Proc. Univ. Bristol Spelaeol. Soc., 1983, **16** (3), 175-184

PERIGLACIAL SLOPE DEPOSITS AND FROST STRUCTURES ALONG THE SOUTHERN MARGINS OF THE SEVERN ESTUARY

by

D. D. GILBERTSON and A. B. HAWKINS

ABSTRACT

Four temporary exposures at Clapton Nurseries, Wynhol Valley, Clevedon Court and Tickenham Waterworks and the M5 Avonmouth Bridge are described. Several types of periglacial phenomena were noted, including frost shattered and soliflucted limestone breccias, soliflucted Mercia Mudstone, ice wedge casts, involutions, widened rock joints and aeolian coversand deposits. The stratigraphic significance of the sequences is discussed and it is concluded that there is evidence mainly from the Devensian and possibly from the Wolstonian stages of the Pleistocene.

INTRODUCTION

The periglacial slope deposits developed on the Carboniferous Limestone and Mercia Mudstone (formerly called Keuper Marl) of the Bristol District exhibit a very marked stratification, unlike many of the other periglacial slope deposits in the West Country. The best known stratified periglacial sequences in the Bristol region are at Sand Cliff, Brean Down (Apsimon, Donovan, and Taylor, 1961), and at Holly Lane, Clevedon (Gilbertson and Hawkins, 1974), Fig. 46. Here frost shattered angular breccias dominated by Carboniferous Limestone alternate with layers of red-brown silty sands.

The Devensian cold stage is well represented by stratified deposits in the cave sequence at Wookey Hole, described by Tratman, Donovan and Campbell (1971). Evidence of other periglacial processes, such as extensive slope wash activity or of ice wedge growth, are not recorded in the cave sequences. Consequently in the absence of suitable biogenic deposits of appropriate age, one of the best opportunities for refining our current very inadequate knowledge of the periglacial history of the Bristol area must lie in developing an understanding of the many other stratified periglacial slope deposits which are now known to exist on slopes adjacent to the Carboniferous Limestone.

These deposits have been studied since the nineteenth century when Day (1866) and Prestwich (1892) described the angular rubble drifts or limestone breccias which mantle the hillslopes. Further accounts were given by Palmer (1931, 1934), Vink (1949), Kellaway and Welch (1948), Findlay (1965), Hawkins and Kellaway (1971) and Gilbertson and Hawkins (1974).

