

## Foraminiferal biostratigraphy of the Woo Dale Borehole, Derbyshire and the age of the Dinantian-Basement unconformity

A. R. E. STRANK

**ABSTRACT**—Detailed micropalaeontological analysis of the Woo Dale Borehole shows that Dinantian strata of Holkerian and Arundian age lie unconformably on top of the pre-Carboniferous basement beds. The Chadian and Tournaisian are missing. The chronostratigraphy here recognised is compared with that proposed by Cope (1973) and the differences in the two interpretations explained in the light of recent palaeontological and Midlands regional research.

### INTRODUCTION

Only two deep boreholes, namely Eyam and Woo Dale, have penetrated the complete Dinantian succession on the Derbyshire Dome. During the Dinantian, North Derbyshire was a shallow shelf province depositing thick richly bioclastic limestone sequences off the northern shores of St. George's Land (Fig. 1). To the east of the area a basinal embayment known as the Edale Gulf penetrated the Midlands shelf, depositing shales, sandstones and muddy limestone bands. The area was pulsed by a series of shallow marine events depositing sediments across the submerged areas. A series of local basement highs coupled with differential subsidence resulted in local non sequences caused by non deposition or erosion. The very thick Dinantian succession at Eyam (1803.25 m) contrasts markedly with that proven in the Woo Dale Borehole (273.60 m), 11 km to the W.S.W. illustrating the consequences of different local conditions within an extensive shelf environment.

The Woo Dale Borehole drilled by I.C.I. in 1947-48 was situated on an anticlinal crest at the confluence of Woo Dale and Wye Dale 5 km east of Buxton (SK 4099 3726) and was spudded into Woo Dale Limestone. The borehole was cored throughout having a diameter of 0.2 m at the top reducing to 0.04 m at the base.

The surviving core is housed in the Geology Departments at Keele, Manchester and Reading Universities with the remainder in the care of Professor F. W. Cope. Much of the limestone to 243.20 m is heavily dolomitised and most of the original texture and fossils have been destroyed by recrystallisation. Plentiful corals, brachiopods, foraminifera and algae occur in the less severely dolomitised horizons. Below 243.20 m dolomitisation is only slight and from 266.91 m to the top of the breccia at 271.16 m the limestones are less altered (Cope, 1973).

The brecciated horizons contain waterworn fragments of volcanic rocks indicating penecontemporaneous erosion at the base of the limestone succession (Cope,

1973). A possible deepening of basement from Woo Dale (273.60 m) to Eyam (1803.25 m) corresponds to a descent in the gravity anomaly over the area (Cope, 1973). Cope interprets this as a condensed sequence, a view he supports by the presence of clay band breaks in the succession, the intense dolomitisation and the fabric of the non dolomitised limestones (Cope, 1973). He concludes that differential subsidence of the North Derbyshire basement during the Dinantian is the mechanism responsible for the thickness change.

Cope's (*op.cit.*) biostratigraphical analysis of the macrofauna suggests S<sub>2</sub> (Holkerian) strata to a depth of 110.20 m, C<sub>2</sub>S<sub>1</sub> (Arundian-Chadian) strata to 243.20 m and a probable ? C<sub>1</sub> Zone (Tournaisian) to 273.60 m. This paper presents a revised interpretation of the biostratigraphy together with palaeoenvironmental interpretation to explain the thickness changes between Eyam and Woo Dale.

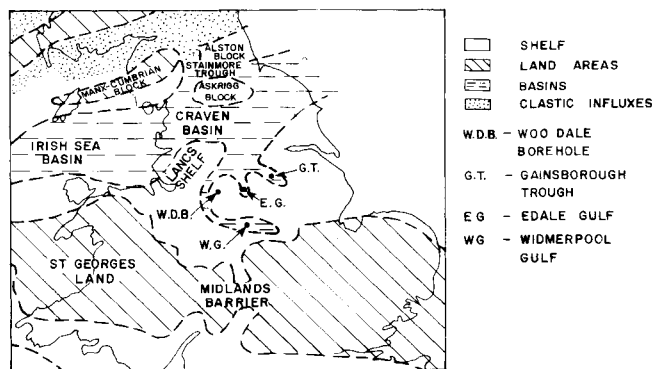


Fig. 1. Generalised Dinantian palaeogeographical setting of the Midlands area.

