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Introductory Remarks

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Introductory remarks

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The papers presented at this meeting have two essential features in common. (i) They are based on detailed subsurface investigations of slopes, using boreholes, trial pits or sections; (ii) the stages of development of the slopes or, more generally, of the valleys or escarpments, have been correlated so far as possible with Quaternary history. In addition, some unity derives from the facts (iii) that the slopes are all in clay strata (Jurassic, Cretaceous or Eocene), whether or not there is a capping of rock; and (iv) the sites all lie outside the ice limits of the Last (Devensian) Glaciation.

The inland sites have therefore been subjected to a complex cycle of climatic changes, including the rigour of one or more glacial periods; and it is evident that no attempt to elucidate the history and mechanics of these slopes, without taking the climatic factors into account, can have any hope of success.

Subsurface investigations constitute a relatively recent phase in the study of natural slopes in England. Apart from exploration by shallow pits, to discover the nature of the regolith and solifluction deposits (see, for example, Ollier & Thomasson 1957; Small, Clark & Lewin 1970) work in this field can be grouped under three main headings:

(*a*) Investigations of subsurface structures and deposits coupled with soil mechanics tests and stability calculations; but without more than a general dating of the slope development. The pioneer example in this category seems to have been the investigation of Walton's Wood landslide, on the M 6 motorway in Staffordshire, carried out (1962–3) chiefly through the initiative of Mr R. Glossop (Early & Skempton 1972). Other examples include the work by Carson & Petley (1970) on valley slopes in Exmoor and the southern Pennines, and by Hutchinson, Somerville & Petley (1973) on a landslide at Bury Hill near Wolverhampton.

(*b*) Investigations which involve work specifically to date the slope development. An early attempt to introduce a time-scale into the study of slopes in a valley eroded in Devensian boulder clay in County Durham was described by Skempton (1953). But the first dating of subsurface slope deposits, by radiocarbon assay and by fauna, appears in a paper by Kerney (1963) on the lower slopes of the North Downs in Kent. This was followed by similar investigations on the Chalk escarpment near Brook, also in Kent (Kerney, Brown & Chandler 1964). Work on the escarpment south of Sevenoaks, mostly carried out in the years 1965–6, resulted in the dating of solifluction deposts. The Sevenoaks research was briefly reported by Skempton & Petley (1967) and by Weeks (1969), and is fully described in Skempton & Weeks in this volume. There is of course a considerable literature dealing with landslides which have occurred in historic times, but Johnson (1965) has presented one of the very few examples where an early Postglacial landslide has been dated, within reasonably close limits, by an appeal to geological and palaeobotanical evidence. An intensive examination of the slopes of the Jurassic escarpment near Rockingham (Chandler 1971) includes soil mechanics investigations and dating. So also do the papers by Chandler, by Chandler *et al.* and by Hutchinson & Gostelow in this volume.

The first of these, on the Hambleton slopes, is the result of work started in 1972; slope investigations in the Bath area began in 1970; while the research at Hadleigh followed Dr Hutchinson's pioneer study on the degradation of London Clay slopes (1967). This was based chiefly on historical evidence, and in a similar manner Brunsden & Kessel (1973) have been able to construct a time-scale for the slope development of a Mississippi River bluff.

(*c*) Systematic geological observations on cambering and valley bulging, in Northamptonshire, were first published in the classic paper by Hollingworth, Taylor & Kellaway (1944). Since that time these remarkable phenomena have been recognized and described from many other parts of England, notably in South Yorkshire (Shotton & Wilcockson 1951), in the Weald (Worssam 1963) and in Gloucestershire (Ackermann & Cave 1967), and also in Czechoslovakia (Zaruba & Mencl 1969) and Canada (Straw 1966). But they have not previously been described with the detail and precision characterizing investigations at the site of Empingham reservoir, which started in 1970 and are reported here by Horswill & Horton.

The mechanics of cambering and valley bulging, though frequently a subject for discussion and speculation, has not been quantitatively considered until Dr Vaughan's contribution, which appears as an appendix to Horswill & Horton's paper. Another controversial topic is the mechanics of periglacial solifluction; a process by which material can be moved for long distances down slopes inclined at angles as low as 1 or 2°. Here the thaw-consolidation theory of Morgenstern & Nixon (1971) shows promise of providing the basis for a solution to this problem, as demonstrated in the paper by Skempton & Weeks (see also McRoberts & Morgenstern 1974), and another illuminating analysis has recently been presented by Hutchinson (1974). Finally it may be noted that a rational explanation in soil mechanics terms is available (Skempton 1964) for the now well established observations that the limiting angles for stable natural slopes in London Clay and Lias Clay, under modern climatic conditions, are typically around 8–11° (Skempton & DeLory 1957; Hutchinson 1967; Chandler 1970); and a similar type of analysis can be applied to the Exmoor and Pennine slopes examined by Carson & Petley (1970). But clearly some other factors must have been involved in the mechanics of 'fossil' cambered slopes, such as those at Empingham (Horswill & Horton's paper), which are inclined at an almost constant angle of slightly less than 4° for several hundreds of metres.

In conclusion: when studying a valley or escarpment or a cliff the questions arise (i) what structures and deposits exist below the surface, (ii) what is the relation between slope form and subsurface deposits, (iii) over what period of time has the slope developed, and (iv) can the mechanics of the processes involved in this development by explained? To answer these questions the disciplines of geology, soil mechanics and geomorphology have to be invoked. The results of such interdisciplinary studies are recorded in the following papers.

Note on Quaternary stages

Quaternary correlations adopted by the authors are essentially as set out in Special Report No. 4, published by the Geological Society (Mitchell, Penny, Shotton & West 1973), and the various stages relevant in the present context are summarized for convenience in table 1. There is evidence that the duration of the Hoxnian Interglacial was of the order 30000–50000 years (Turner 1970). Evans (1971) and Shackleton & Opdyke (1973) suggest, respectively, that this stage ended 200000 or 300000 years ago. Dates given in table 1 for the beginning and end of the Last Interglacial, in the broad sense, are taken from oxygen isotope stratigraphy of ocean-bed cores and radiometric dating of coral reefs (Broecker & van Donk 1970). Dates for the Middle Devensian correspond to the limits of the Upton Warren interstadial Complex (Coope 1975). Following the Late Devensian glacial phase, more temperate climatic conditions prevailed from about 13000 radiocarbon years B.P. until the brief but important return of cold conditions in pollen Zone III just after 11000 B.P. This more temperate phase, the 'Late-glacial Interstadial' of Coope (1975), includes the Allerød (Zone II) and Bølling (Zone Ib) subdivisions (Pennington 1975). It is of particular significance in the study of slopes, as radiocarbon dates ranging from 12600 to 10900 (concentrating around 12000 B.P.) have now been obtained on organic material and fossil soils, buried under landslide or periglacial slope deposits, from eight different localities in England including sites in Wiltshire, Kent, Rutland and West Yorkshire. The end of Zone III, well defined at about 10000 B.P., also marks the beginning of the present temperate period.

Table 1

stage			date (years B.P.)
Flandrian (Postglacial)			
			10000
Devensian (Last Glaciation)	Late	Zone III	
			10800
		L-g Inst.	
			13000
			25000
	Middle		
			45000
	Early		
			80000
Ipswichian (Last Interglacial)			
			125000
Wolstonian			
			200000 or earlier
Hoxnian Interglacial			
Anglian			

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