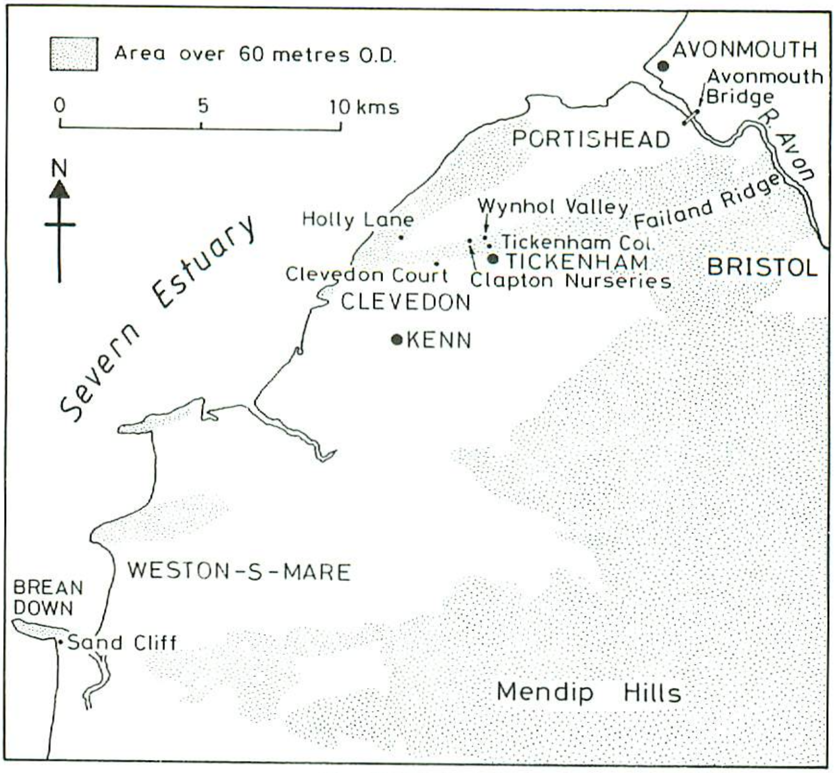

Fig. 46. Location Map

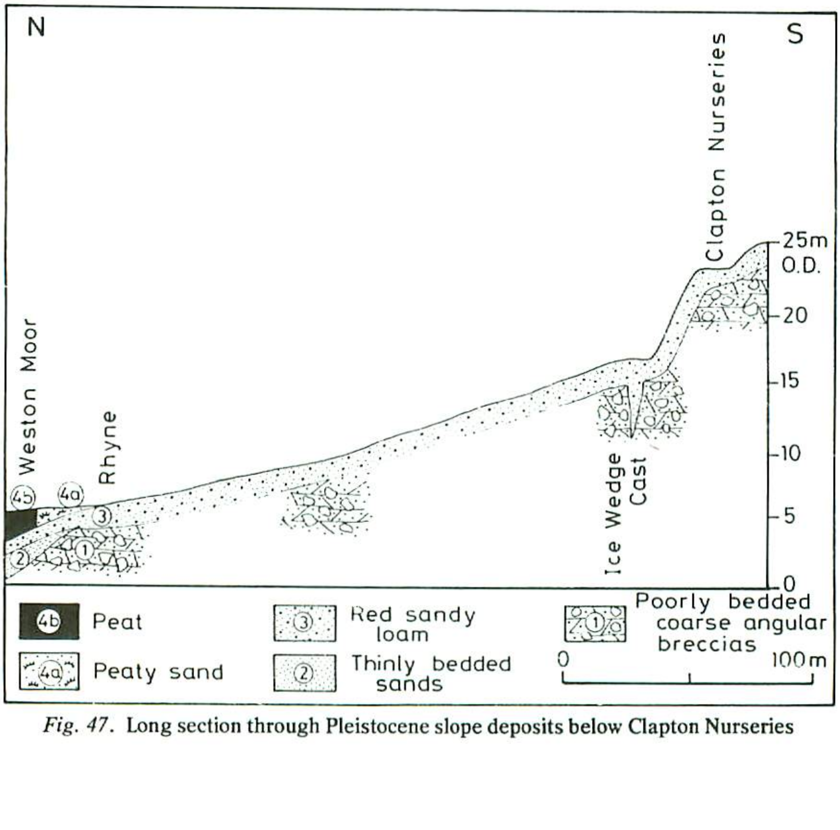

Fig. 47. Long section through Pleistocene slope deposits below Clapton Nurseries

Periglacial coversands were originally described from the area by Vink (1949) and subsequently over an extensive area by Findlay (1965), and Gilbertson and Hawkins (1974, 1978). Comparisons of textural properties and stratification with Tricart's (1970) observations in Antarctica suggest some of these local deposits are niveo-aeolian coversands.

NEW EXPOSURES

a) Clapton Nurseries ST 450.729

A long section drawn from exposures in trial pits and a drainage channel, downslope from the Nurseries, is shown in Fig. 47. The primary aeolian origin of the red sandy loam (Unit 3) is evidenced by its widespread distribution and uniform thickness. It appears to be identical with the red loams at Holly Lane, Clevedon (Fig. 46), where the loams are texturally identified as periglacial coversands (Vink, 1949; Gilbertson and Hawkins, 1974). At Clapton the loam passes under the Flandrian fen peats described by Jeffries, Willis and Yemm (1968). Further indication of the periglacial origin of the loam is given by the observation that it fills a substantial ice wedge cast. This cast penetrates into the underlying angular limestone breccias (Unit 1). A brief phase of reworking by running water is indicated by the presence of the thinly bedded sands (Unit 2) at the base of the aeolian loams adjacent to Weston Moor.

