Discussion of “The correlation of the Speeton Shell Bed, Filey Bay, Yorkshire, to an oxygen isotope stage”

D. Q. Bowen and G. A. Sykes write:
The amino acid data cited by Miss Wilson were determined in our laboratory in 1988 (then in the University of London at Royal Holloway and Bedford New College), when samples of Macoma balthica were analysed for Miss Wilson’s undergraduate project (School of Earth Resources, Hull University). Because neither of us have had the opportunity to read her paper until now, it is necessary to point out errors of fact, and to show that her conclusions cannot be taken as definitive.

Data
The data are presented in Table 1 of her paper but laboratory numbers are not cited. The ratios are described as ‘Free D/L Ratio Peak Height’. This is incorrect. The amino acid ratios represent the total hydrolysate, and the difference between total and free amino acids in a sample is clearly not understood. We now present all the data (Table 1).

<table>
<thead>
<tr>
<th></th>
<th>Free AAR</th>
<th>Total AAR</th>
<th>Hydrolysate</th>
</tr>
</thead>
<tbody>
<tr>
<td>LOND 509</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Macoma balthica</td>
<td>AF 0.530</td>
<td>AH 0.184</td>
<td></td>
</tr>
<tr>
<td></td>
<td>BF 0.482</td>
<td>BH 0.173</td>
<td></td>
</tr>
<tr>
<td></td>
<td>CF 0.570</td>
<td>CH 0.172</td>
<td></td>
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<tr>
<td></td>
<td>DF 0.536</td>
<td>DH 0.182</td>
<td></td>
</tr>
<tr>
<td>Mean</td>
<td>0.530</td>
<td>0.178</td>
<td></td>
</tr>
<tr>
<td>SD</td>
<td>0.031</td>
<td>0.005</td>
<td></td>
</tr>
<tr>
<td></td>
<td>n 4</td>
<td>4</td>
<td></td>
</tr>
<tr>
<td>LOND 510</td>
<td></td>
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<tr>
<td>Macoma balthica</td>
<td>AF 0.468</td>
<td>AH 0.224</td>
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</tr>
<tr>
<td></td>
<td>BF 0.499</td>
<td>BH 0.230</td>
<td></td>
</tr>
<tr>
<td></td>
<td>CF 0.582</td>
<td>CH 0.154</td>
<td></td>
</tr>
<tr>
<td>Mean</td>
<td>0.516</td>
<td>0.203</td>
<td></td>
</tr>
<tr>
<td>SD</td>
<td>0.048</td>
<td>0.035</td>
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<td>n 3</td>
<td>3</td>
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</tbody>
</table>

LOND (LONDON) 509A, 509B, 509C, and 509D were coated in resin so they are unsuitable for amino acid geochronology because of the possible effects of the resin on the D-alloisoleucine—L-isoleucine ratios. These particular analyses were made to test the effect of resin coating and storage, and it was pointed out to Miss Wilson that they should not be used for geochronological purposes.

Three amino acid ratios (LOND 510A, 510B and 510C) would not normally be sufficient to give a definitive value for a stratigraphic unit. In the case of the Easington data (Bowen et al. 1991) for example, 28 separate analyses are used. Furthermore, it is the practice to use mean amino acid values only when one standard deviation is less than 10% of the mean value (Miller & Brigham-Grette 1989). The standard deviation on the Speeton data is 17% of the mean, and the limited data here possibly represents two populations of different ages. This is also suggested because the populations (0.154 and 0.227 ±0.004 (2)) come from different lithostratigraphical units (cf. Wilson 1991, fig. 1 and table 1).

The source of Table 2 of Miss Wilson is described as ‘Bowen & Sykes 1988’. Three comments are necessary: first, we did not use the term ‘Wolstonian’ because we believe it has no stratigraphical meaning (Bowen 1978, 1991; Rose 1988); second, the mean AAR (0.2), correlated with Oxygen Isotope Stage 7, has been revised to give a higher value as the result of new data (in preparation); third, the data are based on Arctica islandica and Macoma calcarea as well as Macoma balthica.

Interpretation
The process of interconversion from L: isoleucine to D: alloisoleucine is called epimerization, and not racemization as described by Miss Wilson. It is not possible to compare directly AAR from genera that epimerize at ‘slow’ and ‘moderate’ rates respectively (Miller & Mangerud 1985). Unfortunately Miss Wilson makes such a comparison when she compares her ratios with those from Ilford and Aveley (Miller et al. 1979). Macoma balthica epimerizes at ‘moderate’ rates, whereas Corbicula fluminalis (which occurs at Aveley, not ‘Macoma’ as quoted), epimerizes at ‘slow rates’ (Bowen et al. 1989). Thus, her correlations are inadmissible.

