In reference to the desirability—emphasized by Sir Lewis—of dating the Cuddapah System in its type area, I can only suggest an application of the helium method to a concentrate of black ores, such as titaniferous magnetite, separated from the post-Cuddapah dolerites (cf. Hurley and Goodman : *Bull. Geol. Soc. Am.*, 54, 1943, p. 305). It should not be overlooked that Dubey (*Nature*, 126, 1930, p. 807) applied the helium method to a basalt flow from the upper part of the Gwalior Series and obtained an " age " of about 500 m.y. Since the helium method yields only minimum ages, except for the feebly radioactive black ores, the Gwalior Series may reasonably be assigned to the Pre-Cambrian. It is worth noticing, however, that Dubey's work on the Whin Sill and the Cleveland Dyke, carried out by the same methods (Dubey and Holmes : *Nature*, 123, 1929, p. 794), gave " ages " that are only a little lower than those now regarded as most probable. This consideration supports the view that the Gwalior Series is more likely to be of late Pre-Cambrian age (say, 550–600 m.y.) than of Aravalli age (900 m.y. or more). The traditional correlation of Gwalior with Cuddapah is therefore at least consistent with the limited evidence available ; obviously, however, its validity remains to be proved. I hope to co-operate with Sir Lewis in making practical arrangements for carrying out the suggestion for settling the age of the Cuddapahs.

ARTHUR HOLMES.

GRANT INSTITUTE OF GEOLOGY,
WEST MAINS ROAD,
EDINBURGH, 9.

5th May, 1950.

BATHONIAN *VIVIPARUS*-LIKE GASTROPODS

SIR,—Dr. T. C. Yen's proposition of a new generic name *Bathonella* for *Viviparus*-like gastropods found in Bathonian rocks in England, Scotland, and France has given rise to an interesting controversy, to which Mr. Hugh Watson has been the latest contributor.[1] Two points are at issue. Did these gastropods live in fresh, brackish, or fully salt water ? Are they so completely indistinguishable from *Viviparus* that they could belong to no other genus, whatever their habitat ? It should be possible to answer the first question by considering all relevant evidence as to the conditions of formation of the deposits in which they are found, for it seems rather unreasonable to suggest that every occurrence is to be explained by transportation by rivers in flood or some such accident. Apart from their presence in the Sharp's Hill Beds of N. Oxfordshire, associated at one locality with marine shells, they have been found at several horizons and localities in the Great Estaurine Series of Skye. Mr. F. W. Anderson (who is convinced from familiarity in the field that the beds containing these shells are not of freshwater origin) has kindly sent me a full list of the occurrences in that island (apart from the one recorded in Dr. Yen's paper) and of the associated fossils. The list is summarized below ; the records are all Mr. Anderson's except for two published by Tate, whose generic determinations have been revised. The beds are cited in descending order.[2]

e. *Ostracod Limestones. Bathonella* has been found at seven localities, associated at one with *Protomiodon* spp. and " *Estheria* ", at a second with *Protomiodon* and ostracods, at a third with *Hydrobia praecursor* and " *Estheria* ", at a fourth with *Quenstedtia staffinensis*, ostracods and " *Estheria* ", at a fifth with ostracods and " *Estheria* ", and at the other two alone.

[1] *Geol. Mag.*, lxxxvii, 1950, 17–25.

[2] For a summary of the succession in Skye and a revision of the fossil determinations of previous authors, see F. W. Anderson and L. R. Cox, *Proc. R. Phys. Soc. Edinb.*, xxiii, (2), 1948, 103–122.

https://doi.org/10.1017/S0016756800076998 Published online by Cambridge University Press

d. *Lower Ostrea Beds.* At one locality with *Protomiodon* ; at Loch Bay with *Neridomus arata, Neridomus staffinensis, Zebina caledonica, Ostrea hebridica, Protomiodon brycei, Anisocardia cucullata,* and *Pleuromya robusta* (Tate's record).

c. *Concretionary Sandstone Series.* At one locality in abundance at the base of a 13 ft. bed full of *Protomiodon* spp. ; at a second locality alone.

b. *Estheria Shales.* At one locality with *Protomiodon,* " *Estheria* ", and ostracods (the shales contain algal beds and *Ostrea*) ; at Eist with *Cylindrobullina inermis, Ostrea hebridica,* and *Protomiodon cunninghamii* (Tate's record).

a. *White Sandstone.* With *Protomiodon.*

From these records it appears that the most frequent associate of *Bathonella* is *Protomiodon.* Other associated forms are *Hydrobia* and " *Estheria* ", both of which could be of fresh or brackish water origin ; *Quenstedtia staffinensis,* an apparently marine form ; several marine species, according to Tate's records (but it might be maintained that these were probably not collected from exactly the same bed), and ostracods. The ostracods will naturally have an important bearing on the question ; Mr. Anderson tells me that their study is not yet completed, but so far there is no evidence of freshwater genera among them. Mr. Watson cites *Protomiodon* as evidence of freshwater conditions. The following, however, are those occurrences in other areas for which I can vouch personally :—

(1) Upper Estuarine Series of Rutland and Lincolnshire. The associated forms are *Eomiodon fimbriatus* (Lycett) and *Cuspidaria ibbetsoni* (Morris), both found also in beds of more purely marine facies.