The angular nature and shallow downslope bedding of the limestone breccias (Unit 1) which have been derived from the Carboniferous Limestone ridge to the south can be interpreted as evidence of periglacial freeze-thaw activity, sheetwash and downslope mass-movement (see Gilbertson and Hawkins, 1974, p. 353, 354). These breccias have a red loam matrix. While this matrix may be partly a later infiltration deposit, its presence throughout the sequence suggests continuous aeolian deposition of silts and fine sands during the period characterised by breccia formation.

The large epigenetic ice wedge cast suggests the sequence contains an important time break of unknown dimensions. There is, however, no reason to believe the sequence represents other than the Devensian (last) cold stage of the Pleistocene.

b) Wynhol Valley ST 449.728

Details of the stratigraphy of the site are illustrated in Fig. 48. In the sides of excavations for the M5 Motorway bridge piers a poorly bedded, angular limestone breccia (Unit 3) was seen resting on Carboniferous Limestone (Unit 1).

Examination of the open joints in the Carboniferous Limestone indicates by their fresh, parallel yet irregular nature that their open state is not the result of solution but is more likely to have occurred due to the sides being forced apart by frost action. Such an open feature has been illustrated by Eyre (1973). Gaps in the rock, up to 0.65 m. across, have been seen. These are infilled with red loamy sands (Unit 2). These openings are identical with those elsewhere in the region on Carboniferous Limestone and Mercia Mudstone surfaces. Overlying the breccias are thinly bedded, better sorted sands with occasional cobbles and boulders (Unit 4) which suggest a period of reworking by sheetwash of the upslope sandy deposits. The distinction between the bedded sands of Unit 4, and the later non-bedded aeolian sands (Unit 5) was very clear in the exposure. Similar periglacial loam-rich drift occurs in the Tickenham Col (Fig. 46; Hawkins, 1972). Gilbertson and Hawkins (1975) discussed whether the degraded sand pits present in the Tickenham Col seen in 1970 were the result of sand quarrying for the Nailsea Glassworks. Clasts of Carboniferous Limestone up to boulder size occur throughout while a small grey pebble probably of Jurassic limestone was found in Unit 4. Such a clast may have been derived from glacial deposits up-valley in the Tickenham Col (Hawkins, 1972).

c) Clevedon Court and Tickenham Waterworks ST 426.714

Excavations for a Motorway maintenance depot and a road diversion provided deep, long sections through thick slope deposits (Fig. 49). A composite section is:

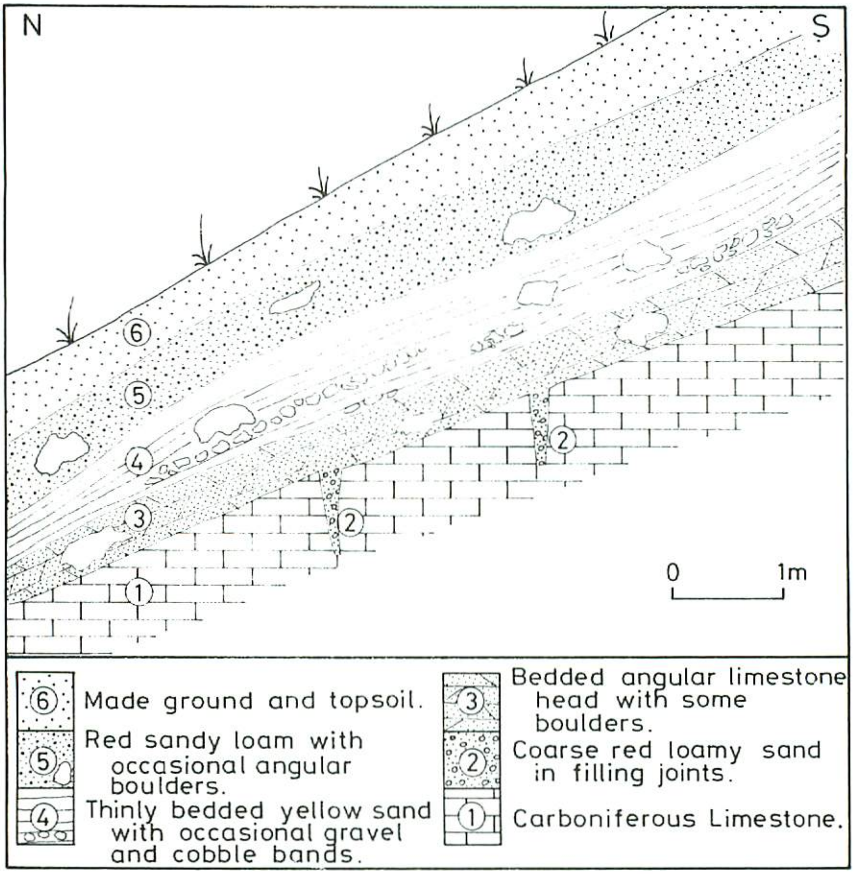

Fig. 48. **Temporary exposure of periglacial deposits in the Wynhol Valley**

UNIT	THICKNESS	DESCRIPTION
B	0.3 m.	Red-brown, thinly bedded sands; hillwash deposits.
A	1.2 m.	Non-bedded, red loamy sand, affected by frost heaving.
6a	2.0 m.	Bedded, fine yellow quartz sand, in layers up to 0.05 m. in thickness. Within this unit are
6b		Darker, black stained sandy horizons up to 0.4 m. thick.
5	0.5 m.	Poorly bedded, coarse gravel, involuted downwards into
4	0.5 m.	Coarse non-bedded, red-brown loamy sand.
3	0.1 m.	Coarse, cobbly gravel.
2	0.6 m.	Stiff, red sandy silts; soliflucted Mercia Mudstone.
1	—	Stiff, red Mercia Mudstone, *in situ*.

The drift deposits rest on the Mercia Mudstone which here overlies the Dolomitic Conglomerate and Carboniferous Limestone of the Failand Ridge. The soliflucted stiff, red silts (Unit 2) are readily distinguished from the underlying Mercia Mudstone. The cobbly gravels (Unit 3) are similarly solifluction deposits which might be derived from either the glacial deposits or the Dolomitic Conglomerate which occurs upslope, described by Hawkins and Kellaway (1971). The red-brown loam of Unit 4 is similar to the aeolian sandy loams which are widespread in the region (Findlay, 1965, Gilbertson and Hawkins, 1974). Its deposition was followed by the introduction of more gravels (Unit 5) either by solifluction or sheetwash, before the sequence was further disturbed by frost heaving (see Fig. 49). The bedded layers of fine, yellow sand (Unit 6a) suggest transportation and re-deposition by slopewash processes. The bedded sands may represent loamy aeolian deposits from which the fine fraction has been removed by the process of sheetwash. Alternatively, the sands may have been derived from the glaciogenic deposits found in the Court Hill Col (Gilbertson and Hawkins, 1978). Unit 6b indicates darker horizons which may represent incipient soil profiles truncated by later depositional processes, or represent localised manganese staining related to ground water levels.

The stratigraphic relationships of the uppermost deposits in Fig. 49B are difficult to correlate and interpret due to agricultural interference and the spatial separation of the exposures. The motorway side trenches above the main exposures (Fig. 49B) show that the uppermost coversands (Unit A) have been involuted into the Mercia Mudstone which is seen to act as a series of upstanding 'pillars'. Overlying the coversands the ground appears disturbed and represents a Hillwash (B) rather than a direct *in situ* soil profile.

The probable order of periglacial events was:

9 Topsoil development
8 Hillwash
7 Involution of coversand into the Mercia Mudstone on the hillslopes
6 Coversand deposition
5 Sheetwash of main sandy deposits
4 Sheetwash of gravel and involution of the 5/4 boundary
3 Aeolian deposition of coversand-like material
2 Solifluction of gravels and cobbles
1 Solifluction of Mercia Mudstone-like deposits
Erosion of Mercia Mudstone land surface.