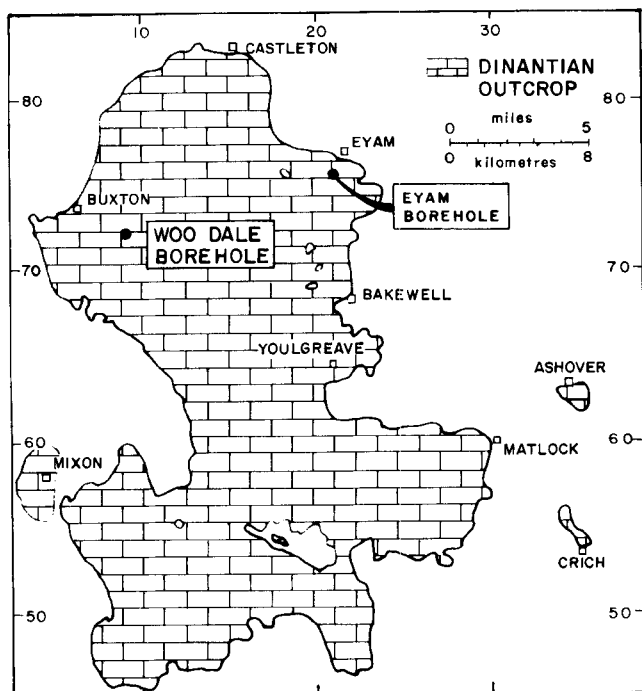


Fig. 2. Location of the Woo Dale Borehole and areas of Dinantian outcrop in the Derbyshire area.

## BIOSTRATIGRAPHY

The microfossil data presented result from examination of thin sections cut throughout the borehole. This includes a collection of slides donated by Professor F. W. Cope for examination by the author. The macrofaunal occurrences recorded are taken from the detailed logs compiled by Professor Cope during the sinking of the borehole and from recent examination of coral sections by Mr. M. Mitchell (B.G.S., Keyworth). No palynological information is available.

### Microfossil Analysis (Fig. 3)

#### 0–115.97 m: Holkerian

A rich, diverse microfossil assemblage together with some well preserved corals and brachiopods characterise the predominantly grey/brown dolomitised limestones found in this interval.

The presence of *Nibelia nibelis* (Durkina, 1959), *Koskinotextularia* sp., *Bogushella* sp., *Eostaffella parastruvei* (Rauser, 1948), *Archaeodiscus stilus* Grozdilova & Lebedeva and *Plectogyransopsis convexa* (Rauser, 1948), together with the alga *Koninckopora inflata* (de Koninck) confirms a Holkerian age for this interval. A rich influx of calcispheres and ostracods, excluding all other fauna is recorded at 114.3 m.

The accompanying corals include *Lithostrotion sociale*, *Haplolasma subibicina* (McCoy) and *Syringopora* cf. *ramulosa* Goldfuss. Amongst the brachiopods present

*Davidsonina carbonaria* (McCoy) and *Composita* cf. *ficoides* (Vaughan) confirm a Holkerian age. A record of *Daviesiella llangollensis* (Davidson) at 26.01 m indicates Holkerian or Asbian strata (Cope, 1940; Somerville & Strank, 1984). This taxon is not restricted to an early Asbian (lower D<sub>1</sub>) age as suggested in George *et al.*, 1976.

The overall faunal assemblage is representative of a shallow shelf environment.

