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AN INVESTIGATION OF THE LOWER PERMIAN MIDDLE ECCA AMMONITE LOCALITY AT ALLETA, NATAL

by

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ABSTRACT

The problematic ammonite *Paraceltites bowdeni* Teichert & Rilett has been recorded only from the Alleta iron-ore mine near Dundee in Natal. It is unique in the Early Permian Ecca Series as it suggests a normal salinity for the depositional environment of sediments that have yielded no other clearly marine fossils. An investigation of the matrix of the specimen slabs, however, yields information which is incompatible with equivalent data from the Alleta mine and the Ecca sediments in general. The matrix contains the distinctive pollen *Classopollis* which is not known from elsewhere in the world in deposits older than Late Triassic. Comparative tests of the degree of thermal diagenesis of the contained organic material suggests that the ammonite specimens have not been subjected to the same degree of alteration as the sediments at the Alleta mine. Results of other tests have not been definitive but do not contradict the suggestion that the ammonites were mistakenly accredited to the Alleta mine. It is concluded that the ammonites derived originally from sediments of Late Triassic to Early Jurassic age at an unknown locality outside of South Africa.

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INTRODUCTION

The Middle Ecca sediments of the northern Karoo facies form a sandy wedge of fluvio-deltaic origin (Ryan, 1968; Hobday and Mathew, 1975) which built out into the basin, being supplied from source areas mainly in the north-east. Economic coal deposits occur at several levels in a broad arc extending from near Welkom in the north-western Orange Free State across the southern Transvaal and into northern Natal as far south as Dundee. Although the basin of deposition has been loosely referred to as being a "sea" or "marine", the invertebrate record is notably sparse. In the course of a review of the paleontological information relating to the nature of the depositional environment of the northern Karoo Ecca sediments, McLachlan (1973, p. 10) concluded that the fossil content (fish scales, fresh water bivalves, Conchostracha, acanthomorph acritarchs, monaxon siliceous sponge spicules) suggests fresh to brackish water and provides no support for normal marine conditions. Anderson (1975) has since described limulid trackways from the top of the Upper Ecca shales in the Orange Free State. Although it was recognised that they might record a restricted relict fauna surviving in the basin after withdrawal of the marine incursion which followed the retreat of the Dwyka glaciers (McLachlan and Anderson, 1973), it was tentatively suggested that their presence might reflect the existence of a link with the world oceans (Anderson, 1975). As the alternative explanation is equally acceptable the evidence provided by the limulid trackways in favour of a marine environment must remain inconclusive. The only real exception to have emerged in nearly

70 years of coal mining and exploration of the Ecca is the ammonite from the Alleta* mine described by Rilett (1963) as *Discetoceras bowdeni* and recently redescribed by Teichert and Rilett (1974) as *Paraceltites bowdeni*. It was cited by Teichert and Rilett as evidence for a marine paralic depositional environment within the Middle Ecca coal measures and was considered to indicate a late Early to Late Permian age. According to Rossouw (1976) the Alleta iron-ore deposit lies approximately in the middle of the Middle Ecca sequence.

The Alleta mine was worked on a small scale between 1939 and 1953 (MacGillivray, written comm. 1975) to exploit a metre thick carbonaceous siderite band as a source of iron. A few years before the mine shut down, Rilett (1951) described a number of specimens of the fresh-water bivalve *Unio alettaensis* which had been recovered from the siderite band by the mine staff in the course of operations. He considered the lenticular iron ore deposit to be clearly lacustrine in origin. In 1963, a decade after the closure of the mine, he described a few compressed but otherwise well preserved cephalopods *(Discetoceras bowdeni)* which he reported had been recovered by the Inspector of Mines, Mr. Bowden, from the shale roof of the small coal seam overlying the siderite deposit at the Alleta mine (fig. 1). He observed that the Middle Ecca beds in northern Natal were laid down in a cyclic manner and that the cephalopods were found in a thin shale above a small coal seam where marine beds would be expected if the classical cyclothem of the European coal measures was used as a model. He pointed out that cyclothems are normally incomplete with the marine portions almost invariably being absent (Teichert and Rilett, 1974).

The present investigation arose from an interest in the depositional environments of the Dwyka and

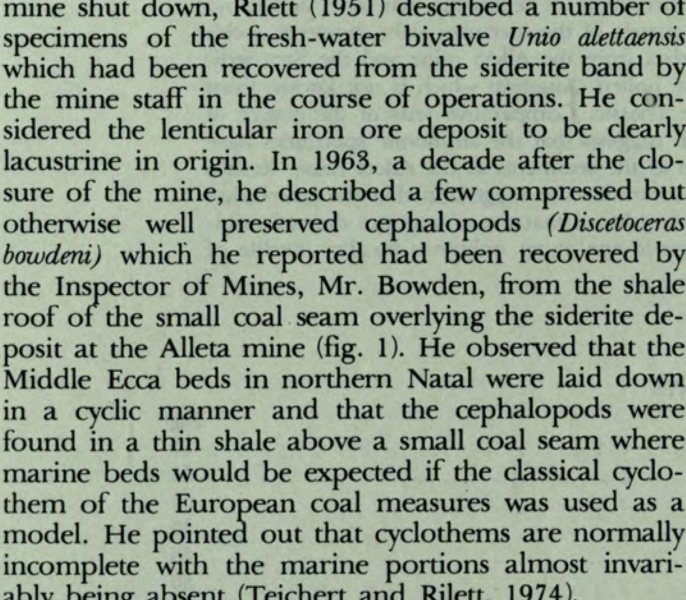

Figure 1. Schematic stratigraphic section at Alleta, compiled from information in Rilett (1951, 1963), Teichert and Rilett (1974), Rossouw (1976) and personal observation.

