Quaternary deposits in the Lake Cutting of the Barnstaple Bypass, North Devon

A.B. HAWKINS and S.C. HAWKINS

Department of Geology, University of Bristol, Bristol BS8 1RJ.

For approximately 3km the recently constructed Barnstaple Bypass traverses an area shown on the British Geological Survey 1:50,000 map (Sheet 293) as Boulder Clay. Of particular interest is the area around Lake, to the west of the River Taw, where the bypass was constructed in cut up to 9m deep.

Maw (1964) was the first to ascribe the term "Boulder Clay" to the deposits at Fremington. He reported a thickness of 23.8m of clay near Roundswell, approximately 1km west of the village of Lake. In the nineteenth century a number of pits were dug in the area, partly to obtain clay for pottery. Although most of the early pits are now infilled or completely overgrown, erratics of sandstone, quartzite, granite, tuff, dolerite, ?quartz-porphyry and andesite were reported by Dewey (1910) and Taylor (1956). In 1970 the British Geological Survey recorded the exposure of the only working pit, Higher Gorse Claypits. The succession they presented is given in Table 1.

Table 1. Section in Higher Gorse Claypits in 1970, as recorded by the British Geological Survey (Edmonds *et al.* 1985).

Description	Thickness (m)
Soil, head and weathered boulder clay clay and silty clay containing many rock fragments and pebbles; mainly sandstone and quartzite but with some slate, vein quartz, chert, granitic rock, pebbly quartzite, Thin soil and subsoil on pale grey and brown dolerite and flint.	4
Boulder clay Chocolate-coloured clay, commonly silty, with scattered small pebbles and stones as above and some lignitic wood	0.5 to 1.75
Lake clay Chocolate and purplish grey sticky tenacious clay, almost entirely stone-free	6
Boulder clay Stony clay	

Stephens (1966) reported well-rounded gravel at the base of the Fremington Deposits, which he equated with the coastal raised beach deposits. Kidson and Wood (1974), however, showed there were distinct sedimentological differences between the basal material and the coastal abandoned beach deposit. In 1972 eighteen shallow holes were drilled in an attempt to determine the extent of stone-free pottery clay. It was noted that basal gravel was only recorded in those boreholes which had relatively pure clay above. Although Edmonds (1972) had likened the gravel to a pebbly boulder clay, Kidson and Wood (1974) regarded the pebbly material beneath the smooth pottery clays to be of glacio-fluvial outwash origin.

The age of the material has been given by both Stephens (1966) and Kidson and Wood (1976) as Wolstonian. Stephens (1966) considered the Wolstonian ice mass entered the Bristol Channel complex while Hawkins and Kellaway (1971), Gilbertson and Hawkins (1978) and Andrews *et al.* (1984) have indicated that it was more likely to have been ice of Anglian age which passed into the Bristol Channel, as far east as the Clevedon area.

As the new road cutting was excavated the batter faces were inspected. The deposits exposed on both cut faces were recorded in detailed sections measured at 20m intervals. Fig. 1 gives a detailed profile of the geology, divided into five for publication purposes. Table 2 gives details of the deposits at Chainage 11000. Two clear deposits are identified above the thick, dominantly clay-rich material. In the upper deposit (Unit A) there is a significant proportion of angular and subrounded gravel/cobble clasts, in places up to 50%. The layer below (Unit B) contains a smaller proportion of clasts which are generally of gravel size. The matrix of both units is a clayey silt/silty clay and in the lower deposit there is some indication of horizontal laminations. Clasts of pink/grey/green sandstone, grey mudstones and vein quartz are dominant. Discontinuities are not well developed but when present there is some gleying and iron staining. In some places there is no clear distinction between Units A and B and it is likely Unit A was not present everywhere.

Table 2. Logged profile at Chainage 11000 where the bedrock was exposed in the deepest part of the cutting.

Unit	Depth (m)	Description
A/B	0.00 - 0.60	Firm yellow brown and red silty sandy CLAY with many angular clasts of sandstone and mudstone less than 200mm in size. Variable thickness.
C	0.60 - 2.90	Firm to stiff red brown silty CLAY with well developed extremely closely spaced discontinuities and rare gravel. Occasional very silty pockets.
D	2.90 - 3.00	Continuous loose brown fine silty SAND.
E	3.00 - 5.50	Loose grey and black sandy GRAVEL with cobbles.
	5.50 - 5.70	Discontinuous very soft black organic silty CLAY.
	5.70 - 6.00	Weak black SHALE.

