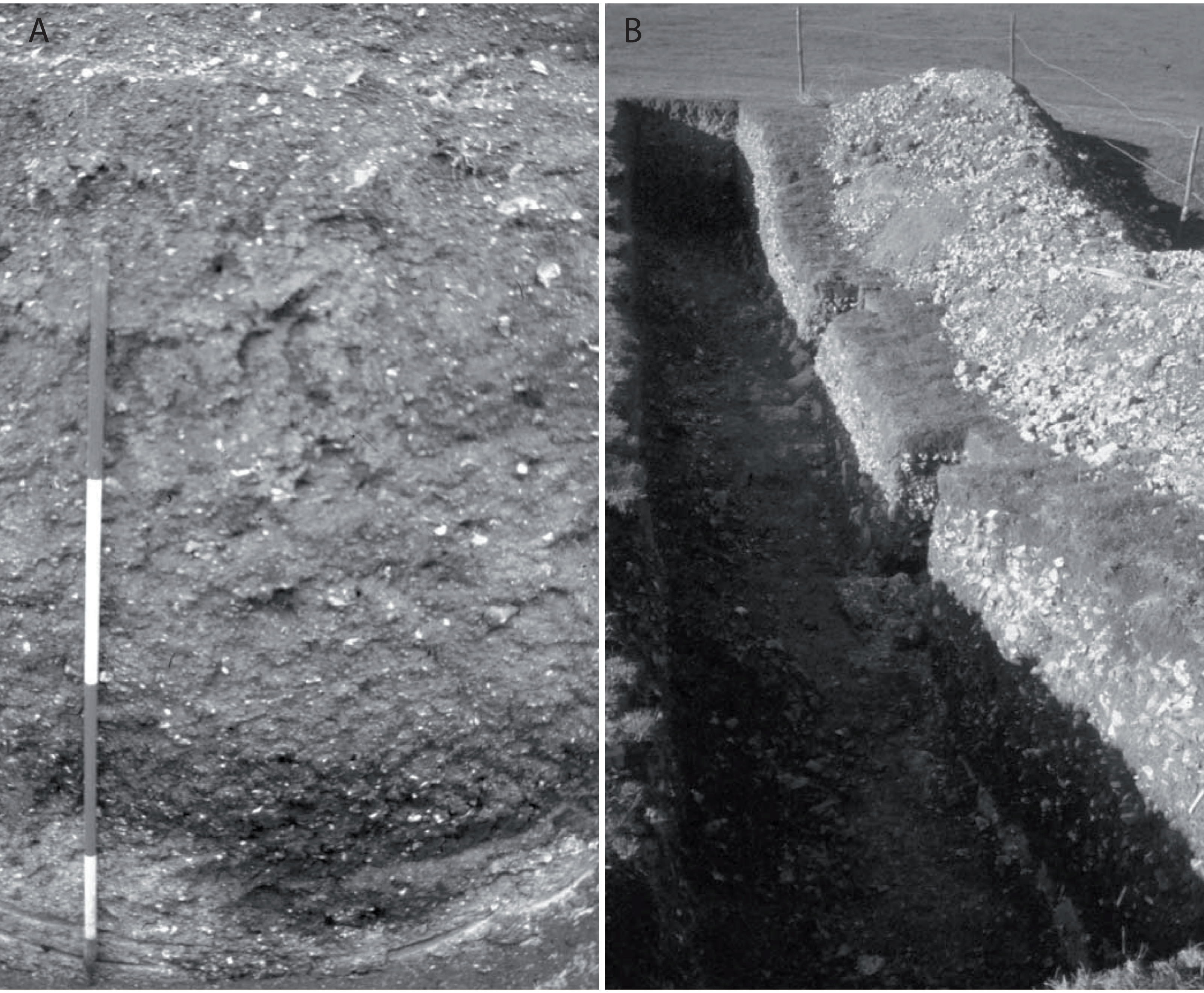
RESEARCH DEPARTMENT REPORT SERIES no. 3-2009 ISSN 1749-8775