Ecca sediments as revealed by micropalaeontology. The matrix of the ammonite specimen slab was initially studied in 1971, in the hope that marine microfaunas or acritarchs might be present which would shed further light on the environment and age of the sediments and which could perhaps aid recognition of the horizon in boreholes further afield. These studies were inconclusive because of the difficulty of effectively disaggregating the sample material. In June, 1973, the ammonite specimen was examined at the Natal Museum. The manner of preservation, particularly the bright fresh appearance, seemed anomalous when compared with other invertebrate fossils known from the Karoo. A comparative study was accordingly undertaken to discover whether there is any positive information to confirm that the ammonite specimens did derive from the Karoo sediments or whether they were from some other source and had been mistakenly credited to the Alleta mine.

A. Description of Alleta Mine

The mine is situated 12 km north of Dundee, near the southern limit of the Natal Middle Ecca coal fields (fig. 2). The geology of the area is described in some detail by Rossouw (1976). A schematic section, (fig. 3) shows the relative positions of the main elements. The mine was briefly visited in 1973 to obtain a set of comparative samples. A number of adits and stopes extended from an open cut and followed the horizontally bedded siderite into the hillside for 600 m. The workings are in a dangerous condition and in most cases falls of hanging-wall strata have buried the siderite and coal bands. Only one adit was open and safe for a short distance. A careful search did not reveal any sediment resembling that of the ammonite matrix. This absence could be explained by the weathered state of sediments and the poor exposures. Furthermore, Teichert and Rilett (1974) pointed out that the thin layer was probably impersistently developed. Figure 3 shows a sketch of an exposure in the easternmost open pit and the positions of the samples collected.

The extensive Zuinguin dolerite sill (fig. 1) lies 15 metres above the workings and is about 30 metres thick.

B. The Ammonite Specimen Slabs

Teichert and Rilett (1974) provided a careful description of the specimens and matrix, so only the main points and any new observations are recorded here. The most striking feature of the fossils is the bright fresh orange colour of the ? aragonitic shells and their relatively good state of preservation. They occur as compressions on a pale grey matrix of highly calcareous shale. Teichert and Rilett observed

* This spelling follows the usage of the 1:125 000 geology map of the area (Elandslaagte 2829B and Dundee 2830A, printed 1967) and the 1:50 000 topographic map 2830AA (printed 1973). The farm name on the latter is spelt Alletta. Rilett (1951) used the spelling Aletta.

