LETTERS TO THE EDITOR

THE TEMESIDE BONE–BED AND ASSOCIATED SEDIMENTS FROM WALES AND THE WELSH BORDERLAND – Reply, to letters published in the *Mercian Geologist, vol. 8, no. 4,* pp. 311–315, received from D.D.J. Antia.

Dear Sir,

I would like to thank Drs. Lawson, White and Squirrel for their comments on the above paper, published in vol. 8 no. 3 pp. 163–216 of the Mercian Geologist. Typographical and other errors were printed on p. 316 of vol. 8 no. 4, Mercian Geologist. Other points raised were as follows:

Localities. Dr. Lawson suggests that the Downton locality reference p. 166 is incorrect. The location to which I referred is a sandstone quarry about 1 km east of the Downton Castle Bridge along the River Teme on the south side of the river. The Downton Castle Bridge locality described by Elles & Slater (1906) and referred to by Dr. Lawson exposes a section across the Downton Castle Formation to the Overton Formation boundary.

Ozarkodina remscheidensis. (a) The conodont specimen recorded (which is still retained by Dr. Aldridge at Nottingham University) is the earliest known and only published record of this species in the Welsh Borderlands. It is clearly stated on pp. 174 and 182 that I only found a single specimen of this conodont.

(b) My reasons for stating on p. 176 that the specimen indicates a possible lowest Gedinnian age for the section may be amplified as follows:

When I first examined this section, which had been assigned to the Temeside Group by Elles & Slater (1906), I was surprised to find well developed palaeosols and other sedimentary features which would indicate a correlation within the lithologically defined Ledbury Formation of Allen (1974a). I presumed at this stage that the ostracod faunas which were typically found in the Temeside Group (Elles & Slater, (1906); Shaw, 1969)) would also be recorded in this section. However the fossils recorded (p. 174) included a rare but diverse fauna of smooth calcareous ostracod carapaces and valves belonging to species not normally found in the Temeside Formation (Shaw, 1969). They suggested a possible Upper Downtonian age for the section layers 1 – 11 (cf. Copeland, (1964)). This age assignment for the section is consistent with the record of a *Hemicyclaspis murchisoni* fish fauna (Elles & Slater, 1906) in the Temeside Bone–Bed (cf. Dineley & Loefler, 1976, p. 52). The thelodont – cephalaspis fauna recorded contained fairly typical Downtonian thelodont species (cf. Turner, 1973), many of which are also found in the Ludlovian. I wrote (p. 129, 182) that in the Temeside Bone–Bed:

> "The vertebrate remains are black in colour and are highly weathered (see Antia, 1979a) and highly abraded. An X.R.D. analysis of these grains shows that they are made up of a pure carbonate apatite, while the vertebrate remains in the underlying red beds are a translucent yellow colour suggesting that they might be made of a fluorapatite enriched in organic debris (Antia 1979a). Similar colour variations have been recorded elsewhere in the geological column on fish debris, but not interpreted (for example, the Triassic – see Sykes & Simon, 1979). The most likely explanation for the highly corroded, worn and weathered nature of these fish scales, which appear opaque black in all three bone–beds, is that they have been eroded out of underlying red beds and have been redeposited in the vertebrate lags in which they are now found, suggesting that the layer 12/layer 11 boundary may represent a disconformity and that an unknown amount of sediment may have been removed. It is interesting to note that the conodont specimen was unworn and had a translucent fresh appearance suggesting that it might be a contemporary fossil of bone–bed BK1 age, unlike the fish which were almost certainly reworked from an older sediment."