SOUTHERN REGIONAL REVIEW OF GEOARCHAEOLOGY COLLUVIUM

Keith Wilkinson



ARCHAEOLOGICAL SCIENCE

ENGLISH HERITAGE

Research Department Report 003/2009

Regional Review of Geoarchaeology in the Southern Region: Colluvium

Keith Wilkinson

ISSN 1749-8775

The Research Department Report Series, incorporates reports from all the specialist teams within the English Heritage Research Department: Archaeological Science; Archaeological Archives; Historic Interiors Research and Conservation; Archaeological Projects; Aerial Survey and Investigation; Archaeological Survey and Investigation; Architectural Investigation; Imaging, Graphics and Survey, and the Survey of London. It replaces the former Centre for Archaeology Reports Series and the Archaeological Investigation Report Series.

Many of these are interim reports which make available the results of specialist investigations in advance of full publication. They are not usually subject to external refereeing, and their conclusions may sometimes have to be modified in the light of information not available at the time of the investigation. Where no final project report is available, readers are advised to consult the author before citing these reports in any publication. Opinions expressed in Research Department reports are those of the author(s) and are not necessarily those of English Heritage.

Requests for further hard copies, after the initial print run, can be made by emailing: Res.reports@english-heritage.org.uk.
or by writing to English Heritage, Fort Cumberland, Fort Cumberland Road, Eastney, Portsmouth PO4 9LD
Please note that a charge will be made to cover printing and postage.

Research Department Report 003/2009

REVIEW OF GEOARCHAEOLOGY IN THE SOUTHERN REGION: COLLUVIUM

Keith Wilkinson

Summary

Colluvium is the sedimentary product that results from Newtonian transport of weathered soil, sediment and rock. If small-scale archaeological features such as pits, ditches and post holes are excluded, colluvial sediments in southern England are most commonly found within dry valleys and solution features such as dolines, and behind lynchets and other field boundaries. The first two of these have been investigated by physical geographers and all three have been studied by archaeologists since the 1960s. Although dry valley colluvium was originally interpreted as a sediment resulting from supposedly adverse climates of the Middle and Late Holocene (e.g. Sparks and Lewis 1957), the consensus since 1980 is that such deposits are the result of human manipulation of the landscape (e.g. Bell 1982). Consequently there is a strong link between the human past and the colluvial stratigraphic record. Previous reviews commissioned by English Heritage (i.e. Bell et al 1984; Macphail 1987) have examined archaeological studies of colluvium that were published before 1982. The present text reviews archaeological and physical geographic work undertaken in southern England since that date. However, in addition to simply reviewing the literature relating to sites where colluvial stratigraphy has been investigated, this document also discusses the sedimentary properties of colluvium, formation and modification processes that impact the colluvial record and the biological proxies that are commonly associated with colluvial sequences. The final section provides a chronological summary of patterns of colluvial deposition within dry valleys in southern England for the Middle and Late Holocene.

Keywords
Geoarchaeology
Soil/Sediment
Environmental Studies
Radiocarbon Dating.

Author's address
Department of Archaeology, University of Winchester, Winchester, SO22 4NR

CONTENTS

1. INTRODUCTION

In the previous review of environmental archaeology in England (Keeley 1984, 1987), colluvium is briefly discussed under heading 'Soil science in archaeology' by Macphail (1987, 338-344) and by Bell *et al* (1984, 84) in relation to the environmental archaeology of South-west England. The lack of space given to the topic in the early 1980s is perhaps of no great surprise given that few archaeological studies of colluvium had been *published* before the April 1982 deadline for text submission for both review chapters (Bell *et al* 1984, 107). Indeed Macphail's (1987) account of the archaeological study of colluvium was of necessity largely based on Martin Bell's study of three dry valleys in Sussex and Hampshire included in his then unpublished PhD thesis (Bell 1981b). The years since 1982 have seen an initial florescence and then a decline in the archaeological study of colluvium in southern England[1]. This report reviews developments in the study of colluvium during this time and it therefore concentrates mainly on those studies published since 1982. Nevertheless, in order to provide a coherent background, key projects undertaken in the 1960 and 1970s are also discussed. As well as providing an account of the archaeological conclusions reached as a result of the more influential studies of colluvium in southern England, the chapter also discusses colluvium as a geomorphological phenomenon and the methods that have been developed to extract archaeologically relevant information from colluvial deposits.