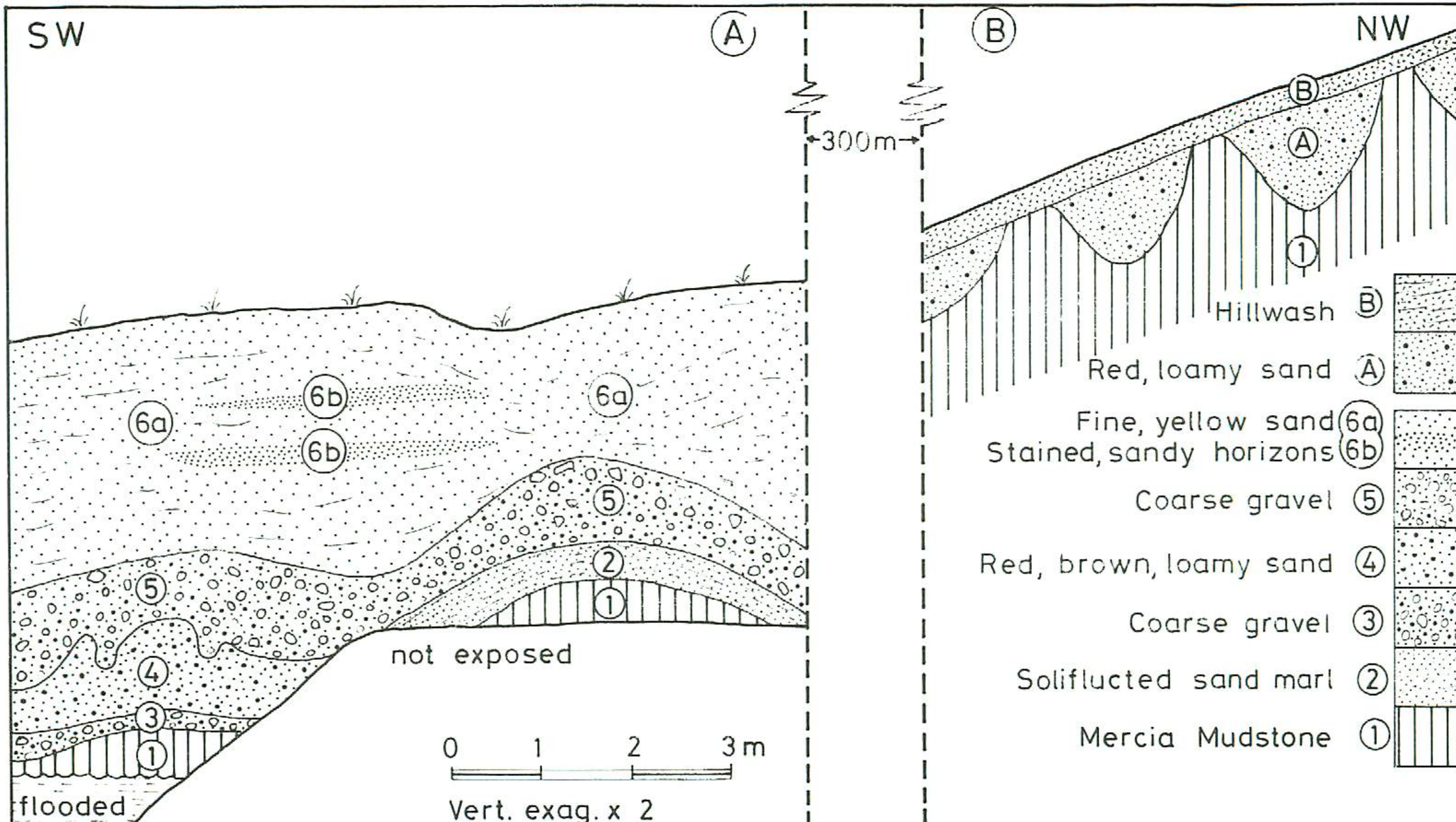

Fig. 49. Temporary exposures of periglacial slope deposits and frost structures at Clevedon Court, Motorway Service Area.

With the exception of the *in situ* Mercia Mudstone and the uppermost Hillwash, the entire sequence of aeolian and slopewash deposits provides evidence of cold, open, relatively vegetation-free environments. The involutions suggest the environment was either continuous or discontinuous permafrost; note Kerney (1963) has shown that discontinuous permafrost is sufficient for their formation.