If this conclusion is valid and the layer 12/layer 11 boundary represents a faunal as well as a sedimentological disconformity, then the conodont and plant remains recorded may be the only contemporary fossils of bone–bed BK1 age. When Dr. Aldridge first identified the conodont in 1978 he suggested that it could be of Gedinnian age. If this interpretation is correct then it is probable that the disconformity represents the Siluro – Devonian boundary as I suggest (p. 182). However, the presence of this conodont by itself is certainly not diagnostic of a Devonian age as Dr. Lawson rightly asserts. Its range extends from the highest Silurian into the Devonian. My own examination of the relevant literature during 1978 and 1979 pertaining to this species suggested that it was generally more abundant in Devonian conodont assemblages than in those of the highest Silurian. Consequently, a solitary conodont specimen found in highest Silurian sediments is less likely to be *Ozarkodina remscheidensis* than one found in lowest Devonian sediments. After considering both the sedimentological and

faunal data collected from this section I concluded that it is probable that the layer 11/12 boundary represents the Silurian - Devonian boundary.

However, as discussed, the evidence for this assignment is in part circumstantial, and the pure faunal evidence only supports the conclusion that the sediments in the section are of late Silurian age or younger. It is obvious from both this discussion and Dr. Lawson's comments that much more palaeontological and sedimentological work needs to be done in the Welsh Borderlands on the Ledbury and overlying Formations before the position of the Silurian – Devonian boundary can be identified with certainty in this region.

Fourth Silurian Series. There is no statement made in my paper (as Dr. Lawson contends) that the name Downtonian is no longer a contender for the fourth Silurian series. Indeed I even published a lengthy paper (Antia, 1980a) on the sedimentology and palaeontology of the type section at Ludlow of the Ludlow – Downton Series boundary as defined by Holland *et al.* (1963) and use the term throughout my paper (e.g. pp. 168, 176, 184, 185, 192, 194, 195, 196, 200, 201, 207). However, as noted (p. 168) an increasing number of authors are using the term 'Pridoli Series' in preference to the term 'Downton Series'. Many of them (e.g. Leggatt, 1980) are using the former term as a synonym of Downton Series when applied to the Welsh Borderlands, despite palaeontological evidence that the position of the bases of the two series, as currently defined, are not identical (Kaljo, 1978).

Lithostratigraphy. Recently Drs. Holland, Lawson, Walmsley and White (1980) renamed a number of essentially faunally defined stratigraphical units (identified in the late 1950's by Holland, Lawson and Walmsley (1963)) by replacing the suffix 'Bed' by 'Formation', thus implying that the units were lithologically defined. These units were originally defined using stratigraphical principles which were in widespread usage in the early part of this century but are outmoded by modern standards. The principal fault (by modern standards of these various stratigraphers was their reluctance to distinguish separate biostratigraphical and lithostratigraphical units. They defined units mainly on fauna but took some account of lithology in their unit definitions. As a result there is a proliferation of stratigraphical terms relating to locally mapable units throughout the Silurian of the Welsh Borderland and with unit names and definitions changing at the boundaries of the various authors' particular area of study. Cocks *et al.* (1971) have attempted for the Welsh Borderland to show how each of these locally defined units fits within the general Silurian chronostratigraphy as outlined by Holland *et al.* (1959, 1963). Cocks *et al.* (1971) correlation was helped to a large extent by the fact that main fossil distributions appeared to be the chief factor in determining the boundaries of locally defined stratigraphical units. However, serious difficulties have arisen in applying Holland *et al's.* terminology in the Welsh Borderland. Phipps (1962, 1963), Phipps & Reeve, (1967) outlined some of the difficulties in attempting a correlation within the Welsh Borderland and using criteria defined by Holland *et al.* (1963). Their basic conclusion was that it is impossible to use the 'new' type stratigraphy (Holland *et al.*, 1959, 1962, 1963) in its present form. The main difficulty was caused by Holland *et al's.* refusal to recognise both biostratigraphic and lithostratigraphic units. A typical example of the serious difficulty so caused is quoted here from Phipps & Reeve, 1967, pp. 352–353:

> "According to Holland *et al.* (1962, 1963) the Aymestry Limestone is a rock stratigraphic unit which cuts obliquely across the boundaries of their new "combined units" (1962, 396). However, they insist that their "combined units" are based upon both biostratigraphic and rock stratigraphic criteria, such that we have the position where a rock stratigraphic unit cuts obliquely across another rock stratigraphic unit! In addition, the Aymestry Limestone is clearly diachronous. In the Bradlow district the upper 40 ft of the Aymestry Limestone yields a typically Mocktree (or Leintwardine) fauna, i.e. these 40 ft are characterized by the lithology of the Upper Bringewood Beds and the fauna of the Lower Leintwardine Beds of Holland *et al.* (1959). Because Holland *et al.* (1962) insist that their "combined units" are rigorously defined on the basis of both biostratigraphic and rock stratigraphic characteristics, it follows that these 40 ft have no equivalent in the Type Area and no correlation is possible. This difficulty would disappear if a dual classification existed for the Type Area. If the Bringewood Beds and Lower Leintwardine Beds were properly distinguished as biostratigraphic zones, and were given biostratigraphic names, it would be possible to demonstrate that the top of the Aymestry Limestone in the Bradlow district crossed a zonal boundary.
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> The same difficulties apply equally when attempting correlations with other of the "combined units". Because they are all defined on the basis of both biostratigraphic and rock stratigraphic criteria, they cannot exist outside of the Type Area whenever there is a change in facies or where diachronism takes place. This would require complete new sets of local names whenever it occurred. This proliferation of local names could be avoided if the Type Area revision provided both biostratigraphic and rock stratigraphic units."

It should be stressed that *Holland et al.* have not yet replied to these serious objections and do not consider them in their recent paper (1980). My introduction (Antia 1980b) of lithostratigraphic terms (e.g. Overton Formation) was intended to

supplement the biostratigraphy of Holland *et al.*(1959, 1962, 1963) to allow a more rigorous approach to be made in the understanding of the region. Holland *et al's* (1980) introduction of biostratigraphically defined 'Formations' in the region does little to aid the understanding of the overall sedimentology, stratigraphy and palaeoenvironments and will hinder geological research in these areas.

Ledbury Formation/Temeside Formation. Dr. Lawson has kindly clarified his understanding of the terms, Ledbury Formation, Downton Castle Formation and Temeside Formation. His usage of the terms strictly conforms to the old stratigraphical system of Elles & Slater (1906) and Holland *et al.* (1963). Their definitions have been largely superceded by a modern sedimentologically defined lithostratigraphy outlined by Allen (1974a), who has adapted existing names like Temeside Group or Downton Castle Sandstone and defined proper lithostratigraphic formations. This usage can create unnecessary confusion. In addition to this lithostratigraphic revision Shaw (1969) defined biostratigraphical ostracod zones in the Downtonian which can be correlated with similar well defined ostracod zones in Nova Scotia (e.g. Copeland, 1964). Between them these two papers have completely transformed the pre-existing concepts of the British Downtonian and provided a modern framework for research. The two sections described in my paper, which Elles & Slater (1906) recorded, were both originally assigned to the Temeside Shales. The Onibury section contains undisputed intertidal sediments representing the Temeside Formation (Allen, 1974). However, the Temeside Bone–Bed section contains 'supertidal' sediments and palaeosoil horizons which are characteristic of the Ledbury Formation (Allen 1974). Murchinson's (1852) drawing of the river section is far more complete than any currently exposed and is more complete than that documented by Elles & Slater (1906). This section reproduced on p. 164 (Antia, 1981) clearly shows the red bed sequence described (p. 172–182) and indicates that they occur just below the base of the main red bed sequence in the area. The stratigraphical position of this unit with respect to both the Downton Castle Formation and the Ludlow Series is confused by the presence of a fault (Antia, 1981b, p. 164) across which **accurate** field mapping correlation is not currently possible. The sediments within this section show some similarity with leveé deposits and hydromorphic soils deposited in Devonian alluvial plains and could be interpreted as such. However, the presence of marine microfossils in the sequence suggests that the marginal marine environment outlined (Antia, 1981b) is perhaps a more probable explanation.