Both in colour and consistency the underlying red clay/silty clay (Unit C) is a very different deposit. The upper boundary of the red clay is sharp; it does not appear to be weathered and hence is unlikely to have been a land surface for any length of time. The consistency of the upper clay and the very closely spaced discontinuities are typical of material which has been over-consolidated and then suffered stress relief. With depth the clay becomes more silty, with sand and some gravel at the base. Beneath the red clay is a thin silty fine sand horizon (Unit D). This is always present and shows a sharp colour and lithological boundary with the overlying clays. Underlying the fine sand is a coarse rounded gravel in a sandy matrix (Unit E). The clasts are generally oblate and of gravel to cobble size. Poorly developed imbricate structures were observed, indicating a depositional accretion towards the east. The gravels show evidence of pulse accumulation and are clearly framework dominated. The gravels overlie slates of the Codden Hill Chert Formation. Although the slates were weathered there was no indication of any bending of the slatey cleavage.

Between Chainages 11000 and 1100 the lower gravelly clay deposit (Unit B) was separated from the red clays by a major sand horizon up to 3m in thickness (Unit F). At least 70% and in places up to 91 % fine sand was present hence there was effectively no interparticle cohesion. Although such sand is similar to the modern basal estuarine deposits, in the Barnstaple situation no estuarine foraminiferids were recovered. Occasional thin black pebbly horizons interrupt the continuity of this sand deposit. Further to the east some sands and silts were observed as pockets and lenses in the Unit B material (Fig. 1).

For classification purposes particle size distribution analyses were undertaken and Atterberg limits determined on the matrix of each cohesive unit. Although there was a distinction in the field between the upper gravelly clay (Unit A) and Unit B, it is noted that two of the particle size distribution curves from Unit B (from 1.25 and 1.5m) are almost identical to that from Unit A. The third particle size distribution analysis of Unit B (from 1.75m) would be similar but for the presence of about 20% gravel (Fig. 2a). The grading of the thick sand body (Unit F) indicates it to consist mainly of silt and fine sand (Fig. 2b). This figure also includes three gradings from a sand pocket at Chainage 11160N. The non-cohesive nature of the main sand body was clearly displayed near the Lake Road bridge where seepage erosion produced a significant hollow in the cut face.

Table 3. Atterberg limits of various lithological units described in the text and plotted in Fig. 3.

Depth (m)	Description	Unit	WL	WP	IP
Chainage 11140 South					
			(%)	(%)	(%)
1.00	Yellow brown silty stoney CLAY	A	39	25	14
1.25			29	20	9
1.50	Pink brown stony CLAY	B	28	18	10
1.75			36	22	14
2.00			53	26	27
2.25			51	25	26
2.50			45	22	23
2.75	Purple brown CLAY	C	46	22	24
3.00			36	19	17
3.25			36	18	18
3.50			38	21	17
Chainage 11000 North					
0.75	Red CLAY	C	48	23	25
1.25			59	29	30
1.75			52	27	25
1.90			39	25	14
2.25			38	22	16
2.75			51	25	26
Chainage 11080 North					
0.5	Yellow brown stony CLAY	A	36	22	14
	SANDY BODY				
2.20			69	34	31
2.50	Red brown CLAY	C	59	28	31
2.70			55	20	25

The upper part of the red clays (Unit C) comprises up to 80% clay (0.004mm) with less than 5% sand. With depth, however, there is an increase in the proportion of sand and a corresponding decrease in the clay fraction to approximately 45%. This clear trend (Fig. 2c), noted from seven particle size analyses within a vertical height of 1.5m, implies a steady change in sedimentology. Rare fragments of lignitic wood were found within this deposit, consistent with accretion

