at Cow Low and Treak Cliff

The Cow Low specimens have all been obtained from a pocket deposit, crowded with goniatites, in Cow Low Nick. Bisat (1934) described species collected by Alexander, and Ford (1965) added to the list, which comprises the following forms:

*Beyrichoceras rectangularum* Bisat
*Beyrichoceras submicronotum* Bisat
*Beyrichoceras vesciculiferum* de Koninck
*Dimorphoceras gilbertsoni* (Phillips)
*Goniatites cf. hudsoni Bisat*
*Goniatites maximus* Bisat
*Prolecanites discoides* Foord and Crick
*Prolecanites serpentinus* (Phillips)
*Pronorites cyclolobus* (Phillips)
*Sagittoceras discus* (Roemer)
? *Discitoceras sp.*

In the abstract of Ford's paper, the horizon of the pocket deposit was given as Upper $B_2$, but the author informed me *in litt.* that "Upper $B_2$" should have read "Upper B", which would indicate any horizon of Upper *Beyrichoceras* age.

The two commonest species are *B. submicronotum* and *G. maximus*. The latter species ranges throughout $B_2$, but the former has apparently not been recorded from beds, either here or elsewhere, demonstrably of Upper $B_2$ age.

Hudson and Cotton (1945a, p.301) tentatively suggested a goniatite succession, within the reef limestone of $B_2$ in the Central Province, consisting of faunas designated A, B, C, D, E, in ascending order; A and B were representative of Lower $B_2$ and C, D and E, of Upper $B_2$. *B. submicronotum* was placed only in fauna A.

The presence of *B. rectangularum* in the Cow Low pocket, on my reading of the succession, is puzzling, since this species is a characteristic Upper $B_2$ form and is apparently uncommon in other areas in the lower part of $B_2$. This is the only goniatite that can be cited to support an Upper $B_2$ age for the Long Cliff - Cow Low segment of the apron-reef.

On Treak Cliff, goniatites have been collected by various workers and in particular by Jackson (1927). Bisat (1934) described a number of species, including forms from Jackson's collection. The reader is also asked to refer to papers by Shirley and Horsfield (1940), Hudson and Cotton (1945a), Parkinson (1953), Shaw (1970) and Stevenson and Gaunt (1971). The list from Treak Cliff includes:

| | |
|---|---|
| *Beyrichoceras delicatum* Bisat | *Dimorphoceras sp.* |
| *Beyrichoceras cf. micronotum* (Phillips) | ? *Goniatites antiquatus* Bisat |
| *Beyrichoceras rectangularum* Bisat | *Goniatites crenistria* Phillips (early form) |
| *Beyrichoceratoides truncatus* (Phillips) group | *Goniatites cf. Hudsoni* Bisat |
| *Bollandites castletonensis* (Bisat) | ? *Goniatites wedberensis* Bisat |
| *Bollandoceras cf. excavatum* (Phillips) | *Nomismoceras aff. vittigerum* (Phillips) |
| *Bollandoceras aff. phillipsi* (Bisat) | |

This assemblage indicates unquestionaly an Upper $B_2$ age since it includes early varieties of species dominant in $P_{1a}$, e.g. *Goniatites crenistria* and *Beyrichoceratoides truncatus*. On the other hand, the Cow Low assemblage has no representative of these near-$P_{1a}$ forms, which means that, on the evidence of the goniatites alone, the Cow Low pocket is earlier in date than the high high horizons of Treak Cliff. The Beach Bed deposits are thus diachronous but their age limits still do not attain the $P_{1d}$ - $P_2$ zones indicated by Stevenson and Gaunt (1971).

## The Bowlandian earth movements

The middle $B_2$ uplift at Castleton approximates in time to the Mid-$D_1$ unconformity between Hartington and Alsop in the Dovedale area (Parkinson, 1973) and the Bowlandian upward movement near the Lancashire - Yorkshire border (Parkinson, 1974). In the Clitheroe-Bowland - Craven area, there is a paucity of Lower $B_2$ goniatite species and the Bowlandian unconformity is taken to mark the boundary between Lower and Upper $B_2$. In this respect, the Castleton area is important in providing goniatite records supposedly from below the Bowlandian break.

The existence of a boulder bed overlying the apron-reef at Treak Cliff has been demonstrated by Simpson and Broadhurst (1969). In the discussion of the paper, (p. 149), Dr. Ramsbottom argued that the formation of the boulders must have been pre-Namurian and suggested a possible correlation with the Beach Beds; in the memoir, (Stevenson and Gaunt, 1971, p. 163), the boulder bed was suggested to be of early Namurian age. If the age of the Beach Beds is $B_2$-$P_{1a}$, as suggested on Table 1, Ramsbottom's argument cannot be supported.

## Conclusions

It is concluded that, on considerations of geographical distribution, relationship with other fore-reef deposits and on faunal content, the Castleton Beach Beds are of $B_2$-$P_{1a}$ age and post date the formation of the lower apron-reef. They are formed as a consequence of deposition and erosion, resulting from the Bowlandian earth movements, of pre-existing reef limestones.

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