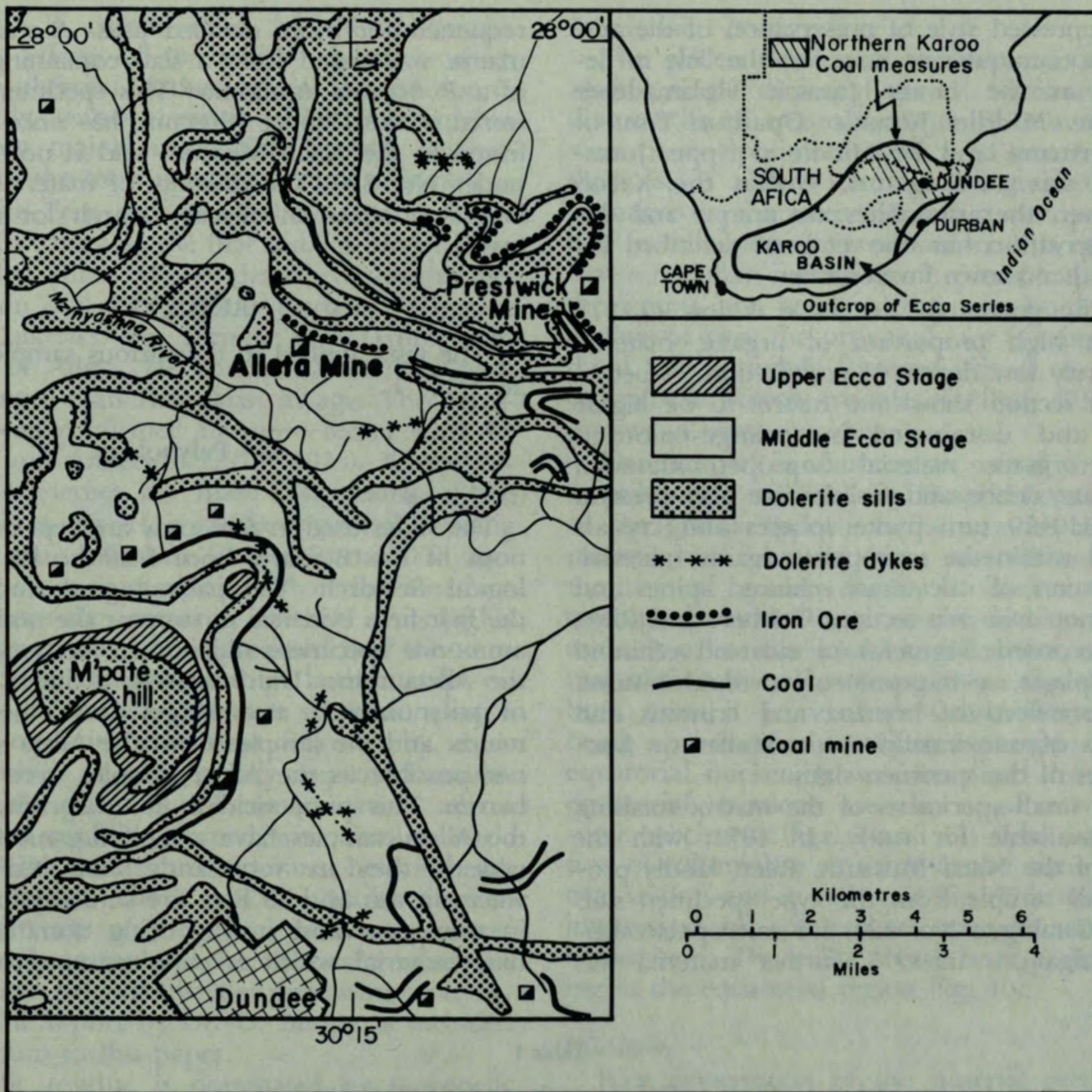

Figure 2. Plan showing regional geological setting of the Alleta iron-ore mine from which the ammonite *Paraceltites bowdeni* is said to have originated. (Modified after Figure 1 of Teichert and Rilett, (1974). Baseplan: 1/125 000 Geol. map. 2829B Elandslaagte and 2830A Dundee, Geol. Surv. S. Afr.)

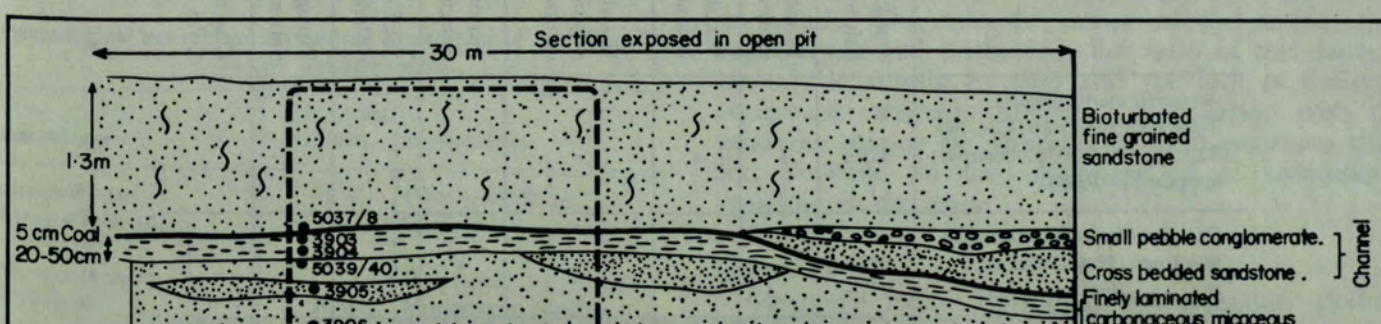

Figure 3. Sketch of section exposed at Alleta mine. Sample positions 3903 to 3906 and 5037 to 5042 are shown.

that the compressed style of preservation of the ammonites is not unique but is in fact the rule in deposits such as the Lower Jurassic Holzmadener Schiefer, the Middle Jurassic Opalinus-Ton of southern Germany, and the Middle to Upper Jurassic Oxford clay of England. Within the Karoo basin, however, the ammonites are unique and this style of preservation has not yet been described for any of the other known invertebrates.

The specific gravity of the shale is low (2.131), suggesting a high proportion of organic material and a relatively low degree of compaction. A petrographic thin section shows the matrix to be highly calcareous and dominated by orange-coloured amorphous organic material (sapropel) although tracheitic plant debris and fusinite are also present. Very small (10–20 μm) pyrite spheres and crystals are crowded within the sapropelic organic material. A few fragments of calcareous echinoid spines and plates were noted in thin section; Teichert and Rilett previously recorded fragments of cidaroid echinoid spines and plates, a fragment of mytiloid bivalve, possible impressions of bryozoa and crinoids and the remnants of one indefinite foraminifer on fractured surfaces of the specimen slabs.

Only two small specimens of the matrix totalling 7 g were available for study. In 1971, with the permission of the Natal Museum, Rilett kindly provided a small sample from the type specimen slab (No. 1012, Catalogue No. 820) for micropalaeontological investigation. In 1973, further material was requested for more detailed tests. A small piece of matrix was sawed from a slab containing a portion of a *P. bowdeni* ammonite. This specimen, originally stored in the Dundee Museum, has since been transferred to the Natal Museum and is now catalogued under No. 820. The quantity of material was insufficient to allow an effective search for microfaunal fossils.

RESULTS

The tests applied to the various samples are listed in Table 1.