^{14}C dates cited in the text have been recalibrated from raw data used in the original publications and unpublished reports/theses using the IntCal04 curve (Reimer *et al* 2004) and OxCal 3.10 software (Bronk Ramsey 2005). All quoted calibrations are at two standard deviations (95.4% probability).

1.1 Colluvium

'Colluvium' is defined geologically as sediment that is 'eroded, transported, and deposited on and at the base of slopes by gravity' (Waters 1992, 232). Colluvial sediments are almost universally poorly sorted, albeit that they can range in calibre from boulders deposited by cliff collapse to clay-sized particles deposited as a result of low-energy overland flow. According to Waters (1992, 230-232) colluvium forms as a result of five different processes (see also Figure 1):

Falls	resulting from collapse of a cliff with rock debris forming a talus cone or scree at the base of a slope;
Slides	where rock and other debris is moved along a bedding plane or fault leaving a scar on the slope;
Slumps	are closely related to falls and occur when a block of sediment moves en masse along a curved trajectory producing a concave trajectory;
Flows	are formed by the movement downslope of water-saturated sediment producing mudflow and debris flows;

[1] Although this account is written on the basis of evidence from English Heritage's Southern region (a combination of the South-west and South-East regions), it is in effect a review of the archaeology of colluvium in England as a whole, given that very limited archaeological work has been undertaken of colluvial deposits in other areas of the country [exceptions are Hertfordshire (Waton 1982a) and the Yorkshire Wolds (The Wolds Research Project 2004)].

Creep occurs by the downhill movement of soil particles in the upper meter of the profile as a result of rainsplash, rolling, bioturbation, cryoturbation, argilliturbation and ploughing. Unlike the first four processes, creep occurs over timescales measured in months and years rather than minutes to days.