(2) Shales above Millepore Bed at Yons Nab, Gristhorpe Bay, Yorkshire. Besides *Protomiodon concentricus* (Bean), these contain plant remains, but also abundant *Trigonia* (Mr. P. C. Sylvester-Bradley, *in lit.*).

(3) " Bathonien saumâtre " of the Moulinets mine, Dourbie valley, Causses du Larzac, France (*P. ruthenensis* (Gourret), redescription in course of publication by Monsieur P. L. Maubeuge and myself). The associated species, in the same hand-specimens, are *Nerinella* n. sp. and *Naricopsina matheroni* (Gourret), both marine forms.

Clearly, therefore, *Protomiodon* cannot be cited as evidence of freshwater conditions, and the earliest recorded occurrence of its successor, *Neomiodon,* is in the marine Sables de Cordebugle of the Corallian beds of Normandy. Mr. Watson cites *Corbicula* as a freshwater genus found in Bathonian rocks and " known to have been common in Jurassic times ", and remarks upon the improbability of marine forms coming to resemble it. He is, doubtless (as required by the rules of nomenclature), using this name for the genus more familiarly known as *Cyrena,* ignoring the fact that the Jurassic shells referred to it by early authors are (with a few exceptions) precisely those now included in *Neomiodon* and *Protomiodon* on account of their very different cardinal dentition. In the paper by F. W. Anderson and myself already cited it is shown that a few other supposed species of " *Cyrena* " from the Great Estuarine Series actually belong to the marine genera *Astarte, Anisocardia,* and *Eocallista.* Far from having " been common in Jurassic times ", *Corbicula* (*alias Cyrena*) did not make its appearance until late in the Cretaceous.

The evidence suggests that the Scottish beds in which *Bathonella* occurs were deposited in brackish water, inhabited at times by marine forms which (like many modern ones) could tolerate diminished salinity. It is interesting to note that Mr. Watson, after maintaining that its occurrence fossil with marine species may have been due to one of several circumstances, but not to association during life, finally admits the possibility of a brackish-water origin for *Bathonella.*

The second question, whether morphological similarities demand the reunion of *Bathonella* with *Viviparus* even admitting that it probably did not

https://doi.org/10.1017/S0016756800076998 Published online by Cambridge University Press

live in fresh water, is none too easy to answer. Unfortunately, the general morphology of a gastropod shell, in the absence of knowledge of the soft parts, operculum, and radula, is not always an infallible guide to its affinities. Besides the marine species which I mentioned in my previous letter there are, for example, members of the Palaeozoic family Trochonematidae which are remarkably similar to *Viviparus*. The figures published by Mr. Watson show the general similarity between *Bathonella* and *Viviparus* which led Hudleston and Cossmann, before him, to regard them as identical, but at the same time they bring out differences in the outline of the earlier spire whorls and (less clearly) in that of the posterior end of the aperture which I considered might justify Dr. Yen's generic distinction. It could, of course, be maintained that these differences are specific and not generic, but as the mere mention of the genus *Viviparus* suggests freshwater conditions, the generic distinction seems all the more desirable.

Textbooks [1] tell us how the freshwater and terrestrial mollusca were derived from marine forms by gradual invasion of new habitats, beginning (in the first case) with brackish water. The affinities of a supposed *Viviparus* (*V. garwoodi*) from Lower Carboniferous beds seem very doubtful. It may be that in *Bathonella* we have a derivative of the marine family from which the Viviparidae sprang, caught in the first stage of this invasion.

L. R. Cox.

British Museum (Natural History),
Cromwell Road,
London, S.W. 7.

Sir,—Since my paper "On some Bathonian Mollusca from Skye" was published, the problem whether a *Viviparus*-like group of gastropods found in the Bathonian beds, and for which I have proposed the name *Bathonella*, is of marine or freshwater origin has arrested the attention of several palaeontologists, one zoologist, and one anatomist. As this problem is of fundamental importance, their comments are welcome, and my appreciation goes as much, if not more, to those who oppose my interpretation that this group of gastropods is of marine origin as to those who accept it. Recently somewhat misleading comments on the subject have come to my attention, and it is necessary to discuss the matter further to help clarify the issue.

Before considering details, two important points should be noted. First, my generic description of *Bathonella* and the supplementary notes should be taken as a whole; if a description is broken into fragments and each is cited at convenience, the basic facts are bound to be distorted.