I do not dispute the occurrences of the Temeside Formation in the vicinity of Downton Castle (as documented by Allen, 1974). However, I was pointing out that in the Quarry at Downton this Formation is absent and that the Ledbury Formation rests directly on the Downton Castle Formation. This observation shows that locally in the Downton – Ludlow region the Temeside Formation is absent, and that some diachronism of the Downton Castle and Ledbury Formations may occur, a point not demonstrated before in the area and important because it shows that the Temeside Formation may always be expected to occur as a mappable unit.

The Brewins Bridge canal section, which I first visited in 1977 with Dr. Lawson, consists of two exposures split by a canal. The inaccessible exposure (from the point of view of sediment sampling and section examination) containing the Temeside Bone–Bed is a cliff going down to water level which can be adequately sampled while suspended from ropes. The easily accessible part of the section on the opposite bank of the canal, exposes an igneous body and a few feet of red shales. The bone-bed is not exposed in this part of the section. The Ludlow railway cutting section was not exposed during 1976–78 inclusive.

Fossil identifications and location of collections. Fossil identifications were made with reference to identified material and collections at Ludlow Museum; Geological Survey Museum, London; the Natural History Museum, London; I.G.S. North Acton Rock Store; and Leicester University. Original species descriptions were examined and reference made to appropriate experts: macrofossils – chiefly Dr. Lawson; ostracods – Dr. Siveter; conodonts – Dr. Aldridge; thelodonts – Dr. Turner. In mid 1979 the collection was edited to 20 – 30 Admat boxes of fossiliferous material at Dr. Lawson's request. Subsequently, Dr. Lawson kindly arranged despatch of this remaining material from Glasgow University to the National Museum of Wales, Geological Survey Museum and Ludlow Museum in mid 1980. Prior to their despatch some boxes of specimens (including the Cennen Beds samples) were lost. I have deposited in Ludlow Museum petrographic slides, microprobe slides, microfossil collections, photographic record of sections, S.E.M. photographic negatives and macrofossil photographic negatives, including photographs of key fossils in the Cennen Beds collection.

Sedimentology. Dr. Lawson questions the reliability of my sedimentological conclusions. They are broadly in agreement with those of Professor J.R.L. Allen who has spent many years studying the sedimentology of the highest Silurian/lowest Devonian sediments of Wales and the Welsh Borderland (e.g. Allen 1974(a)), but differ in interpretation from many earlier (pre 1970's) studies in detail. For example Hobson (Ph.D thesis, 1963, Birmingham University) suggested that the Downton Castle Sandstone was a deltaic deposit; whilst this may be true in South Wales and the Malvern area, which I have not studied, it is certainly not true of the Ludlow area where the deposit is a marginal marine facies. However, ideas and concepts do change

and it is probable that a detailed sedimentological study will be made for the region which may produce yet another answer.