d) Avonmouth M5 Bridge Foundations ST 523.774

During the construction of the M5 motorway bridge at Avonmouth three ice wedge casts were noted under 2 m. of grey Flandrian silts. These penetrated *in situ* Mercia Mudstone. In the excavations for Pier 15W the ice wedge measured 1 m. in width at the top and was at least 2 m. deep, continuing to an unknown depth beneath the floor of the pier excavation. The contact between the drift and the Mercia Mudstone was irregular with clay bound gravel up to 0.5 m. into what would otherwise have appeared undisturbed Mudstone. It is believed the gravels in a sandy clay matrix are the remnants of a till deposit which has been found elsewhere in the Avonmouth area. The gravels contained Carboniferous Limestone, Coal Measure Sandstone, Old Red Sandstone, flint, chert, and quartz pebbles. The ice wedge contained a filling of gravel and was overlain by loamy coversand. Roots of a Flandrian tree cover had grown into the infill and the Mercia Mudstone alike.

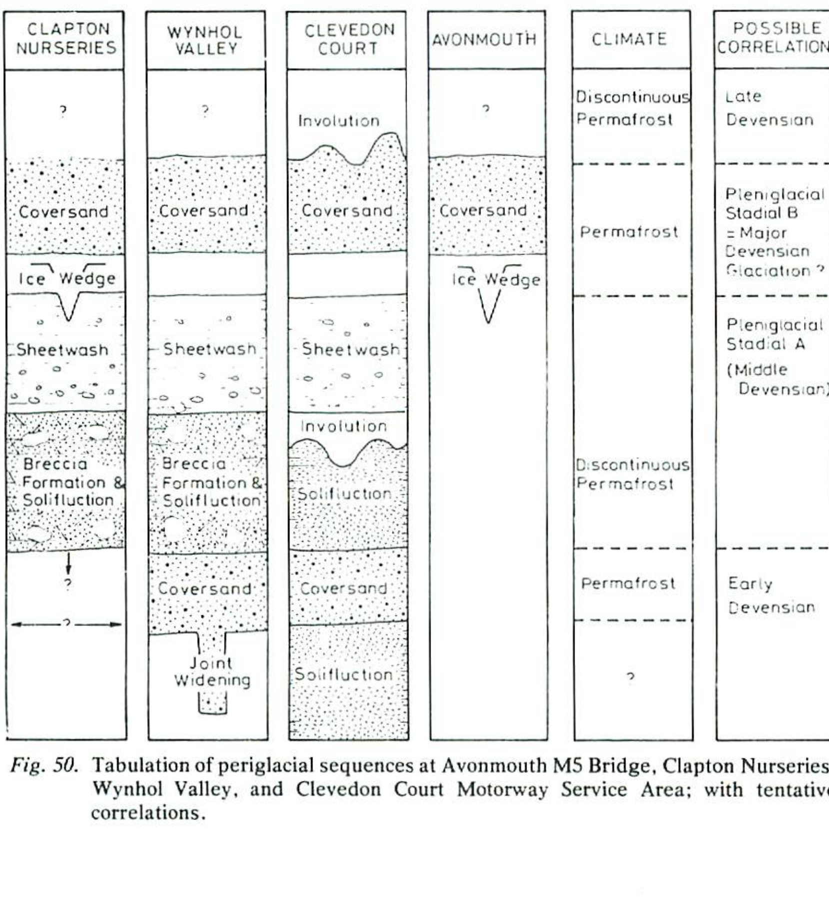

Fig. 50. Tabulation of periglacial sequences at Avonmouth M5 Bridge, Clapton Nurseries, Wynhol Valley, and Clevedon Court Motorway Service Area; with tentative correlations.

Ice wedge growth is usually taken as evidence of the former presence of continuous permafrost. Péwé's (1966) studies of ice wedge growth in Alaska suggest that mean annual temperatures as low as -6 to -8°C are necessary for ice wedge formation. In Fig. 50 the ice wedge is shown as preceding the upper coversand. The wedge may however be much older as the glacial deposits are now considered to be older than Wolstonian (Andrews, Gilbertson and Hawkins, in prep.).

DISCUSSION

With the possible exception of Avonmouth, no evidence has been found to suggest that the deposits and frost structures described belong to any stage earlier than the Devensian (last) cold stage of the Pleistocene. Although there are clear indications of important time breaks in the sequences, deposits and features specifically associated with the milder interstadial periods have yet to be located. It is clear, however, that the nature of the geomorphic processes operating at any locality have changed rapidly on a number of occasions.