Secondly, to study the problem objectively the geological criteria pertaining to the fossil-bearing beds, including lithology and other like evidence of conditions of deposition, should be borne in mind, in addition to the morphology of the fossils and the assemblage of the organic remains.

On morphological grounds I maintain that my original description of *Bathonella* is complete (including "acutely conical spire", "aperture . . . barely attaching to the preceding whorl", "lines of growth . . . distinctly curved towards the base", etc.), and that it describes a genus which is readily separated from *Viviparus* Montfort. It is possible to detach the reference to a naticoid feature, or any other single character, from the description to argue for the opposite conclusion, but that is to destroy the unity of the generic characters. It is not permissible to build up an argument by taking one feature from a description to match that of a living species in North America, another feature to match that of species now existing in Africa, still another feature to match that of a species of Jurassic age in England, and then on the basis of such morphological resemblances to draw a conclusion that "the characters of the shell seem to afford little justification for placing in a separate genus . . . ".

[1] Cf. A. H. Cooke, "Molluscs," *Cambridge Natural History*, iii, pp. 11–14 (1895).

https://doi.org/10.1017/S0016756800076998 Published online by Cambridge University Press

My illustrations had to include figures of specimens in different states of preservation. The feature of an almost detached parietal wall is not well preserved in every specimen, and it cannot, therefore, be shown in every figure. My descriptive term " thin shell substance " (p. 168) clearly means in comparison with that of a *Natica*. Any student of conchology has, or should have, a conception of a *Natica* and its thick shell substance. That a shell is thinner than *Natica* does not mean it is thinner than *Viviparus*.

Sometimes morphological differences of seemingly minor importance may well turn out to be distinctive characters when such differences are substantiated by considerations of time and space. In dealing with an extinct fauna, time constitutes a far more important factor.

Referring to habitat conditions I have stated clearly that there are two fossiliferous beds at the locality in Skye from which my specimens were obtained, namely a band of fine-grained cementstone about 4 inches thick overlying a bed of limestone 1 foot thick. The contact between the beds is even and there is actually but little change in colour or lithologic character. Under such circumstances there is small ground for the assumption of abrupt change in habitat conditions from marine to freshwater. If a " slow uplift " ever took place, then the change should be gradual ; I have mentioned the possibility that estuarine conditions existed, and that gastropods of marine origin were carried to the deltaic area by sea current, wave, and tidal actions.

Moreover, some of those who have commented on my paper suggest the possibility that freshwater gastropods were carried into the sea by " an exceptional flood ". Since dead molluscan shells are generally precipitated to the bottom and buried in the sediments at the bottom, it certainly would require " an exceptional flood " to drift large numbers of shells of *Viviparus* a considerable distance along a river course. But at same time, as such a flood would have also carried all loose objects, pebbles and gravel, these would form a kind of conglomeratic bed, or at least a bed of coarse texture. The *Bathonella*-bearing bed exposed in Skye consists of sandy limestone of fine texture, in North Oxfordshire of " marl " and in France also of limestone. One can hardly see how fossil beds of such fine texture can be attributed to " an exceptional flood " followed by " minor floods ", or how nature could have sorted out and carried elsewhere everything in the debris but these supposed freshwater gastropods.

In reference to Charophyte gyrogonites and *Metacypris*, Mr. Sylvester-Bradley has mentioned that he has found gyrogonites also in beds usually regarded as marine. Species of *Metacypris* have been found in beds of brackish origin. The Jurassic and Cretaceous species attributed to " *Cyrena* " are of brackish and perhaps sometimes of purely marine origin, and are nowadays referred to the genera *Neomiodon* and *Protomiodon*. *Valvata*-like species found in Bathonian beds, as well pointed out by Anderson and Cox (p. 118), may belong to *Tornus*. As a result of such corrections, the list given by Mr. Watson (p. 23) of five Bathonian freshwater genera, which is compiled from various sources, has to be reduced to one, namely *Viviparus*, and for this I have had the privilege of proposing the name *Bathonella*, and I have considered it and still consider it to be of marine origin.

TENG-CHIEN YEN.

REFERENCES

ANDERSON, F. W., and COX, L. R., 1948. *Proc. Roy. Phys. Soc. Edinb.*, xxiii, (2), 103–122.
ARKELL, W. J., 1948. *Geol. Mag.*, lxxxv, 247.
COX, L. R., and ELLIS, A. E., 1948. *Ibid.*, 313–315.
SYLVESTER-BRADLEY, P. C., 1948. *Ibid.*, p. 367.
WATSON, HUGH, 1950. *Geol. Mag.*, lxxxvii, 17–25.
YEN, T. C., 1948. *Geol. Mag.*, lxxv, 167–171,

https://doi.org/10.1017/S0016756800076998 Published online by Cambridge University Press