CANADA
DEPARTMENT OF MINES
HON. CHARLES STEWART, MINISTER; CHARLES CAMSELL, DEPUTY MINISTER

NATIONAL MUSEUM OF CANADA
W. H. COLLINS, ACTING DIRECTOR

BULLETIN No. 58

GEOLOGICAL SERIES No. 50

# Mesozoic Palæontology

OF

# Blairmore Region, Alberta

OTTAWA
F. A. ACLAND
PRINTER TO THE KING'S MOST EXCELLENT MAJESTY
1929

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# JURASSIC AMMONOIDEA

*By S. S. Buckman, Southfield, England*

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## INTRODUCTION

Two ammonites from the Fernie formation of Blairmore were submitted for identification by the Palæontological Division of the Geological Survey, Canada. I expressed the opinion that they were of *Macrocephalites* aspect, indicating that the Fernie formation was of about the same date as the highest part of the Cornbrash of England (*macrocephalus* hemera), but that further investigation, particularly in regard to suture-line, was necessary before the exact conclusion could be reached. Experience has shown the need for caution about like forms, especially those from distant areas: forms may masquerade under the guise of external similarity to European species and yet may possess internal differences which convict them of belonging to lineages of quite distinct origin. Literature is strewn with incorrect identifications, the result of reliance on external similarity: it is undesirable to add to them. Subsequently, six more specimens from the same locality and formation were forwarded to me with the request for a full investigation.

Such an investigation would appear to be, and should be, quite simple, seeing how much work has been done on *Macrocephalites*, including *Macrocephalitoids*, of Europe and of other parts of the world; but, in reality, it is complicated. Many investigations have not been built on sure foundations, essential characters have been ignored or overlooked; as a consequence the elaborate superstructures that have been reared come crumbling to pieces almost at a touch. For, obviously, if these Fernie ammonites have a Macrocephalitic aspect, the first question to be asked of prior workers is, what is the genotype of *Macrocephalites* exactly?

Fortunately the genotype is defined with some precision; it was not left, as formerly it was very frequently and often still is even at the present day, unsettled among a crowd of like species, without any indication to guide a subsequent worker choosing a genolectotype. This task should

not be left: the author of a new generic name should state, when he creates it, not only which species, but exactly and without ambiguity which specimen of that species is to be taken as genolectotype—which specimen is an important proviso, for with the best of skill and intention an author may be mistaken in his identification; therefore, if he leave the question open between various specimens belonging, as he thinks, to one species, he is leaving, possibly, a legacy of trouble. If he leave it open between many species he is risking disaster.

The genotype of *Macrocephalites* is *Macrocephalites macrocephalus* Zittel[1] (not *Ammonites macrocephalus* Schlotheim) from "Callovian, Ehningen (Wurttemberg)" (Fig. 655, p. 470). He gives a woodcut representing the side-view of the specimen, but does not say whether it is natural size or reduced. This omission is serious, for a large species with coarse, somewhat distant ribs apes, when reduced, the form of a small species with fine ribs: this is misleading. But there is a more serious omission—no suture-line is figured. The information is given that the suture-line is "tief zerschlitzt"—deeply divided. There are certainly two species like Zittel's figure, supposing it to be of natural size: one has quite a simple suture-line, the other has a very elaborate one. Like as it is, therefore, to Zittel's figure the first one may, perhaps, be ruled out, but it is not certain that the second one can be accepted. Deeply divided is not an exact term: it might be applied to a suture-line less elaborate than that of the second one. The possibility that there may be a third like species—one intermediate in regard to suture-line—is not to be overlooked: the suture-line of such third hypothetical form might be called deeply divided without being so remarkably elaborate as that of the form No. 2. But, further, Zittel has not given the necessary evidence that he actually described the suture-line from the specimen that he figured. This may not have shown a suture-line: the observation as to suture-line may have been made from another, apparently quite similar, example. From the remarks made above, it can be seen how unsafe and misleading this may possibly be. Therefore, at the very outset it is obvious that this investigation is not as simple as it should be considering the work done. In order to lay a really sure foundation it is necessary to see the actual specimen that was portrayed in Zittel's woodcut. But here may be trouble; the woodcut may not be an original one, it may be merely a copy of some figure, so much reduced as to be recognizable with difficulty.

The interpretations that have been given of Zittel's figure are notable. Parona and Bonarelli (p. 118) cite Zittel's figure in their synonymy of *Macrocephalites canizzaroi* (Gemmellaro), and then say that this species "est la forme la plus comprimée du groupe des [*Macrocephali*] *rectecostati*." But Zittel's figure does not show truly straight ribs: they are mainly arcuate, in places somewhat S-shaped, on the lateral area. I have not been able to see the original figure of *Stephanoceras canizzaroi* Gemmellaro (1, Pl. IX, figs. 9-11), as the work is not in the Library of the Geological Society of London; but Dr. L. F. Spath kindly informs me that "Gemmellaro's *canizzaroi* is a slightly distorted specimen of probably the same species as his later *macrocephalus*" (2, Pl. iv, fig. 1): this is a flexiradiate form.

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[1] *See also* page 8.

Blake cites Zittel's figure as a synonym of his *Macrocephalites typicus* (p. 42). The large example of this species (Pl. III, fig. 1) which, though Blake does not say so, is presumably the type, is distinctly flexiradiate—it differs from Zittel's figure by the greater coarseness of ribbing; but if Zittel's figure is a much reduced one this difference would vanish.[1] Blake's Pl. III, f. 1, will now be taken as the lectotype of *Macrocephalites typicus*, for the young specimens which he figures (Pl. III, f. 2; Pl. IV, f. 5) are different by being decidedly recticostate. It might be argued that recticostation is a true feature of young forms, being changed later to flexicostation. This is possible, but Blake gives no evidence: a specimen or specimens showing such a change would have been the necessary proof. On the contrary he figures by the same name of *M. typicus* (Pl. III, fig. 3) another example of about the size required—this shows flexicostation changing to recticostation. Further, there is no evidence of suture-line to prove that all these forms belong to one species. Nor is suture-line given by Blake for his large shell, so that, however like this specimen may be Zittel's figure, there is, taking account of homœomorphy, no certain proof of identity. Blake, on the other hand, mentions (II, p. 42) a specimen from "Peterborough (No. 27)" which "shows the last suture followed by a complete whorl." This specimen is in the collection of the Geological Survey of England (No. 8651) and on it is a label relating to the suture-line saying "Diagram 4." In Fig. 4, Blake (p. 46), is a reproduction of the suture-line of this specimen; but Blake has omitted to say anything about it: the title of Fig. 4 "Adult suture-line of *Macrocephalites compressus*" can only refer to the large suture-line. This large one is very different from the small one—the former could be called "deeply divided"; the latter could not—it is particularly simple. Such a suture-line cannot allow the specimen to agree with Zittel's description. This specimen is the one that I have referred to above as so like Zittel's figure, but differing from his description in its simple suture-line.

The exact identification of the genotype of *Macrocephalites* is a necessary prelude to any determination as to which family the genus should belong and, also, as to whether species of Macrocephalitoid aspect can be grouped in the same family. How easily homœomorphy may mislead in this respect can be judged from the forms which Zittel cited as examples of his genus. He says (p. 470) that about 40 species belong to it, among them *A. morrisi* Oppel which is now placed in the family Tulitidae S. Buckman (3, p. 43), *A. keppleri* Opp. which Neumayr and Uhlig separated as *Kepplerites* (p. 53) recognizing its affinity to *Cosmoceras* (Kosmoceratidae, Hyatt, S. Buckman, 3, p. 53). The Macrocephalitoid aspect of certain adult Kosmoceratids is an interesting phenomenon; these Kosmoceratids and the *Macrocephali* occur at about the same date, which may be a cause of trouble.

From the above remarks it is obvious that the palæontological part of this investigation is by no means simple. The same may be said of the investigation in its chronological aspect. In a general way the *Macrocephali* of Europe are known to be about of the date of the upper Cornbrash-lower Kellaways of England or Bathonian-Callovian border-line of continental geologists. But when more exact information is required, as

[1] *See*, however, page 8.

it is at the present day, details are sadly lacking. The occurrence and positions of *Macrocephali*, even in a country like England which has been geologically so much investigated, are known with very little precision.

At how many horizons do the *Macrocephali* occur? It is very necessary to have exact information on this point and as to the chronology of Macrocephalitids before any attempt is made to deal with their geographical distribution. *Macrocephalites* has been regarded as a fine example of wide distribution of an Ammonite genus—in other words that a deposit of a given date, characterized by yielding species of *Macrocephalites*, was not only laid down over a very large geographical area, but, what is more important, that this deposit has been preserved: it has not, like so many other deposits which were, perhaps, laid down over an area equally widespread, suffered from denudations both pene-contemporaneous and post-contemporaneous. It would be interesting to think of the Fernie formation as a part of this widespread deposit and to draw a map showing its connexion with South America, the Arctic, Europe, Asia, and perhaps Australia; but it would be hazardous. There are not only the palæontological doubts as to generic and specific, not to mention possibly family, identity which have been referred to, but there are the geological doubts as to whether the species are found in one deposit or in various sequent deposits: both these engender chronological doubts as to whether the *Macrocephali* lived at one date or at several dates; and all these together produce doubts as to whether such a palæogeographical map would be correct. For it makes all the difference if only one deposit or if several sequent deposits contain the species. In the first case there would be a phenomenon of stratal spread and preservation which is rather exceptional; in the second place there would be a phenomenon of the more usual type—limited spread of strata of each particular date because of pene-contemporaneous erosions—an isolated patch of one date at one place, another isolated patch of a somewhat different date at another place, and so on, the whole spread having a false appearance of contemporaneity, first, because of stratigraphical position and, secondly, because of the general similarity in form of the contained ammonites; but when the suture-lines come to be thoroughly investigated it is to be expected that such likeness will be found to be more apparent than real.

Sufficient has now been said to show that the questions that arise in connexion with a few specimens cannot with present knowledge be answered off-hand, for the investigation raises issues that are fairly complicated. But having said this much it is advisable to describe the Canadian specimens; afterwards it may be possible to supplement these remarks.