A. Palynology

(i) *General*

The slides used in this study are kept in the collections of the Bernard Price Institute for Palaeontological Research. The palynological study provided the first firm evidence to support the notion that the ammonite specimens did not, in fact, originate from the Alleta mine. Unfortunately, a direct comparison of palynomorph assemblages from the ammonite matrix and the samples from the Alleta samples was not possible as the Alleta samples were very nearly barren. This poor yield is not surprising. Although the Alleta samples have a high organic content (see table 3) they are very sandy. Such sediments elsewhere in the Middle Ecca are similarly impoverished in miospores and cuticle, being dominated by lignitic material which is very resistant to oxidation.

Table 1

Schedule of tests applied to samples from the ammonite specimen slabs and from the Alleta mine.

Sample Description	SOEKOR palynology No.	Palynology studied	Visually estimated TAI	Visual estimate of organic material composition	Vitrinite reflectance	Total organic material (T. org.)	Petrographic thin section	Clay mineralogy by X-ray diffraction
Ammonite matrix samples								
Type specimen slab. Cat. No. 820, type No. 1012. (Sample supplied by Rilett).	3769	+	+	+				
Dundee Museum ammonite specimen. Natal Museum Cat. No. 820	3834	+	+	+	+	+	+	+
Alleta mine samples								
Finely lam. carb. mic. shale	3903	+	+	+	+	+		+
Finely lam. carb. mic. shale	3904	+	+	+				
Bioturb. sl. carb. mic. sltst.	3905	+	+	+				
Bioturb. sl. carb. mic. sltst.	3906	+	+	+				
Coal band above siderite	5037	+	+	+				
Coal band above siderite	5038	+	+	+				
Siderite ore from dump.	5041	+	+	+				
Siderite ore from dump.	5042	+	+	+				

The situation is compounded by the destructive metamorphic effects of the nearby dolerites which have caused thermal darkening of the miospores and probably some corrosion. Weathering has probably been mainly responsible for the destruction of all but the most resistant organic material.

The Middle Ecca unit as a whole is nonetheless well dated. In what was the first publication on Ecca palynomorphs, Rilett (1954) described assemblages from the main coal seams of the Durban Navigation Group of Collieries No. 3 mine near Dannhauser, 25 km west of Alleta. He concluded that the coals are not younger than Artinskian in age. This assessment has been confirmed by more recent work by Hart (1967) and Anderson (1973, 1975). As the Alleta deposit underlies the main coal seams of the Dannhauser area (fig. 1), it can be regarded as being not younger than Artinskian (Lower Permian) in age.

Very poor yields were obtained from the initial attempt to process the ammonite material as its highly sapropelic nature was not appreciated and the sample could not be disaggregated. A later attempt on the matrix of the Dundee Museum specimen using a fairly severe oxidation treatment followed by staining with safranin O gave greatly improved results. To preclude the possibility of contamination, all receptacles were carefully cleaned with fuming nitric acid mixed with potassium chlorate, before being used. As a further check on the results detailed below, the director of the Natal Museum was requested to send a sample of the ammonite matrix to an independent palynologist for processing and examination. The report by Dr. D. Burger is included as an addendum to this paper.

The organic residue is dominated by sapropelic material with miospores constituting less than 5 % of the whole (table 3). The palynological assemblage consists almost entirely of *Classopollis* with minor amounts of other pollen grains and acritarchs (table 2). Preservation of the microfossils is not good but is certainly adequate to allow confident identification of the elements which are considered significant.

Table 2

Palynological assemblage recognised in samples of the *Paraceltites bowdeni* specimen slabs.

Assemblage	% in count of 200	Preservation
Classopollis spp.	82 %	Poor to moderate
?Araucariacites sp. }	8 %	Moderate
Miospores indet. }		Very poor
Acritarchs	10 %	Moderate to good

(ii) *Systematic descriptions*

POLLEN

Genus: CLASSOPOLLIS Pflug emend. Reyre, 1970

Classopollis sp. cf. *C.meyeriana* (Klaus), De Jersey, 1973
Figures 4–11

Description

The pollen occurs as tetrads in a ratio of 1:4 against single dispersed grains. Specimens range in diameter from 44 µm to 20 µm. The average dimensions of ten specimens is 36 × 31 µm. Average exine thickness is about 1,6 µm. The grains show some variations in character. While a certain part of this is due to differences in preservation, it is quite possible that more than one species is present. In polar view, the grains are nearly circular in outline while in equatorial view the proximal face is tapered and the distal face is slightly flattened (fig. 4). A sub-equatorial circular furrow (rimula of Pflug, 1953) is clearly present in most specimens.

The ratio of its diameter to overall amb diameter in polar view is 0,78:1 for 10 specimens. The surface of the grains appears to be smooth and unornamented but this may be a preservational effect. A number of grains display a distinct pseudopore (average diameter 9 µm) on the distal surface (figs. 4 to 7). A trilete scar could be discerned on the proximal surface in only two specimens (figs. 8 and 9); in both cases it is relatively small with the laesurae being approximately 2–3 µm in length. No marked equatorial thickening was seen, and definite circum-equatorial striations are also apparently absent. In some specimens (figs. 7 and 11) there is the suggestion of columellate structure in the exine seen in optical section and in only one (fig. 7) is there a distinct impression of columellate structure on the distal hemisphere. The exine shows only a slight thickening in the equatorial region (fig. 10).

Discussion

Poor preservation of the material precludes confident specific allocation.