#### 135.94–273.60 m : Arundian

The upper grey/brown dolomitised limestones of this interval are characterised by a paucity of microfauna but some diagnostic corals including *Dorlodotia briarti* Saleé (135.94 m), *Lithostrotion minus*, *L. martini*? Edwards & Haime and *Syringopora* sp. have been found. Together these indicate an Arundian age. Lower down in this succession the less dolomitised limestones contain a rich microfaunal assemblage including *Glomodiscus* sp., *Eoparastaffella simplex* (Vdovenko, 1953) and *E. restricta* Postojalko & Garini, 1972, confirming an Arundian age. Associated taxa include *Brunsia spirillinoides*, *Palaeospiroplectammina mellina* (Malakhova), *Glomospiranella* sp. and *Dainella* sp. together with the algae *Koninckopora inflata* and *Solenopora* sp. The lowest diagnostic Arundian taxon *Glomodiscus* occurs at 258.47 m. The occurrence of *Koninckopora inflata* lower down at 268.98 m and ?*Koninckopora* at 269.9 m indicates that Chadian strata have not been penetrated at these depths. The lowest 3.7 m of grey/blue limestone and brecciated limestone in the Dinantian succession contain a sparse undiagnostic fauna. From the absence of Chadian microfauna, the lowest 3.7 m are assumed to be of Arundian age.

The overall palaeoenvironment represented is that of a shallow shelf. The general paucity of fauna may reflect periodically unfavourable conditions for a foraminiferal habitat. The original diversity of the fauna is difficult to assess due to the destruction by dolomitisation of many taxa.

#### 273.60–312.00 m (T.D.) : Pre Carboniferous

These lavas, volcanic breccias and pyroclastic rocks have been dated by K/Ar techniques as Devonian or older (i.e. 383 Ma or older) by Cope (1979). No refinement of this age determination is yet available.

## DISCUSSION

The biostratigraphical results differ markedly from those given by Cope (1973).

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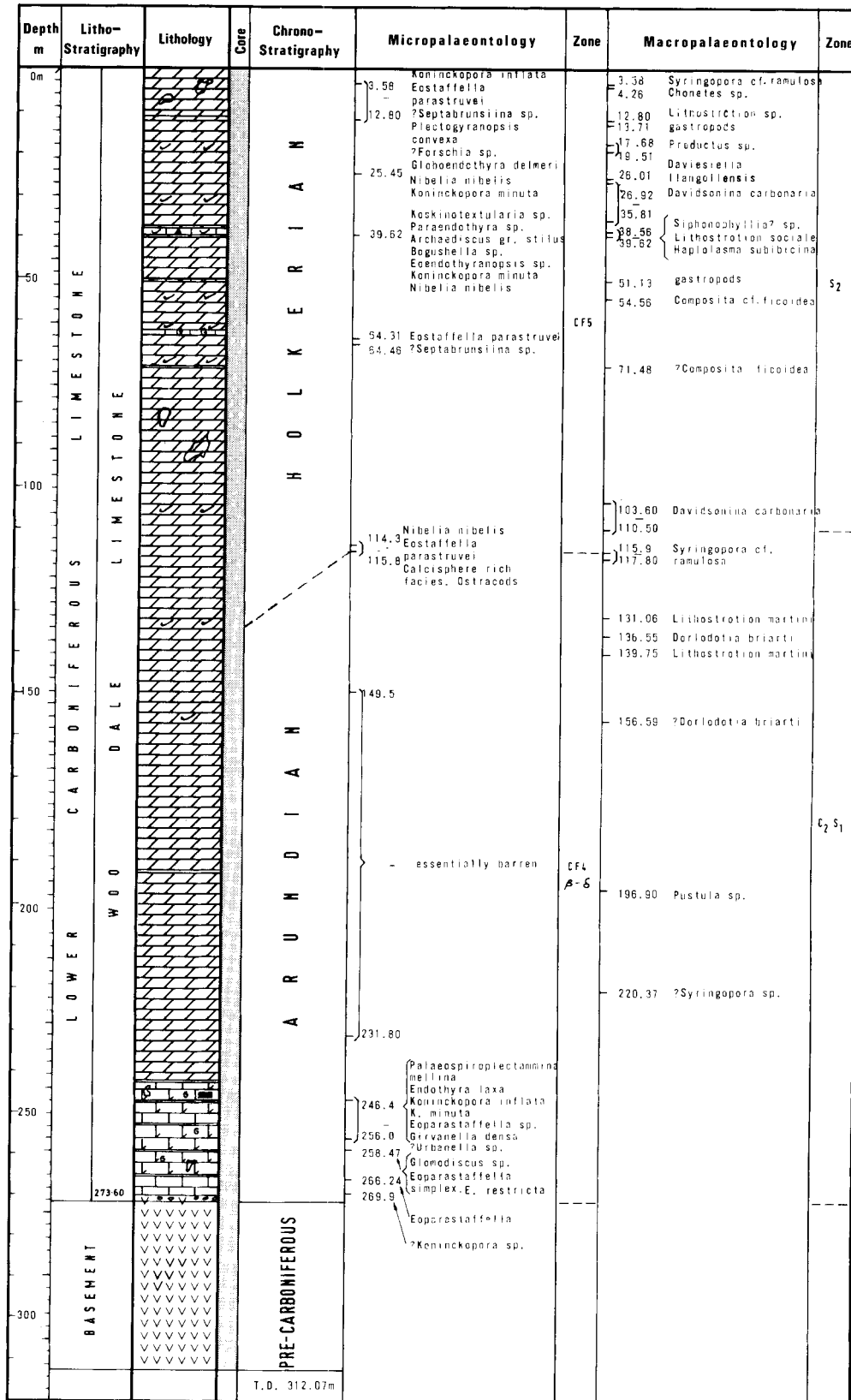