A casual comparison of d'Orbigny's figure of *Ammonites macrocephalus* (Pl. CLI) and Zittel's figure of *Macrocephalites macrocephalus* (p. 470, fig. 655) has given rise to the opinion, informally expressed in various quarters, that Zittel's figure is a copy of d'Orbigny's, in spite of the fact that Zittel says his specimen is from Ehningen. Blake, though not actually expressing this view, comes to the conclusion that they are the same species, as shown by his synonymy of *Macrocephalites typicus* (p. 42).

A critical comparison of the two figures is interesting as showing the importance of comparing figures of species point by point before coming to the conclusion that they represent the same species, certainly before accepting one figure as a copy of another. D'Orbigny's figure has a quite straight end cutting across several ribs; it shows the ribs strong on the inner lateral area right up to the end, the ribs are also represented as regularly bifurcate about the middle of the side, no intercalate ribs being shown: there are 46 primary ribs − 2 unfinished = 44 primaries and 89 secondaries = 1 to 2: the curve of the ribs in relation to a straight line is somewhat S-shaped.

Zittel's figure has a decidedly jagged end, running roughly parallel to the ribbing; the primary ribs are represented as becoming quite indistinct on the inner part of the lateral area towards the end—about the last quarter of the whorl; the ribs are shown as sometimes trifurcate, with many intercalate ribs which run well on to the inner lateral area; there are about 35 to 40 primary ribs and about 118 secondaries = roughly 1 to 3; the curve of the ribs is somewhat arcuate with slight S-curve in places: a guide-line does not touch the arcuate ribs until arrival at venter.

One can imagine that an artist in copying d'Orbigny's figure could and would make certain mistakes; but it is difficult to imagine that he would make all these. He would scarcely draw a jagged border to an aperture where a straight one was shown; he would not draw obsolescent or rubbed-away ribs where they were shown quite strong and clearly; he would not draw persistently a trifurcate figure when the original exhibited uniformly bifurcate: he might make mistakes in the number of ribs and in their curvature, but he would rather tend to exaggerate the S-form than turn it into a bow-form.

To my request for information Professor Edgar Dacque, of the Palæontological Museum of Munich, most kindly made search among Zittel's specimens and forwarded to me an example from Ehningen which agrees well with Zittel's figure—the concave notch in the side of the aperture about the middle helps the identification. The figure is reversed and is reduced by one-third. The specimen has considerable likeness to *Macrocephalites macrocephalus* race *noetlingi* (altered to *madagascariensis* p. 51) Lemoine (Pl. III, 3) but Lemoine's figure being reduced by one-third and yet larger than Zittel's specimen, evidently represents a much more coarsely ribbed form—the difference being especially noticeable at the early part of the whorl where Zittel's specimen has very fine ribs—in Zittel's figure the primary ribs are drawn much too strongly.

It is hoped to give in "Type Ammonites" figures of Zittel's specimen—the genotype of *Macrocephalites*—at an early date.

# PALÆONTOLOGY

## *DESCRIPTION OF CANADIAN SPECIES*

### Order, **Ammonoidea**

#### Superfamily, **Stepheoceratacea**

All the Canadian specimens (8) to be described come from a railway cutting through the Fernie formation, from two spots distinguished as Loc. 6591 and Loc. 6593,[1] Grassy mountain, Blairmore area, Alberta; they are in the collection of the Geological Survey, Canada, Victoria Memorial Museum, Ottawa, and were obtained by F. H. McLearn. The intractable matrix in which they occur has made the study and attempt to obtain suture lines particularly difficult.

#### Family, MACROCEPHALITIDAE S. Buckman

1922. *Macrocephalitidae* S. Buckman, Type Ammonites, vol. IV, legend of Plate CCLXXXIII.

More or less of sphaerocones (ex cadicones?) passing to platycones. Overlap of whorls considerable; umbilicus relatively small. Venter rounded in all stages of growth. Ribs usually numerous. Suture-line sometimes showing a high degree of complexity, but with very little backward curvature of umbilical lobes. Simplification of suture-line is presumably a phylogerontic feature. Diminution of whorl-thickness and loss of ribs leading to complete smoothness are phylogerontic features attained by different genera independently of each other and independently, so far as the characters themselves are concerned—thus smoothness may appear before there has been much diminution of thickness of whorl or it may be delayed until after the diminution of thickness has become very pronounced.

The attempts to place *Macrocephalites* in the family Pachyceratidae, as an early offshoot of that stem (S. Buckman, p. xiii), or to place it in the Sphaeroceratidae as a late development of that (S. Buckman, p. 22) are not satisfactory solutions. It is evident that *Macrocephalites* has been used to cover more forms than can be fitted into one genus, and that the forms attributed to *Macrocephalites* by Parona and Bonarelli and by Blake, to go no further afield, require separation into several genera which deserve a family name.

Dr. Paul Lemoine (1910, 1911, pp. 28, 51) has given most useful bibliographic lists of the species of *Macrocephalites* (=Macrocephalitids and Macrocephalitoids). He has analysed these species according to their affinities and according to their genera, thus in many cases doing the great service to the reader of preventing him going on useless errands—very essential, considering how great is the number of works which have to be consulted and the difficulty in many cases of obtaining them. But it is safe to say that if Dr. Lemoine had had at his disposal more generic names

[1] Loc. 6591. Rock thrown out from railway cut in upper thin calcareous sandstones and shale, Grassy mountain, Alberta. Loc. 6593. Same as 6591.

he could have very greatly increased the usefulness of his lists; because generic names, as he shows by those that he does employ, tend to narrow the field of bibliographic research.

The original source of the Macrocephalitidae may be looked for in the Bajocian coronates: the forms of the family have presumably passed through stages of development similar to those shown in the Sphaeroceratidae, particularly in the genus *Labyrinthoceras* S. Buckman (Pl. CXXXIV), but the Macrocephalitidae are at present only known in the costate state, congruous with *L. perexpansum* S. Buckman (op. cit.) and are not known in the coronate stage, exhibited by *L. extensum* S. Buckman (Pl. CCXIV).

On this theory, then, the Macrocephalitidae are, as regards their ribbing, in the post-coronate, or post-tuberculate stage and no forms in the coronate stage are known, though the young example figured by Blake (*Macrocephalites macrocephalus*, Pl. III, 4) comes very near to the cadicone coronate which this theory postulates.

In regard to suture-line the Macrocephalitidae show a character pertaining to the Sphaeroceratidae, the Tulitidae, and the Pachyceratidae—feeble development of the backward curvature of the umbilical lobes: in the Stepheoceratidae this character is very strongly developed.

In geological position the Macrocephalitidae follow the Tulitidae; but are separated from them by part of the Great Oolite, by the Forest Marble, and by the main of the Cornbrash—formations which represent a far longer interval of time than has hitherto been supposed. That the Tulitidae can produce macrocephalitoid forms is shown by the genera *Pleurophorites*, *Morrisites*, and *Morrisiceras* S. Buckman (3, pp. 43-48); but the feebleness of ribbing in the Tulitidae is against that family being regarded as the direct ancestor of Macrocephalitidae. A form like *Tulites cadus* S. Buckman (p. 45) with ribs much stronger and running straight, not curved, across the venter, may be expected as the ancestral form of the Macrocephalitidae.

Evidence for straight ventral ribs as the primary feature in Macrocephalitidae is shown by young examples figured by Blake (Pl. III, 2, 14, 3, IV, 5), and may be inferred in others of which he does not give ventral views (Pl. III, 4, Pl. III, 5). In fact, none of his *Macrocephalites*, large or small, seems to show anything but ribs straight across venter.

To Cadoceratidae the Macrocephalitidae have a superficial resemblance at times, but the manner of development is different: the Cadoceratidae pass from platycone with sometimes sharp almost carinate venter to cadicone or sphaerocone, losing ribbing with increase of thickness; the Macrocephalitidae pass from sphaerocone to platycone, losing ribs as thickness declines.

From certain Kosmoceratidae with macrocephalitoid aspect the Macrocephalitidae differ by showing, in the inner whorls, no sign of the flattened zone on the venter, which is known as the runcinate stage. Moreover, the Kosmoceratidae generally show decided lateral uni- or bi-tuberculation and a simple suture-line. One, sometimes two, of these characters will be present to reveal a Kosmoceratid in cases of doubt, as when the runcinate venter of inner whorls is not visible.

## Genus, PARACEPHALITES nov.

### Genotype, *Paracephalites jucundus* nov.

Sphaerocone, flexicostate [passing to platycone, smooth][1]; suture-line fairly elaborate, [becoming less so in smooth stage]; EL (external lobe) longer than L1 (first lateral lobe), L2 (second lateral lobe) about three parts as long as L1; umbilicus gradate with convex walls, the chord of the arc at right angles to the plane of the conch.

The primary ribs begin at contact-line of whorl, passing over umbilical wall with a curve concave forwards, they bifurcate a little beyond the umbilical wall, about on line of S2 (second lateral saddle), and there are occasional intercalate ribs—the secondary ribs are about versiradiate in direction and pass straight over venter. All ribs are rounded and not of very strong relief.

The genus differs from *Macrocephalites* in having a much simpler suture-line.

A few words may be said about *Ammonites mĕcrocephalus* Schlotheim. This was named by Schlotheim in 1813 (p. 70). The protolog reads as follows: "*Ammon*[*ites*] *macrocephalus* Oryct. *nor suppl.* T.XII, F. 8." Thus the figure in Baier (Suppl. Pl. XII, f. 8), is the protograph and the specimen which it depicts is the holotype. The protograph has been reproduced by Blake (p. 43): it represents a sphaerocone, something like a cricket ball with a small umbilicus, fairly strong ribs, and, presumably, a rather elaborate suture-line. This form would not at the present day be regarded as the same species nor even as the same genus as the *Macrocephalites macrocephalus* Zittel, which is the genotype of Macrocephalites. Zittel happens to have followed approximately d'Orbigny's incorrect determination of Schlotheim's species.

It is obvious that *Paracephalites* in shape, ribbing, and, possibly, suture-line is nearer to *Am. macrocephalus* Schlotheim, than it is to *Macrocephalites*. But it would not, therefore, be advisable to say that Schlotheim's species is a *Paracephalites:* observation of certain English material which has a more satisfactory similitude to Schlotheim's species suggests that still another genus is involved and that the complexity to be unravelled in regard to Macrocephalitids is far greater than the hitherto very casual naming of forms expresses.