The presence of the following features leaves little room for doubt (see Pocock and Jansonius, 1961; Reyre, 1970) that the genus represented is *Classopollis:* general shape of the grains, sub-equatorial furrow, proximal trilete scar and distal pseudopore, columellate structure of exine, common occurrence as tetrads. The smooth surface of the grains, the slight equatorial thickening, the ratio of the diameter of the rimula to amb and the lack of definite equatorial striations suggest a comparison with *C. meyeriana* (Klaus) De Jersy, 1973. The specimens differ, however, in the suggestion of a columellate structure in the exine.

Occurrence

Classopollis is a distinctive cosmopolitan pollen which has a well established first evolutionary appearance in the Upper Triassic (Chaloner and Clarke, 1961; Pettitt and Chaloner, 1964; Chaloner, 1969; Reyre, 1970; Singh, 1971; De Jersey, 1973; Pocock, 1972). It is robust and is often recognisable in preparations where most other elements of an assemblage have been destroyed or severely damaged by corrosion. It characteristically dominates Jurassic and Lower Cretaceous ("Neocomian") assemblages and thereafter declines in importance until it finally dissappears in the Senonian.

The record of *C. belloyensis* by Pocock and Jansonius (1961) from the Permian has been shown by Chaloner and Clarke (1961) to be erroneous. *Classopollis* has not been recorded from the Karoo basin Permian or Triassic rocks in spite of extensive sampling by Hart (1967), Anderson and Anderson (1970) and Anderson (1973, 1975), nor has it been reported from Karoo sediments of the age in Rhodesia (Mrs. R. Falcon. pers. comm.) or Zambia (Dr. J. Utting, pers. comm.). De Jersey (1973) gives the range of *C. meyeriana* as being Upper Triassic (Carnian) to Lower Jurassic.

Genus: ARAUCARIACITES Cookson ex Cooper, 1953

Araucariacites sp.

Figure 12

Description

The pollen is oval to circular in outline and has a finely grandular exine. No evidence of apertures was seen. The dimensions of four specimens average 50 × 41 μm with a maximum dimension of 54 μm and a minimum of 38 μm.

Discussion

Because of poor preservation, the identification is not confidently made; it is not a distinctive pollen and especially when poorly preserved could easily be confused with other similar long ranging genera.

Occurrence

The range of *Araucariacites* is given by Singh (1971) as Jurassic to Tertiary. It commonly occurs as a dominant element in Jurassic to Lower Cretaceous assemblages in association with *Classopollis*.

ACRITARCHS

The relative abundance of this group in the assemblages is probably due to their superior resistance to diagenetic alteration as well as to depositional environment factors. Preservation is moderate; in the case of *Leiosphaeridia* and *Dictyotidium*, it is good. Unfortunately, the acritarchs provide little positive age information. Most are simple conservative forms that have changed little with time and it seems unwise to place reliance on the age ranges given below.

Subgroup: SPHAEROMORPHITAE Downie, Evitt and Sarjeant, 1963.

Genus: LEIOSPHAERIDIA Eisenack, 1958

Leiosphaeridia granulosa Pocock, 1972

Figure 13

Discussion

Three specimens were noted. The description by Pocock (1972, p. 105) applies very well to these and need not be repeated here. There is no sign of an aperture. Vesicle diameter averages 32 μm and the granules are 0,4 to 0,8 μm wide.

Occurrence

Pocock recorded *L. granulosa* from the Lower to Middle Jurassic of Canada.

Leiosphaeridia sp. B

Figure 14

Description

Vesicle circular in outline and 12 to 14 μm in diameter. Surface uniformly ornamented with short conical granules spaced a little more than their own diameter apart. No apertures seen.

Discussion

Similar to *L. minutaespinosa* Pocock (1972) but the dimensions are consistently smaller. Three specimens seen.

Subgroup: HERKOMORPHITAE Downie, Evitt and Sarjeant, 1963

Genus: DICTYOTIDIUM (Wetzel) Staplin, 1961

Dictyotidium sp.

Figures 15–17

Description

Vesicle circular in outline. Preservation is not sufficiently good to allow the wall structure to be distinguished. Surface ornamentation consists of low membranes which outline polygonal fields of irregular shape and size. No aperture was seen. Vesicle diameter varies from 13 to 19 μm, the height of the ornament membranes is 0,2 to 0,4 μm and the width of the polygonal fields is 0,8 to 3 μm. Seven specimens seen.

Discussion

The specimens studied are all similar in basic organisation but there seems to be a certain amount of gradational variation in vesicle size and the coarseness of ornament reticulation. Some of the specimens are closely similar to *D. eastensis* Pocock but the dimensions are smaller.

Subgroup: ACANTHOMORPHITAE Downie, Evitt and Sarjeant, 1963.

Genus: MICRHYSTRIDIUM (Defl.) Staplin, Jansonius and Pocock, 1969.

Michrystridium lymensis Wall, 1965

Figures 19–20

Description

Vesicle spherical, thin walled (± 0,8 μm) smooth and bearing 15 to 32 spines of variable length in different specimens. Preservation not sufficiently good to allow details of wall or spines to be discerned. The spines are conical and solid, and taper rapidly to a fine point. Vesicle diameter ranges from 17 to 28 μm and averages 26 μm. Nine specimens seen.