Areas underlain by, or close to, Carboniferous Limestone were characterised by the deposition of coarse, poorly sorted limestone breccias. These deposits are common in the lower parts of the Clapton Nurseries and Wynhol sequences, and point to the efficacy of frost action on (presumably) frequently exposed limestone surfaces. Their less common abundance in the upper layers of these sequences parallels the observations at Holly Lane (Gilbertson and Hawkins, 1974). This suggests a change towards a climatic regime favouring more extensive sheetwash, increased aeolian deposition, and a major stage of ice wedge development. These features could be explained in terms of a much colder climate, favouring more extensive freezing of the soil, resulting in decreased infiltration rates yet still facilitating surface water movement.

It is clear from the identification of the two widely separated ice wedge casts, one of which—Clapton Nurseries—was in very coarse sediments, that this region was subject to well developed, intense permafrost, confirming the findings at nearby Kenn (Gilbertson and Hawkins, 1978). The involutions towards the top and bottom of the Clevedon Court sequence show that at least discontinuous permafrost was present at both the beginning and end of the period over which the deposits accumulated.

Detailed correlation between the periglacial sequences or with sequences elsewhere is premature, but a general comparison of the sequences described reveals a degree of parallelism (Fig. 50).

A similar sequence of coversands overlying sandy slope wash deposits and in turn poorly sorted limestone breccias, is repeated at Clapton Nurseries and in the Wynhol Valley. Additionally, Clapton Nurseries have evidence of severe periglacial conditions, in the form of ice wedge casts, between the coversands and the slope wash deposits. There is some parallelism with the Clevedon Court exposures. If it is hypothesised that extensive slope wash activity, the development of involutions and solifluction on the Mercia Mudstone were the counterpart of the extensive formation of poorly bedded breccia on the lower slopes around the Carboniferous Limestone ridges, then a further degree of similarity can be seen between sites. Both the Clevedon Court and Wynhol sites show evidence of distinct periods of predominant coversand deposition in the earlier Devensian; a feature also noted at Holly Lane (Gilbertson and Hawkins, 1974) and Wookey Hole (Tratman, Donovan and Campbell, 1971).

Further detailed correlation between sequences is premature. However, it is pertinent to note a similarity between that described here, the inferred climatic sequence of Kerney's studies in east Kent (Kerney, 1965), and the Pleniglacial stratigraphy of the Low Countries (Hammen, Maarleveld, Vogel and Zagwijn, 1967). The most recent phase of periglacial activity in Kent involved cold and wet conditions associated with the development of involutions. This may equate with the final stage of involutions at Clevedon Court.

The preceding phase of activity in the study area is dominated by widespread coversand deposition and the development of ice wedges. This occurred at nearby Kenn (Gilbertson and Hawkins, 1978), East Kent (Kerney, 1965) and may be contemporaneous with the maximum extent of the Devensian glaciation of South Wales, which Bowen (1970) indicates reached as close as Newport.

The dangers of such lithostratigraphic correlations are well known and further development requires testing against more periglacial sequences to be found in the future.

CONCLUSIONS

The Devensian cold stage was evidenced along the southern margin of the Severn Estuary between Avonmouth and Clevedon by the accumulation of slope deposits whose marked stratification may reflect a series of climatic fluctuations. The area appears to have been sequentially affected by a series of environmental changes:

1) a complex period of cold-wet conditions with interruptions of colder-drier conditions leading to solifluction, breccia formation, involution development and slope wash;
2) a period of extreme cold, possibly much drier conditions associated with ice wedge growth followed by the widespread deposition of coversand;
3) a final phase of involution development and aeolian deposition.

Precise correlation further afield is premature, but certain similarities with other periglacial sequences nearby and in south-east England are noted.

ACKNOWLEDGEMENTS

The authors wish to acknowledge financial assistance from a Natural Environment Research Council grant and from the Universities of Bristol and Sheffield towards the cost of this continuing research programme.

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D. D. Gilbertson
Department of Prehistory & Archaeology
University of Sheffield
Sheffield S10 2TN

A. B. Hawkins
Department of Geology
University of Bristol
Bristol BS8 1TR