### *Paracephalites jucundus* nov.

(Plate II, figures 1-3)

Holotype No. 8600; loc. 6593, Grassy mountain
Proportions,[2] S. 34,-, 65,-, 46, 47, 65, 23
Size of specimen, c. 50 mm. Maximum size, c. 80 mm.
Proportions of suture line of 22 mm. breadth of whorl, EL 64, L1 57, L2 36 per cent
Proportions of suture-line at 38 mm. curve of whorl, EL 37, L1 33, L2 21 per cent

[1] The words placed in square brackets in this and other generic descriptions refer to characters which are taken from specimen or specimens other than the genotype.
[2] For explanation of method of stating proportions and meaning of symbols *See* S. Buckman, 2, p. viii (1913).

Sphaerocone of stout Macrocephalitid aspect, rounded ribs of somewhat low relief, primaries curved, beginning at line of contact and running over a convex, indistinctly defined inner margin; secondary ribs arise from primaries, partly as bifurcates, partly as intercalates, they fall back somewhat from line of primaries and have a general versiradiate direction: they pass quite straight over venter. The rather small umbilicus is gradate, the chord of the convex wall is what is usually called perpendicular, that is at right angles to the median plane of the conch: it does not fall outwards to make an umbilicus larger externally and it does not fall inwards, or overhang, to contract it.

The suture-line, of which the proportions are given above in relation first to the actual breadth of whorl in a plane and secondly to the curve of the whorl, shows a rather long EL with a well-marked accessory branch, a tridactyloid L1, and a somewhat plain L2 which does not quite reach down to the level of the inner dactylus of L1.

*Macrocephalites pila* Nikitin, 1885 (p. 50, Pl. (VIII) X, 45, 46) from "lower Kelloway Clays of Elatma," Russia, is a similar species: primary ribs, however, are straight or very little curved—the figure is not clear, the description says nothing about curving—and proportions F. 34, -, 77, -; 60, 49, 77, 18, show a much stouter shell with smaller umbilicus. The suture-line is somewhat similar, but the two-pointed end of L1 shown by Nikitin looks doubtful: L2 is rather longer than in the Canadian shell and aux.1 is larger.

Several other species may be compared with *P. jucundus: Stephanoceras grantanum* (Oppel) Waagen (Pl. XXXVI, f. 6), from the *macrocephalus* zone, has much the same proportions, but the ribs are more laminate and have considerable irregularity. *Stephanoceras diadematum* Waagen, Pl. XXX, f. 3 (not Pl. XXX, f. 4, which is another, a much thicker species), also from *macrocephalus* zone, has ribs which are similar in their relief and a suture-line which is not unlike that of the present species; but it is too stout to be the same species; it suggests a biologically earlier form of the same genus, but against this is the curvature of ribs on venter and the greater length of L2 of suture-line. *Stephanoceras subtumidum* Waagen, from the Knutkote Sandstone (Argovian?), *Macrocephalites macrocephalus* Blake (Pl. III, f. 4, and Pl. III, f. 5), Cornbrash (*macrocephalus* zone), are all to be rejected on account of their very straight lateral ribbing, like as they are in proportions. *Macrocephalites herveyi* Blake (Pl. III, fig. 7, Pl. IV, fig. 1), *macrocephalus* zone, has somewhat the required proportions and also somewhat of the curved ribbing required; but differs decidedly in suture-line: this is not given by Blake, but I have the specimen before me.

Other comparable species in the run of ribbing are *Stephanoceras zirkeli* Steinmann (p. 269, Pl. XII, fig. 5) and *Stephanoceras chroolithicum* Steinm. (p. 270, Pl. XI, 3) from Caracoles, Bolivia; but in both cases thickness is too great and umbilication too small. Comparison of such forms without any suture-line is of little value; though the likeness may suggest that they lived about contemporaneously.

*Paracephalites glabrescens* nov.

(Plate I, figures 1-3; Plate II, figures 4-6)

Holotype No. 8601; loc. 6591, Grassy mountain

| | | | | |
|---|---|---|---|---|
| Proportions S. | 36, | 45, | 47·5, | 14 |
| | 50, | 45, | 50, | 14 |
| | 65, | 51, | 55, | 14 |
| | 92, | 49, | 50, | 17 |
| | 101, | 46, | 47, | 16·5 |

The specimen was fortunately broken in transit about across the centre, which allowed of these various measurements; but owing to condition of specimen all the measurements must be regarded as approximate (*See* Plate II, figures 5, 6).

Maximum size of specimen c. 125 mm.

Suture-line at 31 mm. breadth of whorl (Plate II, figure 4),
EL 63, L1 55, L2 32 per cent

Suture-line at 45 mm. breadth of whorl (Plate I, figure 1),
EL 51, L1 47, L2 22+per cent

Suture-line at 64 mm. on the curve of whorl,
EL 36, L1 33, L2 15·5+per cent

The L2 of Plate I, figure 1, has suffered abrasion: it would be about 2 mm. longer and so give c.27 and c.19 per cent respectively.

Sphaerocone passing to subplatycone; costate passing to smooth; umbilicus gradate with convex walls, the chord at right angles to plane of conch.

The specimen is entirely camerated, there being no body-chamber; it is broken, having lost a portion of the outer whorl; it is also considerably worn, but it can be seen that the ribs give place to smoothness, though the wearing may have made it appear somewhat earlier than it actually does. There is suspicion of slightly elliptical growth (ellipticone), though this cannot be positively stated on account of the breakage; but there is certainly a slight elliptical character about the coil of the umbilicus—in the next whorl, part of which the specimen presumably possessed as body-chamber—there may have been several cameræ before the body-chamber began—the umbilicus might be expected to expand considerably (excentrumbilication), but all signs of contact line of this whorl have been worn away. Abrasion has somewhat affected length and elaboration of L2 and aux. 1 (first auxiliary) on the side shown in Plate I, figure 1.

This species differs from *P. jucundus* in less thickness, less ornament, and a smaller umbilicus; the suture-line also is somewhat less florid, even allowing for abrasion, as if simplification were setting in with the smoothness. The measurements of the two suture-lines of the specimen show proportionate reduction with growth (*See* above).

This species has some likeness to *Macrocephalites koettlitzi* Pompeckj (1, p. 70, Pl. II, f. 12, letter-press fig. 12, p. 71) from Franz Josef Land. This also becomes smooth. But there are important differences in Pompeckj's shell: it differs in proportions, which he gives as T. 60, 50, 57, 12—that is to say his shell is a little thicker but has a decidedly smaller umbilicus. It might, however, be thought that his shell was a further development of the present one, but it differs in ornament—the ribs pass with a

good forward sweep over the venter and it differs in suture-line—EL is just shorter than L1 and L1 has not such a long—terminal lobule; then S1 is much shallower than ES (external saddle), consequently though L2 is about the same length as in the present species it occupies a different position on the shell, and so instead of ending at about or rather before the line of the inner lobule of the tridactyloid ending L1 it comes below it and extends to the guide-line: in *P. glabrescens* L2 ends well short of the guide-line. The proportions of the suture-line of Pompeckj's species taken from his figures are approximately:

Proportion of whorl-breadth of 29 mm.,
EL 41·5, L1 34·5, L2 28 per cent
Proportions on whorl-curve of 39·5 mm.,
EL 30, L1 25, L2 20 per cent

As both ornament and suture-line of Pompeckj's species differ from those of the Canadian shell, it cannot belong to the same lineage as *Paracephalites*. On the same grounds it is not truly a *Macrocephalites*, though it is one of the Macrocephalitidae.

Pompeckj claims (1, p. 72) that the example figured by Newton and Teall (Pl. XL, fig. 3) from the same locality by the name "*Macrocephalites ishmae*, smooth variety" is another example of his *M. koettlitzi*. The estimated proportions of the specimen are, F.66, 56, 55, 6?: the whorl is broader and the umbilicus smaller than in Pompeckj's species.

With the costate stage of *P. glabrescens* may be compared *Macrocephalites tumidus*: Nikitin, 1881 (Pl. X, figs. 18, 19), from Russia. It is laterally flexiradiate and has a suture-line with an outer portion similar but rather more elaborate and an inner portion very much more elaborate. Proportions of conch are similar—the figures give F.70, 48, 54, 18·5. *Ammonites tumidus* Reinecke (Pl. V, f. 47, 48) has similar proportions—they are approximately F.48, 50, 55, 18; but it is quite a different shell from Nikitin's and from *P. glabrescens:* it is recticostate and has indications of a highly developed suture-line.

## Genus, METACEPHALITES nov.

### Genoholotype, *Metacephalites metastatus* nov.

A Macrocephalitoid, distinct from *Macrocephalites* and from *Paracephalites* by simple suture-line and by ribs curving forward on venter. The primary ribs are curved, small, approximate, mostly breaking into three secondaries, one of which, however, is obscurely joined or is intercalate. Curvature of ribbing over rounded venter is slight and becomes less with growth. The ribs are raised but not laminate. The suture-line, obscurely shown, however, seems to be distinguished by its simple character and by a quite short, broad superior lateral lobe (L1) (*See* Plate III, figure 1).

### *Metacephalites metastatus* nov.

(Plate III, figures 1-4)

Holotype No. 6098; loc. 6593, Grassy mountain

Proportions, S. 30·5, —, 46 —; 43·5, 48, 50, 18. Length of L1 at 13 mm. c.40 per cent

A compressed sphaerocone of Macrocephalitoid aspect, with almost complete body-chamber not quite a whorl in length. Signs of gerontic inflation towards end of body-chamber, with versiradii passing straight over venter, having lost the ventral curvature of the early part of whorl. The subangustumbilicus is gradate, with walls falling about at right angles to the median line of the conch. Primary ribs about 26, short, slightly curved until near end of body-chamber, furcating about on L2.

For some remarks on the significance of curved ventral ribs *See* later under *Miccocephalites*, page 14.