Because of the problem of mixed populations it is not possible to reach a definitive conclusion about the age of the Speeton Shell Bed. The lowest AAR of 0.154, however, could be a pointer to an Ipswichian age. This is the conclusion reached by Knudsen & Serjup (1988) when they analysed amino acid ratios of foraminifera from the Speeton Shell Bed. This would also uphold the correlation of West (1969). But, the free amino acid ratios for this sample are unexpectedly low compared with the higher ratios, and more analyses are required (Table 1). Knudsen & Serjup’s (1988) paper is not cited. Nor is the Ph.D. dissertation of Kathryn Headon-Davies (1984), which contains amino acid ratios of Macoma balthica from Speeton. These were produced using an earlier and different preparation method for samples (as was the data of Miller et al. 1979).

Miss Wilson’s ascription of the term ‘Ilfordian’ to Bowen (1978) is incorrect. In that publication, the word ‘Ilford’ was used in a correlation table. Her further use of ‘Ilford Interglacial’ is unfortunate because the type-localities suggested for correlation with Oxygen Isotope Stage 7 are: for marine beds, Minchin Hole Cave, Gower (Bowen & Sykes 1988); and for non-marine beds, Stanton Harcourt, Oxfordshire (Bowen et al. 1989).

Miss Wilson’s comment that many Ipswichian sites may be older is not new, and has been shown to be so using amino acid data of which she seems unaware (Bowen et al. 1989). We cannot accept that the data she uses show that the Speeton Shell Bed may be correlated unequivocally with the Minchin Hole sea-level event (ascribed to Oxygen Isotope Stage 7) (Bowen & Sykes 1988). Nor do they have any bearing on the age of the Basement Till of East Yorkshire, and certainly not on its correlation with Oxygen Isotope Stage 6. Amino acid data from the Basement Till is in press (Eyles et al. 1992) and

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shows that it is Late Devensian in age (its inclusions of Bridlington Crag are Cromerian). Finally, her repeated use of the term ‘Wolstonian’, which its defenders believe (Gibbard & Turner 1988) refers to the Hoxnian-Ipswichian interval (but see Rose 1988 and Bowen 1991), lacks any stratigraphical or other justification for its use in East Yorkshire.

S. J. Wilson replies:
I thank Professor D. Q. Bowen and Dr G. A. Sykes for their comments. I agree with some, such as the fact that the term epimerization of isoleucine is more appropriate than racemization, that *Corbicula fluminalis* and *Macoma balthica* epimerize at different rates, and that the ratios of the two species cannot be compared. *Corbicula fluminalis* and not *Macoma* shells were analysed from Ilford and Aveley (Miller et al. 1979). For the sake of clarity I give a full list of errata (see footnote).

I also agree with Bowen and Sykes that it is not possible to reach a definitive conclusion about the age of the Speeton Shell Bed. I thought this was made clear in my paper, which states (p. 225) that “The amino acid evidence suggests that the Speeton Shell Bed was deposited in stage 7 rather than stage 5e or the Hoxnian as previously thought”. Greater certainty may have been achieved by amino acid determinations of more shells than I was able to analyse, and the seven shells analysed are of course insufficient to define the age of the Shell Bed as precisely as one would wish.

However, I do take issue with Bowen and Sykes over several other points they have raised. The statement that I have not understood the difference between total and free amino acids is unfair because of course it is impossible to dispute in a written answer. The statements that the analyses of the resin coated museum shell specimens were made “to test the effects of resin coating and storage” and that “it was pointed out to Miss Wilson that they should not be used for geochronological purposes” are inaccurate. The museum shells were originally sent to Professor Bowen and Dr Sykes to test if they could be used for dating. When they reported the shells were suitable because high-pressure liquid chromatography results, after ultrasonic cleaning, had showed no resin contamination, I visited their geochronology laboratory (then at Royal Holloway and Bedford New College) at my own expense to help analyse both these and the fresh shells of *Macoma balthica* I had found at Speeton. I do not understand why they should originally encourage me to go to this trouble, then criticise the work in writing after I enthusiastically followed their advice.