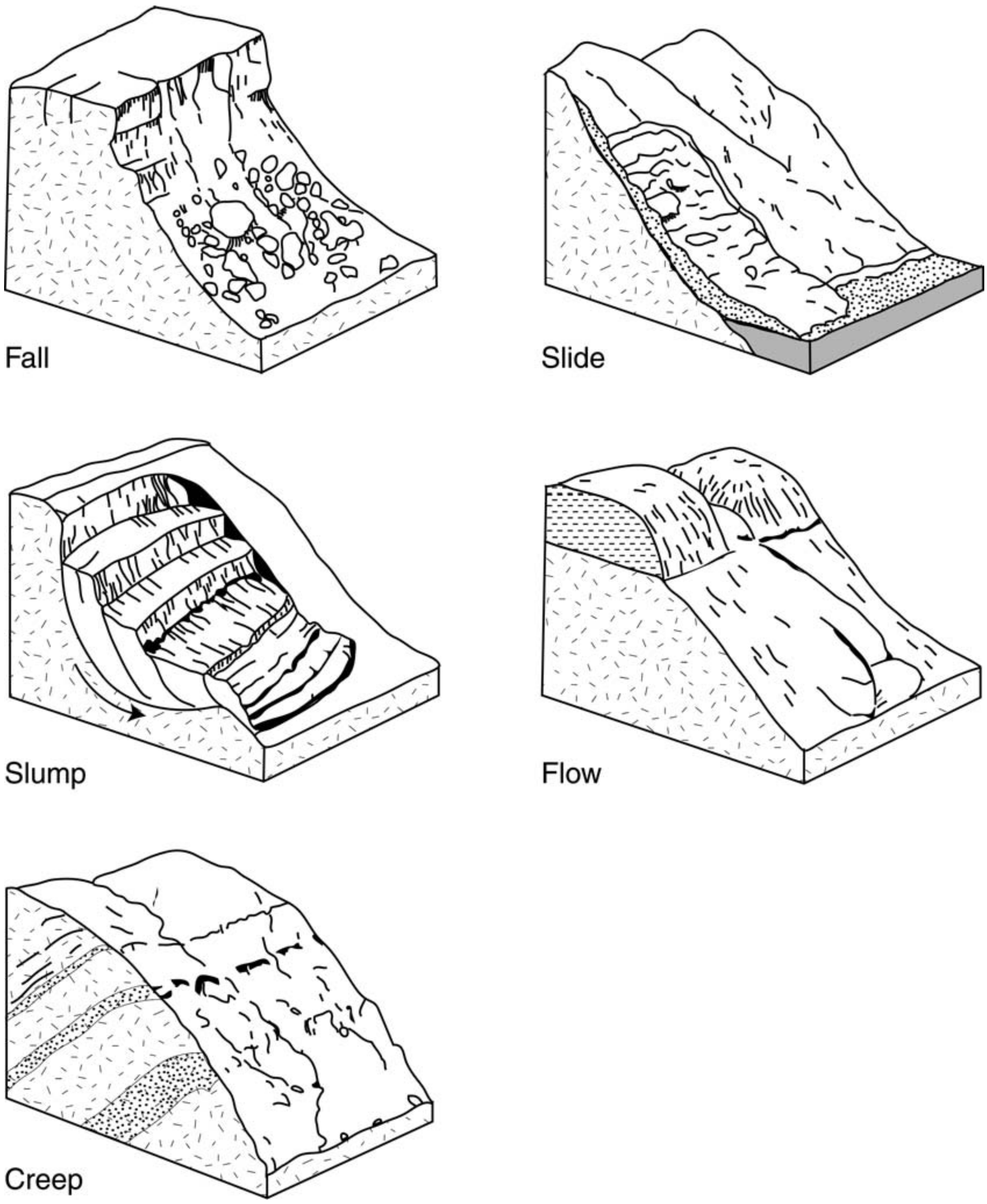


Figure 1: Processes that lead to the deposition of colluvial sediments (after Waters 1992, figure 5.8, 231)

Waters' (1992, 232) definition is not, however, universally accepted and Butzer (1982, 54) for example classifies colluvium as a slope deposit that results only from 'rainwash erosion'. The Soil Survey of England and Wales similarly defines colluvium as unstratified or crudely stratified deposits of Holocene age that have accumulated by slopewash or downslope creep (Avery 1980). Accordingly words such as 'ploughwash' and 'hillwash' are often used in the British archaeological literature as surrogate terms for colluvium (Boardman and Bell 1992), implying that Waters' flow and creep categories are those most commonly associated with 'colluvium' in the UK. Nevertheless for the purposes of this account the broad definition as outlined by Waters (1992, 232) is used. Colluvium is therefore the sedimentary product that results from erosion and subsequent transport by Newtonian processes of soils, other unconsolidated sediments (e.g. loess, solifluction debris) and bedrock. Once deposited, colluvial sediments are not immune to further erosion and consequently, as a result of transport by various mechanisms, they may become incorporated in alluvial, aeolian, colluvial or even marine sequences. For example Bell (1981b) and Macphail (1987) have argued that pre-Bronze Age loess-rich colluvium was flushed from basins in the South Downs and entered the rivers that drain the area.

Given that colluvium is defined in process-based terms, while colluvial sediments can be derived from slopes with a gradient as shallow as 2° (De Ploey 1984), the implication is that significantly large areas of southern England are carpeted by deposits of this type. However, although the latter statement is undoubtedly correct, in practice archaeological studies of colluvium have largely been restricted to basins containing thick colluvial sequences, well-preserved biological proxies to enable palaeoenvironmental reconstruction (usually land snails), and close geographic relationships with (particularly) prehistoric archaeological sites. Therefore the Wessex and South Downs have been intensively investigated and a handful of (mostly unpublished) studies carried out in the Cotswold and Chiltern Hills, but few archaeological studies of colluvium have been conducted elsewhere (see Figure 2). Of necessity this review focuses on those areas which have been investigated in greatest detail and on dry valleys in particular, but potential problems of uneven geographic coverage are revisited in the concluding section.