To *Macrocephalites* aff. *lamellosus* Burckhardt (1, p. 31, Pl. III, figs. 7, 8), from Lowest Callovian, Comisaria Lonquimay, Argentina, the Canadian species shows great resemblance. There is, however, a slight difference in the ribbing, principally that in the Canadian shell the ribs are shorter, stronger, and rather more curved. The proportions of Burckhardt's shell are given by him (p. 32) as T.41, 51, 56, 19. *Ammonites lamellosus* J. de C. Sowerby (Pl. XXIII, f. 8) is quite a different form, with which the Canadian shell could not be compared; but the likeness of the Canadian and Argentine shells is near enough to suggest synchronism of deposits.

To *Macrocephalites kitchini* Uhlig (p. 271, Pl. LXXVII, 6), this species bears very considerable resemblance. The proportions of Uhlig's form are nearly the same, T.37·5, T.49 (F. 50), T.19, but there is much difference in ribbing—particularly, in the Canadian shell, the primary ribs are stronger, shorter, and more curved. The secondaries also are stronger. An intricate suture-line is depicted by Uhlig: nothing so elaborate is to be found in the Canadian shell, even allowing for its indistinctness. Uhlig's shell is from the Spiti Shales, Himalaya, and its horizon is given as "Oxfordian?"

*Macrocephalites pila* Bukowski (Pl. XXVI, fig. 17) is another form with which *M. metastatus* may be compared. The ribbing having in lateral and ventral flexure much likeness to that of the Canadian shell shows that it is not the Russian species of Nikitin and in proportions given by Bukowski F. 32, 40, 78, 18 (p. 127)[1] it differs altogether from the Canadian species. Bukowski's form is from Poland, from "obere Abtheilung des Callovien." According to the other species figured by him with this statement this covers many horizons, mainly about the date of English Oxford Clay. There is no fauna of the Kellaways Rock of southwest England figured by him, though constituents of such fauna occur elsewhere in eastern Europe: hence it is to be concluded that his Macrocephalite is not of that date. If contemporaneity with Kellaways Rock were claimed the local absence of the essential fauna would require much explanation. An earlier or later date for the Macrocephalite would not require this. Bukowski seems to suggest that it is later, but in Europe the bulk of Macrocephalitidae are of much earlier date than Kellaways Rock, though there are traces of them in the rock (*See* later, page 17). Farther afield Macrocephalitoidae occur later than the Kellaways Rock, but it has yet to be proved that they are Macrocephalitidae. Bukowski's Macrocephalite may be a fortuitous relic of a pre-Kellaways deposit: its association with

[1] The figure gives F. 32, 47, 80, 16.

later Callovian species may be an accident of preservation and deposition. The stratum in which a fossil occurs is not always true evidence as to its date.

Five micromorph specimens now remain. That they belong to the genera *Paracephalites* or *Metacephalites* cannot be accepted: they differ both in ornament and suture-line, though the details as to the suture-line are unsatisfactory, partly owing to condition of fossilization, partly owing to the fact that in several specimens the preserved part of the last whorl is body-chamber.

The character of the ribbing is the reason for separating the micromorphs from the other genera: the ribs are elevated and compressed, that is to say, that in cross-section they are lath-like or in the form of laminæ, they pass over a venter of somewhat flattened convexity with what shows as a slight forward sweep, yet on the actual periphery itself the ribs are almost straight—the appearance of curvature is due to the slight forward bending of the ribs on the outer lateral area as they approach the venter. The ribs rise in sharp waves or transverse crests on the venter, like a series of slightly bent laths placed crosswise.

These characters are not seen in the other genera and do not belong so far as is known to genuine *Macrocephalites:* but similar characters are depicted by Waagen in several Macrocephalitoids, for instance in his *Stephanoceras subtrapezinum* (Pl. XXXIII, f. 4) from the Golden Oolite, *macrocephalus* zone.

On the evidence of certain Macrocephalitids from English rocks, which are before me, showing a passage from ribs straight across venter to ribs curving across venter as the shell grows older, it may be inferred that curved ventral ribs are not a primary but a secondary character in Macrocephalitidae.

In the Tulitidae curved ventral ribs are a primary character, already established in the cadicone state: in the Macrocephalitidae curved ventral ribs may not appear at all, but if they do it is not until long past the cadicone stage: they may appear when the contraction leading to platycone stage is beginning or may not appear until it is well advanced. This difference in relative development of characters between Tulitidae and Macrocephalitidae is important and if curved ventral ribs are a feature of fairly late development in Macrocephalitidae, are a secondary not a primary feature, it indicates that the forms that possess curved ribs when quite small may be regarded as biologically somewhat late Macrocephaltid developments. These small forms are not to be regarded as the young of larger examples, but are micromorphs, possibly catamorphs of the Macrocephalitidae. That they possess in most cases nearly complete body-chambers fits in here.

As curved ventral ribs are a later development of straight costæ, so by the law of cyclical development—the tendency in old age to return to characters of youth—renewed development of straight ribs after curved may be expected. This is shown to a small extent in Metacephalites.

## Genus, MICCOCEPHALITES nov.

### Genotype, *Miccocephalites miccus* nov.

Platycone [ex sphaerocone] of Macrocephalitoid pattern, like dwarf "*macrocephali curvicostati*" of Waagen. Costæ laminate, flexed, especially primaries over umbilical edge, and secondaries towards edge of venter, carrying ribs over venter with a curve convex forwards: lamination of costæ well shown on a flatly arched venter. Suture-line obscurely shown, but it can be seen that it is simple with narrow lobes.

*Miccocephalites* differs from *Macrocephalites* and *Paracephalites* in its style and curve of ribbing, which has been described above, and in its simpler suture-line. It differs from *Metacephalites* in the character of laminate ribbing and in suture-line.

Distinction from *Pseudocadoceras* or like forms is to be found in the venter flatly arched instead of fastigate (angulate), in the characters of the ribbing, and in the decrease instead of increase of stoutness with growth.

A species which seems comparable with these forms of *Miccocephalites* is *Macrocephalites* sp. Pompeckj (1, p. 73, Pl. II, f. 11) from 1½ km. northwest of Elmwood, Franz Josef Land. In proportions it agrees nearest with *Miccocephalites laminatus*—the estimated proportions being F. 16, 41, 50, 27±: it is, therefore, a thicker shell; but in ribbing it does not agree—the ribs are of the size of those of *M. concinnus*, but in direction the secondary ribs seem to run less forward. Pompeckj says of the ribs "across the outside they run straight or are almost imperceptibly bent forward."

Also comparable with *Miccocephalites* is what may be called the *Cadoceras grewingki* series—certain species from Alaska named and figured by Pompeckj. These are considered later. *See* page 22.

### *Miccocephalites laminatus* nov.

(Plate I, figures 4, 5)

Holotype No. 8602; loc. 6593, Grassy mountain

Proportions: S.15, –, 45, –,
S.20, 45, 42·5, 30±

A somewhat serpenticonic form with rather wide umbilicus and coarse rather distant laminar ribs which rise strongly in transverse ridge-like form (transverse laminæ) over the subflattened venter. The primary ribs are curved: they bifurcate, but there are occasional intercalates. The secondary ribs are very feebly flexed.

There is only one example and that is broken. It discloses an inner whorl of rather over 6 mm. diameter with distinct rounded ribs passing over a rounded venter with very feeble suggestions of forward arch. On this inner whorl may be detected suggestions of a suture-line rather elaborate for a young shell.

*Miccocephalites miccus* nov.

(Plate I, figures 6, 7)

Genotype and Holotype No. 8603; loc. 6591
Proportions: S. 16, 44, 40, 20 ±

Like *M. laminatus*, but the ribs are smaller and closer together, the umbilicus is smaller, and the thickness is less.

This species has been chosen as the genotype because it gives indications of suture-line: they are, however, not satisfactory.

*Miccocephalites concinnus* nov.

(Plate III, figures 5-11)

Holotype No. 6099; loc. 6591

Paratypes: No. 8604, loc. 6593; No. 8605, loc. 6593; all from Fernie formation, Grassy mountain

Proportions: Holotype, S.12, 43, 44, —;
19·5, 46, 40, 16·5

Paratype, S. 16, 44, 40, 17, ±; size of specimen,
17 mm., max.c. 17 mm.

Paratype, S.13, 46, 39, 17, ±

A neat little species with closely approximate subcostæ or costulæ looking like a very dwarf edition of the genotype species of *Macrocephalites*, but distinguished by the ventral characters of ribbing which have been described above. There are in the holotype about 25 primary ribs which have a distinct curve over upper edge of inner margin. They bifurcate at about one-third from inner edge and there are intercalate ribs. These secondary ribs do not continue the line of curve of the primaries but fall back a little to curve forward later. The whole course of these subflexiradii is prosiradiate. The angustumbilicus is gradate, the wall which seems to carry ribs is about rectangular to the plane of the conch.

Both the paratypes are broken. Plate III, figure 9, shows inner whorls (0·5 mm. diam.) of the *Cymbites* stage—with only very faint indications of ribs.

This species is distinct from *M. miccus* by the fineness of the ornament.

This species has a noticeable likeness to *Stephanoceras subcompressum* Waagen (Pl. XXXIV, f. 4) *macrocephalus* zone. If that shell were reduced to about one-sixth of its size or this one were to be multiplied six times the resemblance would be certainly close, except that the larger shell would show too many ribs. But the proportions are quite similar; the ribbing has similar curvature and direction; there is, however, a difference—the Kutch shell has a tripartite arrangement of ribs—dichotomy of primary and later dichotomy of one secondary, almost a virgatome arrangement.

## *DESCRIPTIONS OF TWO COMPARABLE ENGLISH SPECIES*

A form comparable with *Paracephalites jucundus* occurs in the Kellaways Rock of South Cave, South Yorkshire. It is at first sight so much alike that a short description of it with figures may be of interest.

### Genus, CATACEPHALITES S. Buckman

1922. *Catacephalites* S. Buckman, Type Ammonites, IV, legend of Plate CCLXXXIII.

Genotype, *C. durus* S. Buckman, holotype

Sphaerocone of Macrocephalitoid aspect, also very like *Otoites contractus* J. de C. Sowerby (S. Buckman, Pl. CLVIII) except for a lack of tuberculation and difference of suture-line. Ribs flexicostate, passing straight over venter. Suture-line like that of *Paracephalites* but more simple.