The statement that Bowen and Sykes did not have an opportunity to discuss my results prior to publication is also incorrect, as a copy of my undergraduate dissertation, on which the paper is based, was sent to Professor Bowen in April 1989, but I received no critical comment at that stage.

Bowen and Sykes state that I incorrectly attribute “Ilfordian” to Bowen (1978); the word is in fact used in that book on p. 148, paragraph 5, line 11.

Although Bowen et al. (1986) suggested that the British type localities for correlation with Oxygen Isotope Stage 7 should be Minchin Hole, Gower (marine) and Stanton Harcourt, Oxfordshire (non-marine), I chose to relate the Speeton Shell Bed to Ilford because

a) Ilford is on the eastern side of the country, Minchin Hole on the west.

b) Ilford is in an estuarine situation (like Speeton) whereas Minchin Hole is a sea cave and Stanton Harcourt is completely non-marine.

The comment by Bowen and Sykes that the standard deviation of the amino acid ratios for the fresh Speeton shells is 17% of the mean, and too large for a population from a single interglacial, simply ignores part of the evidence. The 17% standard deviation applies to the fresh shells only, and the ratios of the four museum shells have a much smaller standard deviation of 3% of the mean. If anything this suggests that as a group the museum shells rejected by Bowen and Sykes give a more reliable indication of the age of the Shell Bed than the fresh shells.

In view of their comments about the necessity for multiple analysis with a small standard deviation, it is surprising that Bowen and Sykes are prepared to propose that the Shell Bed is Ipswichian on the basis of the single shell with a somewhat smaller ratio than the remainder.

Bowen and Sykes’ assertion that the Basement Till of East Yorkshire and Lincolnshire is Late Devensian rather than Wolstonian (pre-Ipswichian, post-Hoxnian) does not bear close scrutiny, as this till underlies the Ipswichian (Oxygen Isotope Stage 5e) interglacial beach deposits at Sewerby (Catt & Penny 1966). It would be interesting to have further details of the shells from the till that have Late Devensian amino acid ratios as mentioned by Bowen and Sykes. However, it must be remembered that the upper layers of the Basement Till at many places in East Yorkshire were extensively disturbed by the Late Devensian glacier (Penny & Catt 1967), so late Devensian shells could have been incorporated into the Basement Till at this time, long after the till itself was originally deposited.

My argument for tentatively relating the Basement Till to Oxygen Isotope Stage 6 was as follows: after deposition of the Speeton Shell Bed (probably in Stage 7) the sediments were disturbed by two different ice advances (Edwards 1978, 1981), a later advance from the north east clearly related to the Late Devensian, and an earlier advance from the north. The only known glaciation of North East England before the Late Devensian was the one that deposited the Basement Till, and as the Basement Till underlies Stage 5e deposits at Sewerby it should be related to Stage 6. The amino acid results presented in my paper therefore do have an important bearing on the age of the Basement Till and also on the reality of a Wolstonian glaciation in North East England. I have no contribution to make on the much debated question of the reality of the Wolstonian glaciation in the English Midlands. The evidence from Yorkshire must stand on its own in this respect, though it is significant for my case that amino acid dating of shells found in the Balderton Sands and Gravel of Lincolnshire (Brandon & Sumbler 1991) indicates that the Wolstonian is probably equivalent to Oxygen Isotope Stage 6.

Errata
1. Table 1. “Free” included in error and should be replaced by “Total Hydrolysate”.
2. Table 1. Depths of collection from the top of the Shell Bed should be 120cm and 160cm rather than 1.20cm and 1.60cm.
3. Table 1. Laboratory numbers should have been included, Lond-509 and Lond-510 as given by Bowen and Sykes.
4. Table 2. The classical framework is from Mitchell et al. 1973, not Bowen & Sykes 1988. The line between the two right hand columns of the table should be extended downwards to the foot of the table.
5. Incorrect spelling of ‘diastereomer’, line 7 column 2, p. 224.
6. The *Macoma balthica* shells analysed by Miller et al. (1979) were from Selsey Bill, Sussex (Ipswichian) and Clacton, Essex (Hoxnian), line 33, column 2 paragraph 4, p. 224.
References


D. Q. BOWEN, Ph.D. G. A. SYKES, Ph.D. S. J. WILSON

G. A. SYKES, Ph.D. 67 Storeys Way

Institute of Earth Studies

The University of Wales

Aberystwyth

SY23 3DB

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