Possibly because of the confusion over the definition of colluvium that is alluded to above, Boardman and Bell (1992) have argued that archaeologists and geomorphologists conceive of colluvium in different ways. They suggest that archaeologists think of colluvium in negative terms, i.e. as any terriginous sediment that was *not* deposited by stream or aeolian action. Geomorphologists include under the heading 'colluvium' deposits forming within fields as a result of ephemeral water flow in rills (minor downslope orientated channels within the plough soil initiated during high rainfall events), gullies (semi-permanent channels cutting through the entire soil profile and into the parent material), overland flow and wind action.

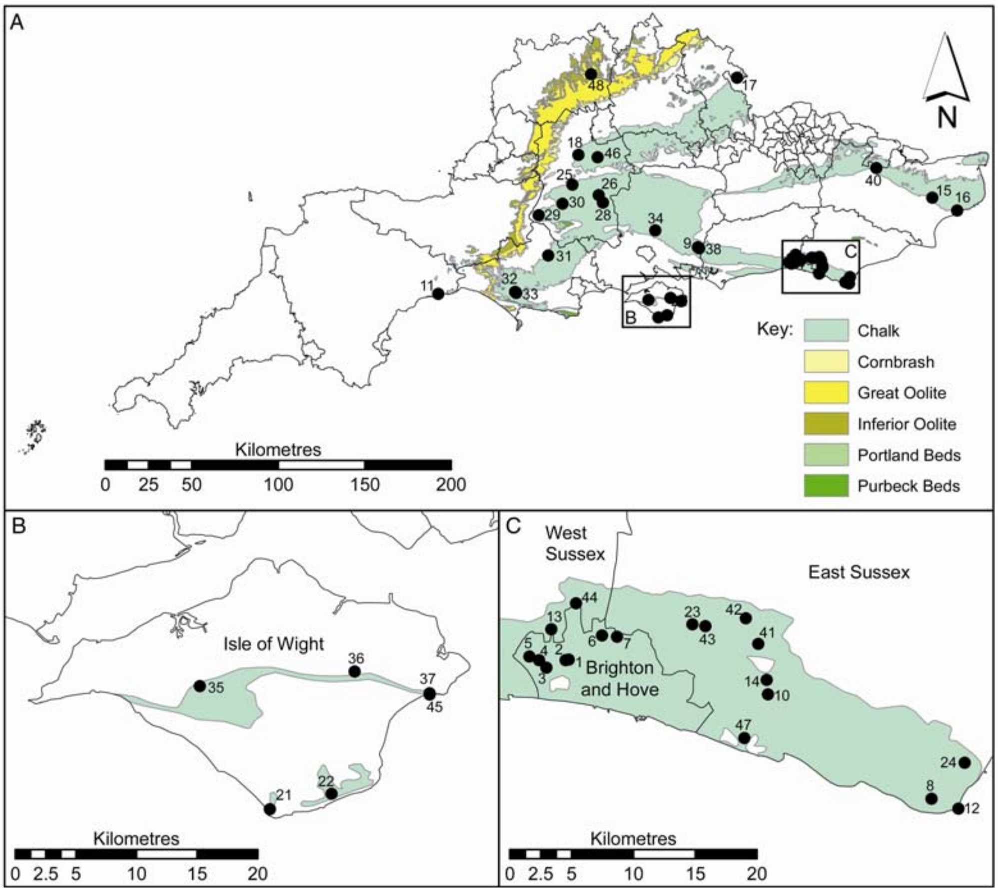


Figure 2: A. Distribution of colluvial sequences studied by archaeologists and Quaternary geologists in the Southern region plotted against the distribution of chalk and limestone bedrock geologies, B. dry valley investigations in the Isle of Wight, and C. Colluvial sequences investigated in the Brighton area. Key: 1. Toadeshole Bottom East (Wilkinson et al 2002); 2. Toadeshole Bottom West (Wilkinson et al 2002); 3. Hangleton Bottom (Wilkinson et al 2002); 4. Benfield Bottom (Wilkinson et al 2002); 5. Cockroost Bottom (Wilkinson et al 2002); 6. Sweetpatch Bottom (Wilkinson 2002); 7. Eastwick Barn Valley Bottom (Wilkinson et al 2002); 8. Kiln Combe (Bell 1981b, 1983); 9. Chalton (Bell 1981b, 1983); 10. Itford Bottom (Bell 1981b, 1983); 11. Beer Head (Wilkinson and Stewart in Tingle 1998); 12. Cow Gap (Ellis 1986); 13. Devil's Dyke (Ellis 1985, 1986); 14. Asham Quarry (Ellis 1985, 1986); 15. Devil's Kneadingtrough (Kerney et al 1964); 16. Holywell Coombe (Kerney et al 1980; Preece and Bridgland 1998); 17. Pitstone (Evans 1966; Evans and Valentine 1974); 18. Cherhill (Evans et al 1978; Evans and Smith 1983); 21. Gore Cliff (Preece 1980); 22. Watcombe Bottom (Preece et al 1995); 23. Ashcombe Bottom (Allen 1984a, 1984b, 2005b); 24. Bourne Valley (Allen 1983, 1994); 25. Strawberry Hill (Allen 1992, 1994); 26. Figheldean (Allen 1992, 1994); 28. Folly Bottom (Allen 1992, 1994); 29. Whitesheet Quarry (Allen 1992; Allen in Rawlings et al 2004); 30. Heytesbury (Allen 1992, 1994); 31. Coombe Bottom, Hambledon Hill (Bell et al forthcoming); 32. Fordington Bottom (Allen in Smith et al 1997); 33. Middle Farm (Allen in Smith et al 1997); 34. Compton Down (Allen 1992); 35. Newbarn Combe (Allen 1992, 1994); 36. Duxmore (Allen 1992, 1994); 37. Redcliff (Allen 1992, 1994); 38. Bascombe (Bell 1981b, 1983); 40. White Horse Stone (Allen 2005c); 41. Southerham Grey Pit (Allen 1995); 42. Malling Hill (Allen 1995); 43. Cuckoo Bottom (Allen 2005a); 44. Pyecombe (Allen 2005c); 45. Redcliff (Allen 1994); 46. Piggledene (Allen 2000); 47. Upper Piddinghoe (Allen 2005d); 48. Turkdean (Time Team, unpublished)