There is no external difference from *Paracephalites* and if it were not for the suture-line it could be placed in that genus. But the suture-line is different—EL lacks entirely the accessory branch passing into ES which is so well developed in *Paracephalites*. L1 is simpler with very feeble development of the tridactyloid character, L2 is fairly long.

### *Catacephalites durus* S. Buckman

(Plate III, figures 12, 13)

1922. *Catacephalites durus* S. Buckman, Type Ammonites, IV, Pl. CCLXXXIII.

Holotype from South Cave, South Yorkshire; Kellaways Rock; Mr. Frank Petch, Coll.

Proportions: S. 33, 45, 72, —
S. 44, 45·5, 65, 22

Size of specimen 51 mm., maximum size c. 55 mm.

Owing to the condition of the specimen the proportions must be considered approximate.

Proportions of suture-line to whorl-breadth of 15 mm.
EL 73, L1 63, L2 37 per cent

Proportions of suture-line to whorl-curve of 27 mm.
EL 41, L1 35, L2 20·5 per cent

Sphaerocone, flexicostate. Primary ribs curve forward over umbilical wall and bifurcate beyond it into about radial secondaries, which pass straight over a well-rounded periphery.

The likeness of *Catacephalites durus* to *Paracephalites jucundus* suggests that it is the European equivalent of the Canadian species.

To *Ammonites (Macrocephalites) ishmae* var. *arcticus* Newton (Pl. XL, fig. 1) *C. durus* has considerable likeness; but the primary ribs of the English fossil are stronger, with more curvature, the secondary ribs are rather more approximate on the venter, the thickness of the conch is greater, the umbilicus is larger. Proportions of Newton's shell are F.

(40, 45, 60, —,)?; F. 66, 45·5, 53, 13·5. Ribbing and umbilicus also separate the English shell from *Ammonites (Macrocephalites) ishmae* Newton ("inflated variety"). The proportions of this are F. 34, 47, 70, —; 59, 49, 66, 13·5.

### A MACROCEPHALITE

(Plate III, figure 14)

When the writing of this paper was commenced nothing from English strata comparable with *Miccocephalites* was known to me. But lately Dr. Edgar Dacque of the Palæontological Museum, Munich, has most kindly sent me for study several of Oppel's types and among them his type of *Ammonites galilaei*[1]. This specimen came from Chippenham, Wiltshire, England; its matrix is Kellaways Rock of a bluish colour; oysters and other lamellibranchs and small gasteropods are in it. There is also included a lump of light blue clay. The colour and condition of the matrix, as well as the included fauna, are different from the usual characters of Kellaways Rock specimens. The included clay strongly suggests that it comes from the basal part of the formation and there are many reasons for thinking that it may represent a deposit earlier in date than I have yet noted in my division of Kellaways Rock.

In the body-chamber of *Ammonites galilaei* is a fragment of the body-chamber of a Macrocephalitid with ribs curving over the venter convexly forward. It agrees, therefore, in such character with the *Macrocephali curvicostati* of Waagen and with *Miccocephalites*; but it differs from the latter by showing ribs which are not so curved on lateral area and not so distinctly laminate.

This interesting find confirms the statements which have been made that "*Ammonites macrocephalus*" ranges from the Cornbrash to the Kellaways Rock in England. The range to the Kellaways Rock had been regarded with some scepticism, even when the term *Am. macrocephalus* was translated into *Macrocephalites*: inexactitude in identification was suspected—it is only too well known in so many cases.

[1] Figured, Type Ammonites, IV, 1922, Pl. CCXC.

## *GRAPHIC COMPARISON OF GENERA AND SPECIES*

Professor Swinnerton has recommended a more extensive and systematic use of graphs in palæontology. For illustration of the difference in development in regard to thickness of *Cadoceras* and *Paracephalites* the graph method is excellent. It is extended for making comparisons in certain other cases, using the following data:

| | —— | Diameter | Thickness, per cent |
|---|---|---|---|
| A | *Paracephalites jucundus* | 34·0 | 65·0 |
| | | 46·0 | 65·0 |
| A[1] | "*Macrocephalites*" *pila* Nikitin | 34·0 | 77·0 |
| | (Pl. X, f. 45) | 60·0 | 77·0 |
| B | *Paracephalites glabrescens* | 36·0 | 47·5 |
| | | 50·0 | 50·0 |
| | | 65·0 | 55·0 |
| | | 92·0 | 50·0 |
| | | 101·0 | 47·0 |
| C | *Metacephalites metastatus* | 30·5 | 46·0 |
| | (Body-chamber) | 43·5 | 48·0 |
| D | *Miccocephalites laminatus* | 15·0 | 45·0 |
| | | 20·0 | 42·5 |
| E | *Miccocephalites concinnus* | 12·0 | 44·0 |
| | | 19·5 | 40·0 |
| F | *Catacephalites durus* | 33·0 | 72·0 |
| | | 44·0 | 65·0 |
| G | "*Am. (Macrocephalites)*" *ishmae* | 20·5 | 73·0 |
| | Newton (Pl. XL, f. 2) | 34·0 | 70·0 |
| | | 59·0 | 66·0 |
| H | "*Am. (Macroc.)*" *ishmae* var. *arcticus* | 38·5 | 64·0 |
| | Newton, Pl. XL, f. 1 | 66·0 | 53·0 |
| I | "*Am. (Macroc.)*" *ishmae* | 22·5 | 52·0 |
| | Newton, Pl. XL, f. 3 | 43·0 | 49·0 |
| | | 67·0 | 52·0 |
| J | *Cadoceras sublaeve* | 20·5 | 52·0 |
| | a topotype | 37·0 | 59·0 |
| | | 57·0 | 77·0 |
| J a | Do. another example | 47·0 | 58·0 |
| | a topotype (S. Buckman, 4), Pl. CCLXXV | 65·0 | 80·0 |
| J b | *Cadoceras modiolare* Nikitin | 29·5 | 44·5 |
| | Estimates from his drawing (Fig. 1, p. 53) and his text (p. 52) | 45·0 | 62·0 |
| | assuming his fig. is reduced × 0·76 | 73·0 | 82·0 |
| | | 111·0 | 90·0 |
| | | 150·0 | 97·0 |
| K | *Cadoceras wosnessenski* | 27·0 | 41·0 |
| | Pompeckj (2, text p. 252) | 48·0 | 56·0 |
| L | "*Cadoceras*" *grewingki* | 8·0 | 56·0 |
| | Pompeckj, text and fig. | 12·0 | 50·0 |
| | | 17·5 | 40·0 |
| | | 32·0 | 40·0 |
| | | 37·0 | 40·0 |

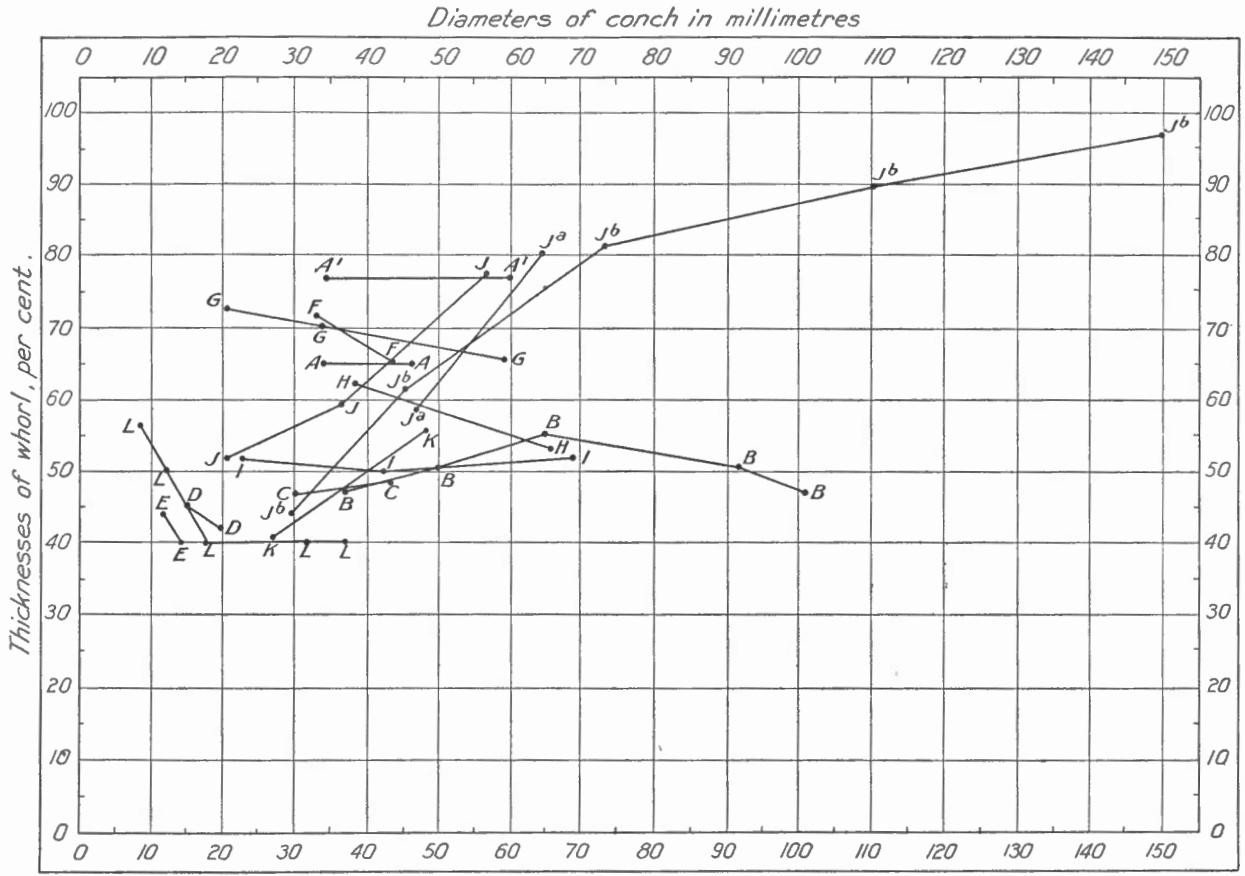


**Figure 1.** Graphic illustration of proportions of Macrocephalitids and Cadocerates.

Some allowance must be made for state of preservation, some for the measurements being taken from figures, and some for the method used in estimating diameter when the whorl is concealed, as, for instance, at the beginning of the last whorl. Unless the specimen be broken or purposely cut through the middle this method of estimating has to be employed in order to ascertain the proportions at the beginning of the last whorl: it is, therefore, advisable to describe it. In a specimen when the rate of coil appears to be regular the major diameter, from centre to end of whorl, is ascertained. This gives the percentage of the major radius to the diameter: in a very large number of Ammonites this percentage is 57. The nearer the specimen is to a circle—that is, the slower the rate of volutional increase or the more polygyral the Ammonite—the nearer the major radius will approximate to 50; in oligogyral forms, with rapid volutional increase the major diameter may rise much beyond 57 per cent. But, the major radius of a specimen having been ascertained, the diameter of the shell at the commencement of the last whorl can be found by measuring from centre to circumference and, on a slide-rule, which is the most useful instrument for the work, setting, say, 57 opposite the measure of the major radius: the position of 100 will then give the diameter.