Discussion

Riley and Sarjeant (1972) gave the range of *M.*

lymensis Wall as being confined to the Jurassic but it is very probable that simple indistinctive acritarchs of very similar appearance also occur much earlier and later.

Micrhystridium deflandrei Valensi, 1948
Figure 18.

Description

Vesicle oval to circular in outline and bearing numerous short straight or slightly curved solid spines which taper to a fine point. No aperture seen. Three specimens recorded.

Discussion

The specimens fit the description of Davey (1970) well but are consistently larger in size.

Occurrence

Riley and Sarjeant (1972) recorded the age range of *M. deflandrei* as being Jurassic and pre-Jurassic. Davey (1970) recorded it from the Cenomanian.

(iii) *Conclusions*

The only palynomorph from the ammonite specimen slab which gives any definite age information is *Classopollis*. It clearly indicates a post Late Triassic age for the ammonites. The remainder of the assemblage, although not in itself of age significance, is compatible with this dating and, together with the dominance of *Classopollis*, forms a typical Jurassic or Lower Cretaceous (Neocomian) microflora. If the age range of *C. meyeriana* is also taken into account, it is considered that the most probable age for the ammonites is Late Triassic to Early Jurassic.

B. Diagenetic Studies

An extensive literature exists on the determination of maximum palaeotemperature employing the degree of carbonisation of dispersed organic material in sediments (Correia, 1971). For this exercise it is reasonable to suppose that, if the ammonites did originate from Alleta, they would have been exposed to the same temperature as the samples 3903 to 3906 and 5037 to 5042, collected stratigraphically a few metres away in the old workings (fig. 3). The nearest dolerite sill lies 15 m above the siderite; over the small area of the mine, temperatures are likely to have been nearly uniform at the time of maximum heating.

The laboratories of Société des Pétroles d'Aquitaine (S.N.P.A.) undertook the quantitative measurements of total organic carbon, CR/CT ratios and vitrinite reflectance, and also made a visual estimate of the composition of the organic material under reflected light. The samples they received were identified only by code numbers. The author completed visual estimates of the composition of the organic material and the thermal alteration index with transmitted light using standard unoxidised palynological preparations. Results of the tests are shown in Table 3.

The composition of the organic material of the two samples tested is quite different. The palynological assessment indicates a dominance of amorphous organic material in the ammonite specimen and, in contrast, a dominance of lignitic material in the Alleta mine samples. This is supported by S.N.P.A.'s reflected light estimates of 80 % exinite, 15 % vitrinite and 5 % inertinite, with strong and

Table 3

Results of tests on content, composition and degree of thermal alteration of organic material.

	Total organic carbon	CR/CT	Palynological assessment of composition of O.M.: Amorphous O.M. (sapropel)	Cuticle, spores, etc.	Tracheids	Lignite	T.A.I.	Vitrinite reflectance
Ammonite specimen	*1 0,25 %	*2 0,80	80 %	< 5 %	10 %	5 %	2,75	1,00
Alleta mine 3903	4,15 %	0,91	—	< 5 %	< 5 %	90 %	3,50	1,35
3904			—	< 5 %	< 5 %	90 %	3,50	
3905			—	< 5 %	< 5 %	90 %	3,50	
3906			—	< 5 %	< 5 %	90 %	3,50	
5037			—	< 5 %	< 5 %	90 %	4,00	
5041			—	—	—	100 %	—	

EXPLANATION

CR/CT = Proportion of residual to total carbon. It provides a rough indication of organic matter type and maturity.

OM = Organic material.

T.A.I. = Visually estimated thermal alteration index. (S.P. of Correira, 1971).

*1 = Low T.O.C. probably due to loss of O.M. which floated on surface of preparation.

*2 = Result possibly not accurate because of low total organic carbon, but S.N.P.A. feel it is compatable with other information.

Analysts: Société Nationale Pétroles d'Aquitaine. Palynological assessment by I. R. McLachlan.

abundant fluorescence, for the ammonite specimen and 75 % vitrinite, 25 % inertinite for the Alleta mine samples. It is suspected that the measured total organic content of the ammonite specimen is low because of inadvertent loss of organic material due to small sample size: the petrographic thin section shows a high content of organic material. The quantitative measurements of thermal alteration also show clear differences, with the Alleta mine sample vitrinite reflectance index of 1,35 % (equivalent to a temperature of about 135 °C) being compatible with the values measured elsewhere in this area by SOEKOR (Rowsell and De Swardt, 1976) and the ammonite matrix giving the anticipated lower value of 1,00 % (equivalent to a temperature of ±100 °C). The palynological visual estimates (TAI's) of the degree of thermally induced carbonisation also indicate a significant difference: the Alleta miospores and cuticle are dark brown in colour and correspond to a TAI of about 3,5 while the material from the ammonite specimen is clearly less carbonised and has a TAI of about 2,75. The CR/CT ratios are in accord with the above data.

These results strongly suggest that the Alleta sediments have been distinctly more heated than the ammonite samples which are reported to originate from the same site.

C. Mineralogy

The results of X-ray diffraction analyses are shown in Table 4. The composition of the Alleta mine samples is not particularly distinctive.

Table 4

Comparison of minerals identified by X-ray diffraction of a sample from the Alleta mine and one from the ammonite specimen slab.