The Cennen Beds. Drs. Squirrel and White (1978) recorded a fauna of 'Leintwardinian' type macrofossils (mainly brachiopods) and an enigmatic occurrence of the Downtonian ostracod *Frostiella groenvalliana* from the Cennen Beds. Their conclusion that the sediments were of Leintwardinian age hinged on two important observations. Firstly that a fragmentary trilobite belonged to a typical Upper Leintwardinian species and secondly, that the macrofaunal assemblage which included the brachiopod *Hyattidina canalis* indicated by comparison with the Ludlow area an Upper Leintwardinian age for the sediment. The material collected by Dr. Atkins and recorded in Appendix 2 contained the fauna listed. The brachiopod ? *Brachzyga* sp. closely resembles *H. canalis* in external appearance, but has its brachial skeleton on the opposite valve to *H. canalis* (photograph in Ludlow Museum). This observation was checked by Drs. Atkins, Lawson, Lockley and Burton. Dr. Burton, after much thought, suggested a possible assignment to *?Brachzyga* sp.with which I concur. The fossils assigned to *Protochonetes* cf. *missendensis* or *P.* cf. *novascoticus* differed principally from the typical Ludlovian brachiopod *P. ludloviensis* in having a very rounded junction where the hingeline and commissure meet. (Photograph in Ludlow Museum). I have only seen one *Protochonetes* specimen like it in the Ludlow area. This specimen was in the Downton Castle Formation of Deepwood, Nr. Ludlow (locality described by Holland *et al*, 1963). The remaining macrofossils recorded could also be found in Leintwardinian sediments. The ostracod fauna recorded contains two positively identified species, *Frostiella groenvalliana* (also recorded by Squirrel and While, 1978) and *Londinia kiesowi* (photograph in Ludlow Museum). The *Londinia* species is not diagnostic of age and has been recorded in the Ludlow – Corvedale region in Ludfordian and Downtonian sediments (Antia 1979b, 1980b). The *Frostiella* species has been recorded in a wide variety of environments throughout the Baltic, Scandinavia and Britain and was generally considered (until Squirrel and White's 1978 paper) to have been a diagnostic biostratigraphic indicator of the Downton Series (e.g. Shaw, 1969). As a result, Squirrel and White were presumably placed in a paradoxical situation, either they believed the trilobite identification and assigned a Leintwardinian age to the fauna or they believed the undisputed *Frostiella groenvalliana* identification and assigned a Downtonian age to the section. Drs' Squirrel and White took the former option. However the Leintwardinian type macrofossils recorded by Squirrel and White and in Appendix C could during the Downtonian have been restricted to the very sandy 'high energy' environment presented by the Cennen Beds facies. Alternatively, since the base of the Cennen Beds is an undisputed unconformity it is possible (but probably less likely) that the fossils (which all occur in a shell laminae) were reworked out of Leintwardinian sediments. (Whitaker (1962) has recorded reworked Ludlovian macrofossils in Ludfordian sediments in the Leintwardine area). Such an interpretation would have allowed the ubiquitous species *F. groenvalliana* to have remained a diagnostic biostratigraphical indicator of the Downton Series. It is currently the only faunal species recorded (Antia, 1980a) in the type section of the Ludlow – Downton Series boundary (Holland *et al*, 1963) which appears to be restricted to the Downtonian. If Squirrel and White are correct in their assertion that the Cennen Beds are of Leintwardinian age, then the last remaining supposedly diagnostic Downtonian fossil in the type section is no longer diagnostic and it will be impossible to correlate, using macrofossils and ostracods, the Ludlovian-Downtonian Series boundary as defined at Ludlow, elsewhere in Britain or Worldwide. Drs. Squirrel and White report that Drs Turner and Dorning have recorded well preserved Ludlovian age acritarchs of equivalent age to that of the Upper Leintwardine Beds or Lower Whitcliffe Beds. They do not, however, say which acritarch species were recorded. It is well established that acritarch species (including British Ludlovian Acritarchs) can be highly facies or environment dependent, (e.g. Dorning 1981a). The Cennen Beds bears no relationship to the Lower Whitcliffian/Upper Leintwardinian facies in the type Ludlow area. As a result two conclusions are possible. Firstly, that the Cennen Beds are of Upper Leintwardinian/Lower Whitecliffian age, or, secondly the supposedly diagnostic acritarch species lived in the Downtonian environments present by the Cennen Beds. The acritarch fauna of the British Downtonian is currently unknown, due largely to the marginal marine and fluvial facies presented by it in the type area.

With regards to the usefulness of palynological versus macrofossil correlations a number of points have to be considered. Firstly, it is not uncommon for palynological and macrofossil information to contradict each other. Secondly, it is not uncommon for palynologists from different commercial concerns to come up with major series boundary identifications whose vertical position differ by several zones. Consequently, until it is unequivocably established that the acritarch species in the Cennen Beds are not present in undisputed British marine Downtonian sediments or alternatively that *F. groenvalliana* does occur elsewhere in Ludfordian sediments where the age is established by graptolites, then the age of the Cennen Beds will be open for dispute. The available but contradictory faunal evidence for these Beds as documented by Squirrel and White (1978) supports either a Ludfordian or a Downtonian age.

I hope in this reply that I managed to clarify most, if not all, the points, raised by Drs Lawson, Squirrel and White, to my paper.

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