When the major radius is 57 per cent, the minor radius is 43. Slide 43 to the position occupied by 57 on the rule: the position of 100 now indicates the diameter of the shell half a whorl farther on, allowing for the ratio of coiling being constant. Repeating the process gives the diameter one whole whorl farther. Reversing the process from the starting point gives the diameters half and a whole whorl previously: and so on.

By such processes as these, diameters of partly concealed whorls can be estimated: also the diameters of fragments of whorls: the process has been employed for the estimation of measurements in Newton's Fig. 3 of *Am.* (*Macrocephalites*) *ishmae.*

The table shows that nearly all the species supposed to belong to Macrocephalitidae, including the so-called *Cadoceras grewingki*, show thickness constant or declining. A small exception, *M. metastatus*, is due to the presence of body-chamber—an inflation of body-chamber in a normally thinning species is usual. The other exception is in the mid stages of *P. glabrescens*—early stages not seen: the thickening in this case may be due to faulty preservation. The slight drop in I, *M. ishmae*, may be due to the same cause.

On the other hand the rapid increase in thickness of the specimens and species of *Cadoceras* stands out in marked contrast. This would, in the case of *C. sublaeve*, be continued much farther at about the same rate. Comparison may be made with the line given for *Cadoceras modiolare* Nikitin (*See* data given above). Nikitin gives some remarkable figures of *Cadoceras* and Cadoceratoids in section: they are marred, however, for the graphic purpose by the fact that the amount of reduction of the figures is not given: if details be taken from a reduced figure as if it were natural size, because of lack of warning, it makes increase or decrease begin too early: this may be the difference between species and is misleading.

## *PALAEONTOLOGICAL SYNOPSIS*

Genera:

*Macrocephalites:* laterally flexiradiate, ventrally rectiradiate; suture-line highly ornate.

*Paracephalites:* laterally flexiradiate, ventrally rectiradiate; suture-line somewhat ornate.

*Metacephalites:* laterally flexiradiate, ventrally feebly flexiradiate; ribs distinct; not laminate; suture-line simple, L1 broad and short.

*Miccocephalites:* laterally and ventrally flexiradiate; ribs strong, laminate; suture-line simple, L1 narrow.

*Catacephalites:* laterally flexiradiate, ventrally rectiradiate; suture-line somewhat simple.

Species:

*Paracephalites jucundus:* perplaty-, subextremipachy-gyral, subangustumbilicate; venter 1; ornament, 4 c.

*P. glabrescens:* perplaty-perpachy-gyral, subangustumbilicate; venter, 1, ornament, 4 c to 1.

*Metacephalites metastatus:* perplaty-perpachy-gyral, subangustumbilicate; venter, 1; ornament, 4 c.

*Miccocephalites laminatus:* perplaty-, perpachy-gyral; sublatumbilicate; venter, 1; ornament, 4 c, laminate.

*M. miccus:* perplaty-, pachy-gyral; subangustumbilicate; venter, 1; ornament, 4 c, laminate.

*M. concinnus:* perplaty-, pachy-gyral; angustumbilicate; venter, 1; ornament, 3 c, sublaminate.

*Catacephalites durus:* perplaty-subextremipachy-gyral; subangustumbilicate; venter, 1, ornament, 4 c.

## GEOGRAPHICAL DISTRIBUTION

The following table shows the geographical distribution of Macrocephalitids which have a fairly close resemblance to the Canadian shells. The main bulk of Macrocephalitoid forms are excluded as their resemblance is insufficient. Possibly some further species should be included, but it has not been possible to obtain all the literature on the subject.

What the table shows is that strata which may possibly be synchronous with the date of the Fernie formation—using the word synchronous in the limited sense which modern palæontological work requires—have been preserved over a considerable area of the globe. It may be taken as axiomatic that the area of original deposition was far larger than that of preservation.

*Distribution of Forms Comparable*

| Canada | Arctic | N. America | S. America | Europe | Asia |
|---|---|---|---|---|---|
| *Paracephalites jucundus* | ..... | ..... | x | x | x |
| *P. glabrescens* | x | ..... | ..... | x | ..... |
| *Metacephalites metastatus* | ..... | ..... | x | x | ..... |
| *Miccocephalites laminatus* | ..... | x | ..... | ..... | ..... |
| *M. miccus* | ..... | x | ..... | x | ..... |
| *M. concinnus* | ..... | x | ..... | ..... | ..... |

## CHRONOLOGY

The English Macrocephalitid forms which have the most resemblance to those from the Fernie formation of Alberta are *Catacephalites* from the Kellaways Rock of Yorkshire—comparable with *Paracephalites*—and the unnamed fragment from the Kellaways Rock of southwest England—comparable with *Miccocephalites*. On such comparison the date of the Fernie formation is later than the Cornbrash of England by some three or four hemeræ—or even more. At any rate it comes into line with the Kellaways Rock, but possibly only with the earliest part of it.

*Miccocephalites*, however, would appear to be a new addition to Macrocephalitid fauna. The small size of the examples suggests that they are catamorphs of the family and, therefore, that they may be expected late in the Macrocephalitid history. They may even indicate a time-episode which is new for the chronology of the Jurassic strata.

The likeness of *Miccocephalites* to a series of species figured by Pompeckj from Alaska (2), attributed to the genus *Cadoceras*, must not be overlooked. It may strengthen the chronological suggestion just made; but, as a preliminary, some consideration must be given to the affinities of Pompeckj's forms.

One species, *Ammonites wosnessenskii*, Grewingk (Pl. IV. f. 1) *Cadoceras wosnessenski*; Pompeckj (2, Pl. V, f. 5), is a Cadoceratid, near to *Cadoceras* s. str. in suture-line and in mode of growth—increase of thickness being from 41 per cent at 27 mm. diameter to 56 per cent at 48 mm. (Pompeckj, p. 252). Another species, *C. stenoloboide* (Pl. VII, f. 2) is not Cadoceratid in suture-line, but, according to the figure, there is Cadoceratid increase of thickness: Pompeckj's text (p. 255), however, does not bear this out—he gives thickness as 36 per cent at 24·5 mm. diameter and as 37 per cent at 41 mm. However, it is not to these forms that the species of *Miccocephalites* bear resemblance—it is to the forms called *Cadoceras catostoma* (Pl. V, f. 1), *C. schmidti* (Pl. V, f. 2), *C. grewingki* (Pl. VI, f. 1), *C. petelini* (Pl. VI, f. 4-6).

There is special likeness of *Miccocephalites laminatus* to *Cadoceras grewingki* and as this is the closest resemblance a statement of difference will serve for all. In *M. laminatus* primary ribs are stronger and are more curved over the inner-marginal edge, the ribs are more decidedly laminate throughout, and the passage over venter is not so distinctly arcuate.

The interest, however, is to determine the affinity of Pompeckj's species; for, if they are closely allied, a similar date for the Alaskan and Canadian shells may, not unreasonably, be postulated, whereas if the likeness is merely deceptive no argument is to be founded upon it. Pompeckj's species, *C. grewingki*, etc., are not *Cadoceras* in a strict sense; they have more likeness to *Pseudocadoceras* and that is where comparison must be made; but they show no sign of the sharpened (fastigate) venter with arrow-like costæ preceding their rounded stage: according to Pompeckj's illustration (2, Pl. VI, f. 1d) there is a continuous stage of rounded venter, whereas the thickness of whorl remains constant—40 per cent at 32·3 mm. and at 37 mm. diameter for *Cadoceras grewingki* (Pompeckj, p. 259). These facts suggest that they are not Cadoceratids but are

related to the Canadian forms and may be reckoned as Macrocephalitids. However, before such a point could be decided much more information than has yet been published would have to be obtained—information about *Pseudocadoceras* and the inner whorls of *Cadoceras* and Macrocephalitids. This cannot be attempted now—to collect it would extend this inquiry unduly.

This indicates, however, the direction which research connected with the Canadian forms should take. If the Alaskan forms of the *C. grewingki* series are Macrocephalitids they would form a genus biologically akin to *Miccocephalites* and chronologically they would be expected to be close: that is, the Alaskan deposit, or some part of it, might be nearly synchronous with the Canadian Fernie formation. As the Alaskan deposit yields a *Cadoceras* (*C. wosnessenski*) it should be about the date of the English Kellaways Rock.

It is for the Canadian geologists to see if their Macrocephalitids actually occur together—not merely in the same formation but in the same block of that formation—or if they occupy two or more different levels, or if the less developed forms—say like *Paracephalites jucundus* and *Miccocephalites laminatus* occur at a lower level than the more developed *P. glabrescens*, *M. miccus*, *M. concinnus*. But, even if they do occur in the same block, this is not actually a proof that they were synchronous during life. It is not at all unusual for species to occur together in an attenuated deposit, yet, where the strata are of good thickness, they are quite widely separated by deposits. Further discoveries of the species in other localities will be the test in this case: then faunal analysis will come in. At present the number of specimens and of localities is far too few for any effective faunal analysis, yet it may be interesting to give it.

| — | *P. jucundus* | *Metacephalites metastatus* | *Mic. laminatus* | *M. concinnus* | *M. miccus* | *P. glabrescens* |
|---|---|---|---|---|---|---|
| Loc. 6591 | ..... | ..... | ..... | x | x | x |
| Loc. 6593 | x | x | x | x | ..... | ..... |

It is now possible to make a few further remarks concerning the date of the Canadian Macrocephalitids of the Fernie formation.