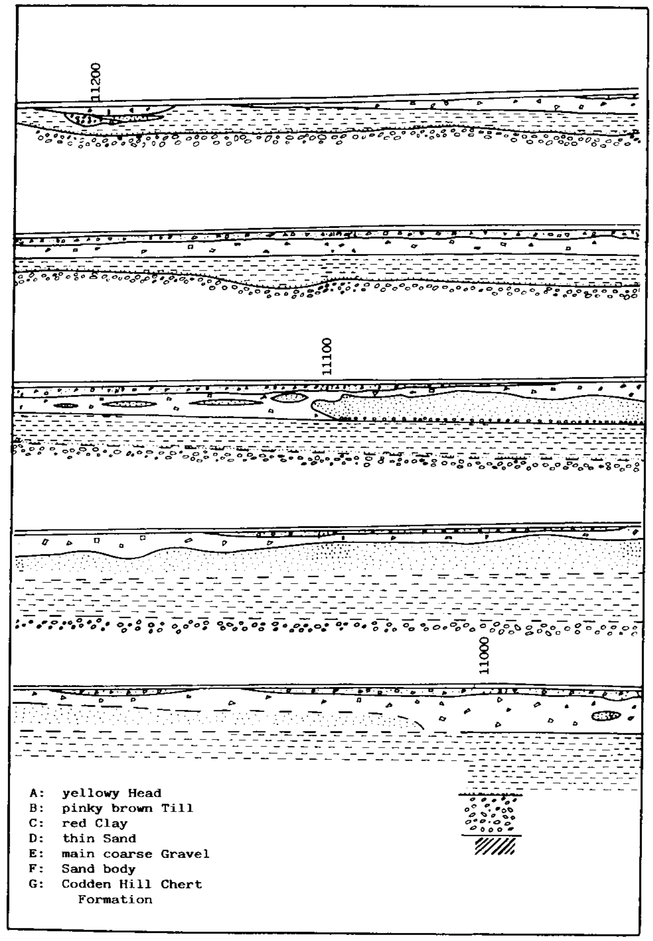


Figure 1. Section along south batter between Chainages 11000 and 11200.

within a lacustrine environment. The basal gravels (Unit E) have less than 10% fines and are generally medium and coarse (Fig. 2d). They are black manganese-stained and free-draining and are likely to be of glaciofluvial origin. Overlying the gravels the thin fine sand layer or coating follows the shape of the upper pebble surface.

The Atterberg limits at Ch 11140S (Fig. 3) show a clear separation between the upper two stony clays (Units A and B) and the red clay (Unit C). Within the red clay itself the Atterberg limits change with depth, consistent with the particle size distribution already noted.

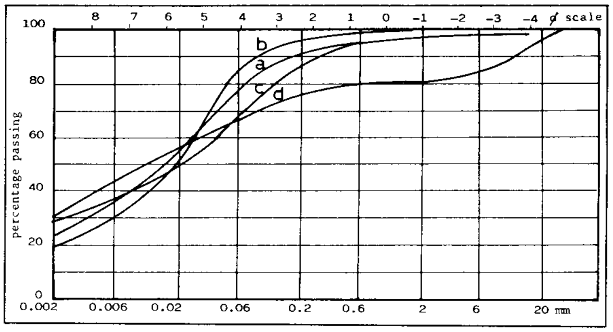
In conclusion, the glacial deposits exposed in the 9m deep Barnstaple Bypass have sedimentological characteristics which indicate the stratigraphic sequence from top to bottom to be: head - Unit A; till - Unit B; lacustrine clay - Unit C and glaciofluvial gravel - Unit E. The thin sand layer (Unit D) may have an aeolian origin. A thick sand body (Unit F), probably of glaciofluvial origin, is present for approximately 100m east of Lake Road. No evidence was seen to support the view that the basal gravels may have formed part of a raised beach. A clear upward fining of the red "pottery" clay (Unit C) is indicated by the classification tests.

Acknowledgements. The authors thank the MRM Partnership for access to the site. Marian Trott is thanked for help in preparing the paper.

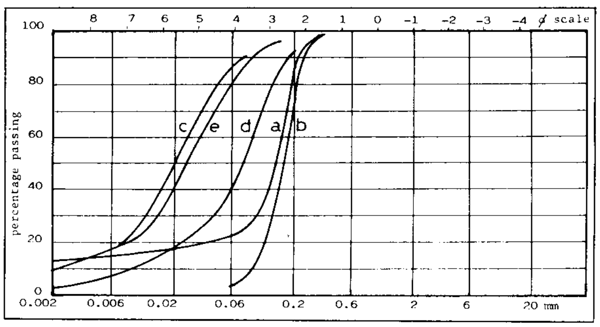
References

Andrews, J., Gilbertson, D.D. and Hawkins, A.B. 1984. The Pleistocene Succession of the Severn Estuary: A revised model based on Amino Acid Racemisation Studies. *Journal of the Geological Society, London, 141, 967*-974.