Fig. 3. Biostratigraphy of the Woo Dale Borehole.

	Cope (1973)	Strank (this paper)
Holkerian	(S <sub>2</sub> ) 0–110.20 m	0–115.97 m
Arundian	(C <sub>2</sub> S <sub>1</sub> ) 110.20–243.20 m	135.94–273.60 m
Chadian		ABSENT
Tournaisian?	243.20–273.60 m	ABSENT
Basement	273.60–312.00 m	273.60–312.00 m

With Holkerian foraminifera recorded down to 115.97 m and Arundian corals at 135.94 m, the Arundian-Holkerian boundary has been placed between these two depths (see Fig. 3).

The major difference in the two biostratigraphical schemes is below the Arundian. Cope records the C<sub>2</sub>S<sub>1</sub> zone (Arundian and Chadian) and the underlying ? Tournaisian. Strank (this paper) can find no evidence of limestones older than Arundian. One reason for this discrepancy may be the records of *Thysanophyllum pseudovermiculare* (McCoy) at 135.94 m and obscurely at 156.59 m. The specimen at 135.94 m has been re-identified by Mr. M. Mitchell as *Dorlodotia briati*, a species diagnostic of Arundian strata (Poty, 1975 & 1981). *Dorlodotia*, a fasciculate species is distinguished from the cerioid species *Thysanophyllum* by the presence of a columella. The taxon *Thysanophyllum pseudovermiculare* is thought to be characteristic of Chadian rocks. At the time of Cope's (1973) publication, these two taxa had not been distinguished and all such specimens were recorded as *Thysanophyllum pseudovermiculare* suggesting a Chadian age.

Cope's record of Tournaisian strata is based on the tentative correlation of *Solenopora* cf. *garwoodi* clasts with the *Solenopora* Subzone of Garwood in northern England. *Solenopora* is not however restricted to Tournaisian strata. The rich foraminiferal assemblage in these beds confirms their Arundian age.

## CONCLUSIONS

The brecciated limestones, lava and pyroclastics in the basal Dinantian sequence indicate deposition of Arundian limestones onto a basement high land area, of pre-Carboniferous age. There is no evidence that any pre-Arundian limestones were deposited in this area. During the early Arundian, a shallow, warm water shelf environment was established in which 137.66 m of richly bioclastic limestones were deposited. This shelf environment persisted throughout the overlying Holkerian when over 115.97 m of limestones accumulated. Evidence from surrounding wells and outcrop sections (Aitkenhead *et al.*, in press) suggests that Asbian and Brigantian limestones were originally deposited in the Woo Dale area and have since been eroded away.

In the nearby Eyam district the basement was engulfed by a marine event much earlier in the Dinantian than at Woo Dale. Thick limestones accumulated throughout the Lower Carboniferous from the Courceyan to the Brigantian. Approximately 490 m of pre-Arundian sediments were deposited at Eyam before the Arundian marine incursion transgressed the Woo Dale area. At Eyam, much thicker Arundian (593.38 m) sequences were deposited compared with Woo Dale.

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