In Europe generally *Macrocephalites* and its allies, which make up the family Macrocephalitidae, occupy a horizon of supposed limited vertical range at the beginning of the Callovian or, as some prefer to call it, at the end of the Bathian. In Asia, however, Macrocephalitoid forms range, according to Waagen who has figured them under the name *Stephanoceras*, from the Putchum Group to the Kuntkote Sandstone inclusive, that is from the Bathian to the Argovian (Corallian). And it may be noted that forms with ribs curved over the venter have this same range. In South America Burckhardt claims an even later date for a "Macrocephalites" (2, Pl. III, f. 6-11), but it is reasonably certain that this form does not belong to the family Macrocephalitidae and that the same result will probably be the outcome of strict investigation of Waagen's species.

The most satisfactory standards of comparison, therefore, are European strata, and, as has been remarked above, it is among English fossils that the most likeness to the Canadian shells has been obtained. Now the English deposits which have yielded such like forms give the following sequences.

| S.-W. | N. Yorkshire [1] |
|---|---|
| Kellaways Rock: Kosmoceratids and a Macrocephalitid fragment (pre-*opimus* hemera? [2] Kellaways Clay: *Proplanulites* and *Gowericeras* (Koenigi, etc., hemeræ)[2] | Kellaways Rock (lower part) Kosmoceratids and *Proplanulites* [3] |
| Radiopole Clay with Macrocephalitids (basal Kellaways Clay?) | Clays of the Cornbrash "*Am. macrocephalus*" |
| Cornbrash Limestone with Macrocephalitids in upper part | Cornbrash Limestone "*Am. macrocephalus*" |

As Macrocephalitids are found occurring in Yorkshire in three and in southwest England in four sequential deposits, which differ from each other in lithic characters quite materially, the supposition that strata with Callovian Macrocephalitoids, which spread over a wide geographical area of the globe, represent a deposit of one date, laid down during a great submergence, is obviously untenable. And it may be still more untenable than it looks from the table of strata given above, for there is reason to suppose that these deposits were not only laid down during four hemeræ but actually occupied several more—perhaps as many as eight—in their accumulation. For I have lately suggested that in southwest England the Kellaways Clay and the Kellaways Rock represent not merely two hemeræ but six (1921, p. 40): now evidence seems to indicate that as an under-estimate.

It may be said that at present this is very largely supposition, lacking good evidence. This is granted, but there are the following facts in its favour:

(1) The Kellaways Rock of north Yorkshire, though fairly uniform in lithic character, was laid down not during one but during many sequent hemeræ as its fossil contents show; for much of its fauna is found not in Kellaways Rock of southwest England but in several sequent beds of the superjacent Oxford clay (1, p. 160): therefore, the Kellaways Rock of the southwest need not, because it is fairly homogeneous, represent the deposit of only one hemera.

(2) In Sutherland, Scotland, the Roof Bed over the coal is of the date of the Kellaways Clay, but, so far as is known at present, it contains some of the species of the earliest layer only; this seems to show that what I have separated as the two later layers of Kellaways Clay are of later date than the Roof Bed. So there is quite a possibility that Macrocephalitids, or what would hitherto have been called *Macrocephalites,* lived during six hemeræ, if they go no higher than the earliest layer of Kellaways Rock of southwest England, or during 7 or 8 if they do go higher. Therefore,

[1] Partly from examination of specimens, partly from information given by Fox-Strangways (VI).
[2] *See* S. Buckman, 3, p. 40.
[3] The Kellaways Rock of South Cave, Yorkshire, with Kosmoceratids, *Catacephalites*, and a form like, but not, *Proplanulites* may be earlier in date. Its fauna differs in detail from the Kellaways Rock of north Yorkshire.

deposits containing *Macrocephalitids* (*Macrocephalites*) though they have world-wide distribution are not truly synchronous and cannot be cited as evidence for wide dispersal of a particular fauna at a given date. How many hemeræ may be represented by all the deposits preserved at certain places, how wide was the distribution of any one constituent of Macrocephalitidæ, are all subjects for future investigation when the members of the family and their deposits have been properly analysed.

But though the idea that the deposits found in nearly all parts of the globe containing Callovian "*Macrocephalites*" are strictly synchronous must be abandoned, so far as the synchronization is concerned, yet it remains true in regard to the wide geographical occurrence—only this wide occurrence is due not to a great synchronous submergence but to the fact that "*Macrocephalites*" lived during a time of far greater extent than had been allowed for. During such time many physical changes could occur, new areas could be opened up, while partial or complete destruction of *Macrocephalites* deposits could take place in other areas. The longer the time for making the record, the greater the possibility that it is fragmentary—it would have greater chance to suffer from penecontemporaneous erosions.

That the idea of synchronization of Callovian "*Macrocephalites*" deposits has to yield to that of sequence opens up an interesting speculation—that the history of the earth, as told in its deposits, has occupied a far longer time than was formerly supposed. All recent work on Jurassic rocks leads to this result—that the postulate as to time required must certainly be multiplied by ten. The deposits and fauna of any one area during any specified period of time cannot be regarded as full evidence for the length of time required: this is only to be obtained by putting together and comparing results from all known areas. Even then there must remain many unknown areas to add their quota. When these have been fully explored it is not certain that the full tale of past events has been discovered—much may have been utterly destroyed beyond the possibility of recall. Thus is reached a conclusion that these palæontological studies give evidence for greatly increasing the time-estimate for the earth's history and yet that such increase based only on present knowledge may be greatly understated.

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## POSTSCRIPT

The foregoing paper was written and left my hands in March, 1922. Since then much work has been done in the determination and chronology of the Macrocephalitidae, so that some of the information can be revised and stated with greater certainty. A postscript seems the most desirable method of bringing the information up to the present time, November, 1924.

Species of Macrocephalitidae belong to several dates, being found in the following rocks in descending order.

(6) Kellaways Rock, Wiltshire, Gasteropod bed—near base of the rock—a Macrocephalitid fragment. *See* Type Ammonites, Pl. CCXC.

(5) Kellaways Sand, South Cave, Yorkshire, possibly equivalent in date to the basal Kellaways Rock of Wiltshire—possibly earlier than deposit No. 6. *Catacephalites durus*, Type Ammonites, Pl. CCLXXXIII.

(4a) Kellaways Clay, Wiltshire—presumably a very early phase of this deposit. *Pleurocephalites*, Type Amm., CCLXXXIV, CCCXLVIII; *Tmetokephalites*, Type Amm., CDXXXIII. This is probably the horizon of *Tmetokephalites* of the Continental Callovian and also of *Macrocephalites* from there.

(4) Clay above Cornbrash, Dorset, possibly synchronous with the Kellaways Clay No. 4a, but also possibly earlier. *Macrocephaliceras*, Type Amm., CCCXIII.

(3) Cornbrash, Yorkshire; "*Macrocephalites*" *typicus* Blake, and other Macrocephalitid species.

(2) Upper Cornbrash, Peterborough, a dark matrix as if in contact with an overlying clay deposit *Dolikephalites dolius*, Type Amm., CCCLXXII.

(1) Upper Cornbrash, Peterborough, a yellowish marly matrix, not in contact with an overlying clay and, therefore, presumably older than No. 2, *Kamptokephalites kamptus*, Type Amm., CCCXLVII. A species of the same genus with a similar matrix among a series of Cornbrash fossils from near Cirencester, Gloucestershire.

Species of Macrocephalitidae, therefore, according to these researches, which are by no means complete, extend into three formations—from Upper Cornbrash, through Kellaways Clay into Kellaways Rock. They mark some six different hemeræ, possibly more; for there is reason to suppose that the rocks in which they are found are deposits of some nine or ten hemeræ—nine or ten chronological units. In time it will be recognized that the Macrocephalitid-bearing strata of the world do not mark one synchronous date and, as the species become better known, it should be possible to separate them into the distinct dates for which the English species give evidence. Such dates may be tabulated as under:

DATES OF MACROCEPHALITID-BEARING ROCKS

| | Age | Hemera |
|---|---|---|
| (6) | Proplanulitan | *Galilaeiceras* |
| (5) | " | *Catacephalites* |
| (4a) | Macrocephalitan | *Pleurocephalites* |
| (4) | " | *Macrocephaliceras* |
| (3) | " | *typicus* |
| (2) | " | *dolius* |
| (1) | " | *kamptus* |

Between (6) and (5) another hemera may have to be named and between (5) and (4a) three more hemeræ have been named after species of *Proplanulites* (Type Amm., III, 1921, p. 40).

PLATE I

(Specimens are of natural size, unless otherwise stated)

From Fernie formation [Callovian], Blairmore area, Alberta.

*Paracephalites glabrescens* S. Buckman n. sp. (Page 10.)

FIGURE 1. Side view of a wholly septate specimen: L2 and aux. somewhat worn. *See* Plate II, figure 4.
FIGURE 2. Ventral view.
FIGURE 3. Apertural view.
*See also* Plate II, figures 5, 6.

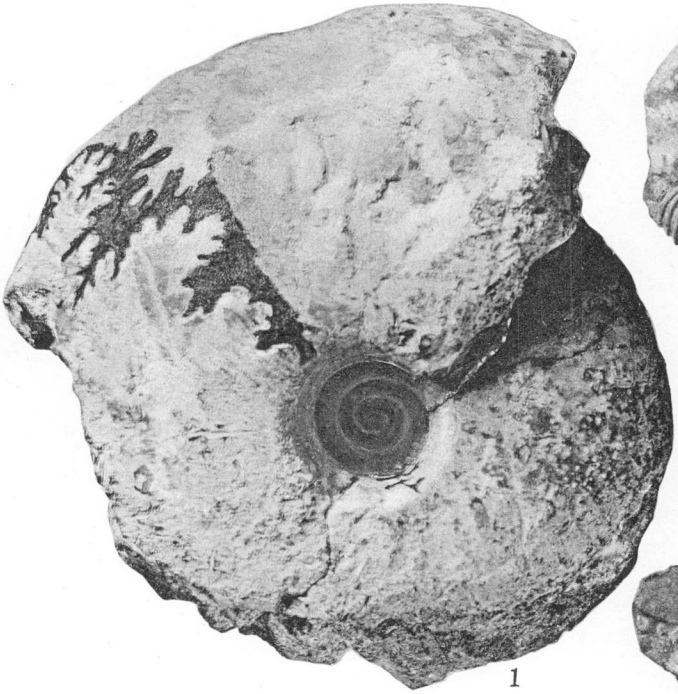
*Miccocephalites laminatus* S. Buckman n. sp. (Page 14.)