ALLETA MINE Sample No. 3903 *1	AMMONITE SLAB	Natal Museum *2 Catalogue No. 820
Illite 80 %	Sericite	
Illite-montmorillonite ± 20 %	Calcite	Results qualitative only
No carbonate	Aragonite	
Abundant quartz	Minor quartz	

*1 Analyst: Société Nationale Pétrole d'Aquitaine *2 Analyst: Geological Survey of South Africa

The presence of aragonite in the ammonite specimen seems incompatible with its supposed origin as aragonite is normally unstable at the temperature determined for the Aletta mine sample. However, Kennedy and Hall (1967) gave examples of situations in which the mineral has retained its crystallographic form at higher temperature due to the protective effect of large concentrations of sapropelic organic material. Nevertheless, aragonite has not previously been recorded from the Ecca sediments (Rowsell, pers. comm.) and its presence at Alleta is anomalous.

CONCLUSIONS

The palynomorph assemblage recovered from the matrix of the ammonite specimen slabs indicates a definite minimum age limit of Early Jurassic. This is corroborated by the results obtained by Dr. D. Burger (see appendix) who independently processed and studied the ammonite material which was sent to him by the Natal Museum. The dating is clearly incompatable with the well established Lower Permian age of the Middle Ecca sediments which occur at Alleta. Thermal diagenesis studies support this conclusion and indicate that the ammonites were not subjected to the temperatures which were attained by the sediments at the Alleta mine.

A clue to the origin of the ammonites is perhaps contained in the discussion by Teichert and Rilett (1974). They mentioned that the type of preservation seen in the *Paraceltites bowdeni* specimens is the rule in Jurassic deposits in Germany and Britain: the similarities of preservation and the nature of the enclosing sediments are certainly compelling, while the opposite is the case when a comparison is made with the sediments and mode of preservation of known Karoo fossils.

Clearly, a direct comparison of *P. bowdeni* with ammonites of this age should be made. It is relevant to note in passing that no marine sediments of Upper Triassic or Lower Jurassic age are known within southern Africa (McLachlan, McMillan and Brenner, in press).

It is concluded that the *Paraceltites bowdeni* ammonite specimens did not originate from the Karoo sediments of the Alleta mine and that the environmental conclusions based on them are therefore invalid.

ACKNOWLEDGEMENTS

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ADDENDUM

PALYNOLOGICAL NOTES CONCERNING THE ALLETA AMMONITE

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Palynological examination was carried out in the Bureau of Mineral Resources on a rock sample forwarded by the Natal Museum from matrix adhering to the Alleta ammonite. The sample yielded a moderately rich assemblage mainly consisting of pollen grains, and including sporadic smooth-walled and sparsely spinose unicellular organisms determined as acritarchs belonging to the genera *Leiosphaeridia* Eisenack and *Micrhystridium* Deflandre.

The pollen assemblage is restricted to the extent that it contains only one type of pollen. The grains are spherical; they have an unlamellated and structureless, psilate wall. Many display a circular aperture (pore) and triradiate feature, respectively in distal and proximal polar areas. A circum-equatorial exine thickening is bordered distally by a narrow ring-shaped zone ("rimula") where the exine is thinner and which in equatorial view is apparent as a local slight invagination of the outline of the pollen grain.

Although the fossils are extremely poorly preserved the lack of exinous features is thought to be authentic. The grains show close affinity to, and are probably conspecific with, *Classopollis meyeriana* (Klaus) De Jersey, 1973. This comparison is confirmed by Dr. Noel De Jersey of the Geological Survey of Queensland, Brisbane (pers. comm.). The species is known in Australia (Queensland) from the late Triassic, and is sporadically present in the Rhaeto-Liassic as well. Further late Triassic occurrences are reported from Austria, Germany and Holland, and Rhaetian occurrences also from Hungary and England.

It thus appears that the age limits of the assemblage include the late Triassic and earliest Jurassic. In view of the exclusive presence of *C. meyeriana*, a late Triassic age seems most likely, in accordance with the Australian record. It is therefore concluded that the matrix sediment, and by inference also the ammonite, is of late Triassic age.