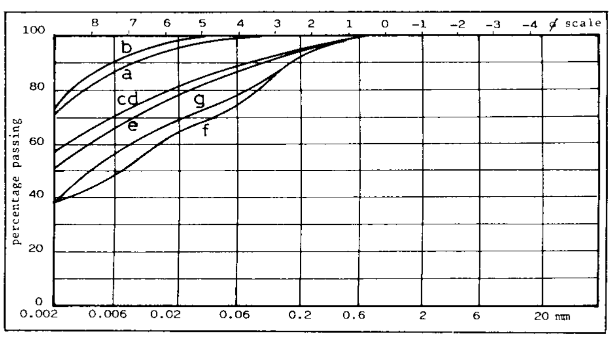
Edmonds, E.A. 1972. The Pleistocene history of the Barnstaple area. *Institute*



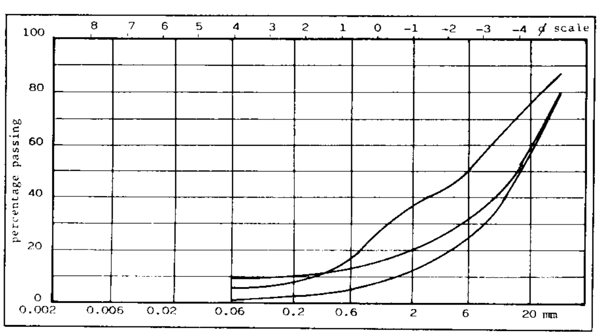
a) a-Unit A, 1.0m; b-Unit B, 1.25m Chainage 11140 S.
c-Unit B, 1.5m; d-Unit B, 1.75m Chainage 11140 S.



b) a-1.0m; b-1.5,; main sand body (Unit F) at Chainage 11080 N.
c-2.5m; d-2.8m; e-3.2m: sand/silt pocket at Chainage 11160 N.



c) Red clay samples at Chainage 11140 S
a - 2.0m; b 2.25m; c - 2.5m; d - 2.75m; e - 3.0m; f - 3.25m; g - 3.5m.



d) Gradings of main coarse gravel.

Figure 2. Particle size distributions.

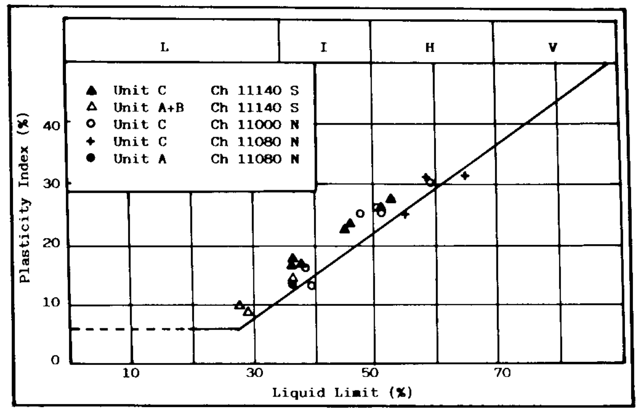


Figure 3. Casagrande Plasticity Chart for Units A, B and C,

of Geological Sciences Report 72/2.

Edmonds, E.A., Whittaker, A. and Williams, B.J. 1985. Geology of the country around Ilfracombe and Barnstaple. *Memoir of the British Geological Survey.*

Gilbertson, D.D. and Hawkins, A.B. 1978. The Pleistocene succession at Kenn, Somerset. *Bulletin of the Geological Survey of Great Britain, 66,* 141.

Hawkins, A.B, and Kellaway, G. 1971. Field Meeting at Bristol and Bath. New Evidence for Glaciation. *Proceedings of the Geologists' Association, 82,* 267-292.

Kidson, C. and Wood, T.R. 1974. The Pleistocene stratigraphy of Barnstaple *Bay. Proceedings of the Geologists' Association, 85,* 223-237.

Maw, G. 1864. On a supposed boulder clay in North Devon. Quarterly *Journal of the Geological Society, London, 20,* 445-451.

Stephens, N. 1966. Some Pleistocene deposits in north Devon. *Biuletyn Periglacjalny, 8,* 103-114.