FIGURE 4. Side view, 4a, X 2.
FIGURE 5. Ventral view, X 2.

*Miccocephalites miccus* S. Buckman n. sp. (Page 15.)

FIGURE 6. Side view, 6a, X 2.
FIGURE 7. Ventral view.
*See also* Plate III.

Plate I



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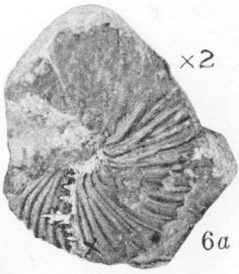

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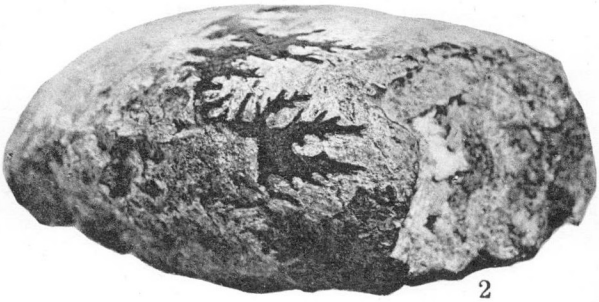

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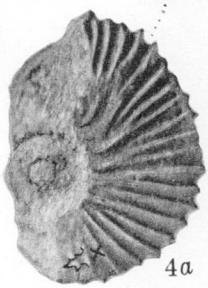

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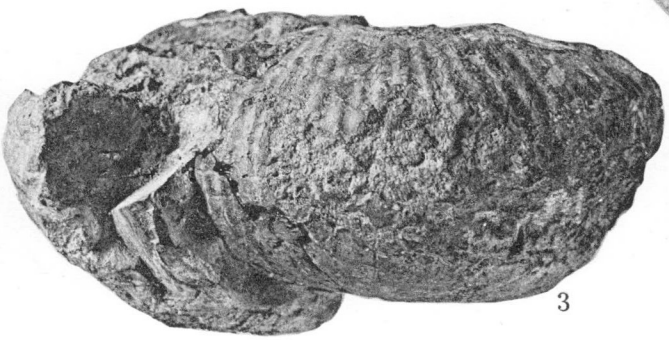
4a



3

×2

5

PLATE II

(Specimens are of natural size, unless otherwise stated)

From Fernie formation [Callovian], Blairmore area, Alberta.

*Paracephalites jucundus* S. Buckman n. sp. (Page 8.)

FIGURE 1. Side view, right side. R. restored.
FIGURE 2. Side view, left side.
FIGURE 3. Ventral view.

*Paracephalites glabrescens* S. Buckman n. sp. (Page 10.)

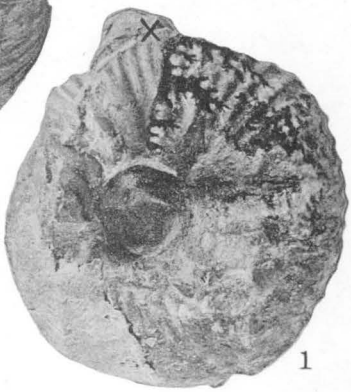
FIGURE 4. Suture-line: L1 with terminal lobule imperfect; L2, not worn. *See* Plate I, figure 1.
FIGURE 5. Cross-section of the larger portion showing contour of inner whorls.
FIGURE 6. The same of smaller portion, also showing suture-line on inner margin. *See also* Plate I, figures 1–3.

6

R

2

3



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5

4

## Plate III

(Specimens are of natural size, unless otherwise stated)

Figures 1–11 from specimens from Fernie formation [Callovian], Blairmore area, Alberta figures 12–14 from specimens from England (Callovian).

*Metacephalites metastatus* S. Buckman n. sp. Holotype. (Page 11.)

Figure 1. Side view.
Figure 2. Apertural view, showing also EL of last suture-line.
Figure 3. Ventral view, early part of body-chamber.
Figure 4. Ventral view, last part of body-chamber.

*Miccocephalites concinnus* S. Buckman n. sp. Holotype. (Page 15.)

Figure 5. Side view, right side, 5a, X 2.
Figure 6. Side view, left side, showing suture-line.
Figure 7. Apertural view, X 2.
Figure 8. Ventral view, X 2.

*Miccocephalites concinnus* S. Buckman n. sp. Paratype. (Page 15.)

Figure 9. Side view, 9a, X 2, outer whorl body-chamber.
Figure 10. Peripheral view, X 2.

*Miccocephalites concinnus* S. Buckman n. sp. Paratype. (Page 15.)

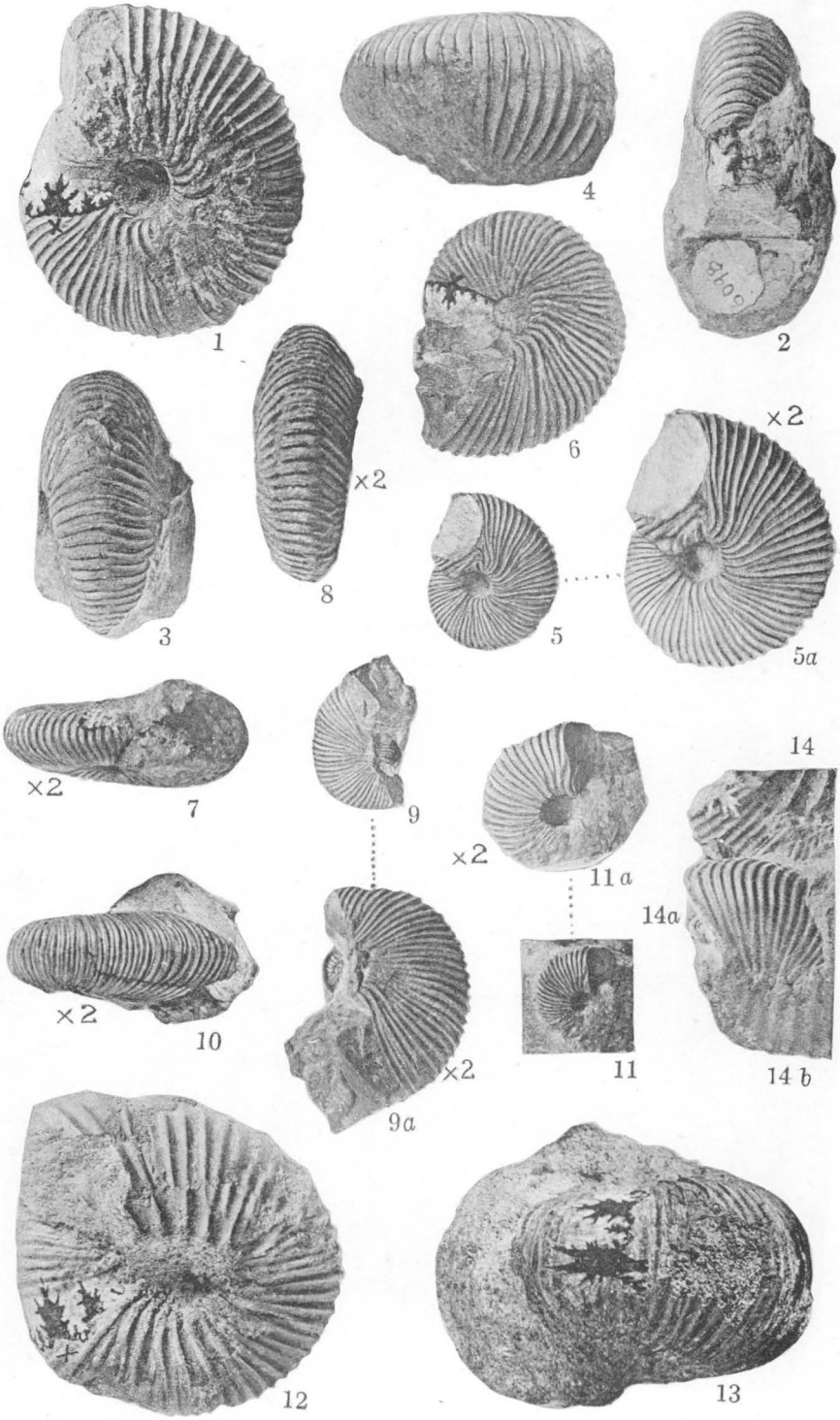
Figure 11. Side view, 11a, X 2, last part of outer whorl is body-chamber.

*Catacephalites durus* S. Buckman. (Page 16.)

Figure 12. Side view. From "Kellaways-Rock", South Cave (Callovian, pre-*koenigi*?), south Yorkshire, England, Mr. Frank Petch, collector. To compare with *Paracephalites*.
Figure 13. Apertural view.

*A Macrocephalite.* (Page 17.)

Figure 14. Fragment of body-chamber (side view). From [lower part of] Kellaways Rock (Callovian, post-*koenigi*), Chippenham, Wiltshire, England. It is embedded in the body-chamber of the holotype of *Ammonites galilaeii* Oppel (b), and is in the Oppel collection in the Palæontological Museum, Munich, Bavaria, kindly lent by Dr. Edgar Dacque. To compare with *Miccocephalites* and *Macrocephali curvicostati*.
Figure 14a. Earliest whorls—smooth, brephic *(Cymbites)* stage belonging possibly to the same specimen, but shifted out of position. For photographs of *Ammonites galilaeii*, *See* Type Ammonites, vol. IV, 1922, Pl. CCXC.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