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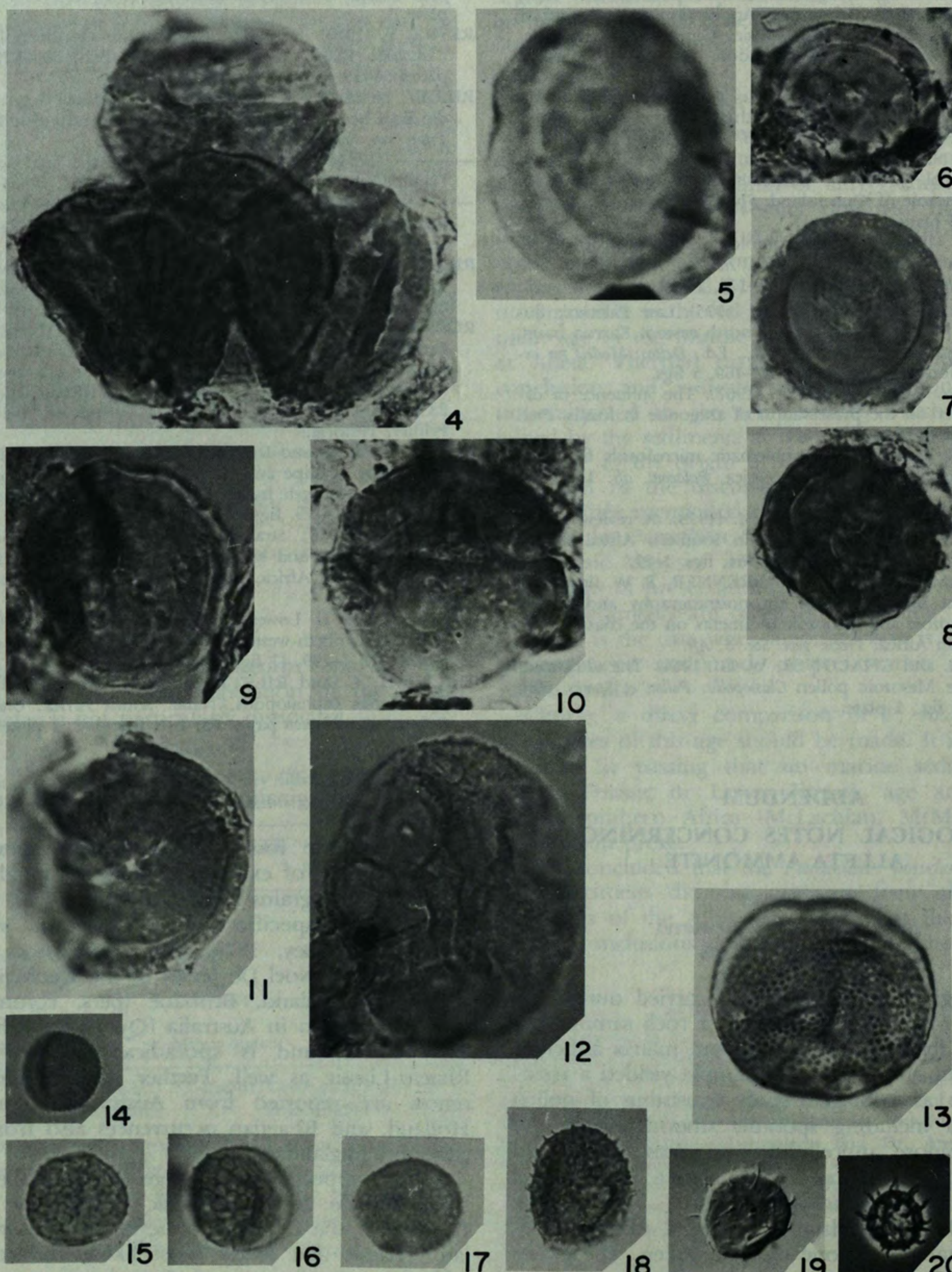
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All magnifications are × 1 000. The co-ordinates refer to Zeiss photomicroscope 67031. The reference in brackets is an ENGLAND FINDER co-ordinate.

Figures 4 to 11. *Classopollis* sp. cf. *C. meyeriana*

Figure 4. Slide 3834 (b) 109, 5/10,4 (R-439/1) Tetrad. A distal pore and sub-equatorial furrow (rimula) can be seen on the top pollen grain.

Figure 5. Slide 3834 (b) 84,5/20,5 (R-V13/4) Polar view. The rimula and distal pore are clearly visible.

Figure 6. Slide 3834 (a) 83/19,3 (R-U12/1) Polar view. Grain showing rimula and distal pore.

Figure 7. Slide 3834 (b) 82/16,6 (R-R11/3) Polar view. The rimula and distal pore can be seen, as well as an indistinct columellate structure in the exine at the top right hand margin of the grain and also on the exine of the distal hemisphere.

Figure 8. Slide 3834 (b) 103,3/2,5. (R-B 33/3) Polar view, showing small trilete mark on proximal hemisphere.

Figure 9. Slide 3834 (a) 118/9,4. (R-K 47/2) Polar view, showing small trilete mark on proximal hemisphere.

Figure 10. Slide 3834 (b) 89,3/5,5. (R-F18/2) Equatorial view showing sub-equatorial furrow, smaller distal hemisphere and columellate structure of exine near equator at right.

Figure 11. Slide 3834 (b) 115,5/10,8. (R-L45/4) Polar view, showing columellate structure of exine at edge of grain.

Figure 12. *? Araucariacites* sp. Slide 3834 (b) 78,4/7,9 (R-H 7/3) Equatorial view showing granular surface ornament.

Figure 13. *Leiosphaeridia granulosa* Pocock. Slide 3834 (b) 122,2/11,2. (R-M 52/2).

Figure 14. *Leiosphaeridia* sp. Slide 3834 (b) 106/3. (R-C 35/4).

Figures 15–17. *Dictyotidium* sp. Slide 3834 (b) 102,3/4,8 (R-E 31/2), 83/17 (R-S 11/2), 91,5/17 (R-R 20/4).

Figure 18. *Micrhystridium deflandrei* Valensi. Slide 3834 (b) 103, 2/2,7 (R-C 32/2).

Figures 19–20. *Micrhystridium lymensis*.Wall. Slide 3834 (b) 99,4/23 (R-Y 29/1), 119,6/22,6 (R-X49/4). Fig. 19 interference contrast, Fig. 20, phase contrast.