1.2 Deposition of colluvium

Early studies of colluvium (e.g. Sparks and Lewis 1957) emphasise the role of climate in the weathering, erosion and transport cycle that eventually produces colluvium in geomorphic depressions. This hypothesis is understandable given that such phenomena as solifluction sediments ('head' – see Section 3.1), which are often found underlying Holocene colluvium, are a product of periglacial climates operating during Pleistocene cold stages (Harris 1987; Ballantyne and Harris 1994). Nevertheless the focus on climate extremes, such as the Little Ice Age, as the prime control on deposition in the early studies was in part the result of a lack of chronological data from colluvial sequences prior to the application of ^{14}C dating in the 1980s. The routine use of the ^{14}C technique since the 1980s, together with artefact data from colluvial sequences, demonstrates that colluvium was not deposited synchronously across southern Britain and therefore that climate is unlikely to be responsible for the deposition (Allen 1992; Wilkinson 1993b). Most authors writing in the 1980s and later have instead suggested that human activities caused geomorphic thresholds to be exceeded, thereby prompting the deposition of colluvium (Bell 1982; Butzer 1982; 1983; Boardman and Bell 1992). Butzer (1982, 123–131) outlines the mechanism whereby woodland clearance and subsequent cultivation leads to soil instability (Figure 3). Forest and indeed grassland buffer the soil surfaces from most forms of sub-aerial weathering, but in particular provide a key intercepting barrier against rainfall. Plant roots bind the soil, while microfauna feeding on organic matter produced by the plants improve soil aeration and enable water to better infiltrate the soil. As a result surface runoff is low, soil moisture high and groundwater flow maintained throughout the year. By removing the vegetation cover, the soil surface is exposed to the erosive impact of rainfall, cultivation breaks up soil structures, organic matter oxidises and the soil compacts. The net result is that both surface runoff and soil erosion increase. Accepting that deforestation and arable cultivation are the key landscape processes that cause erosion it is therefore of no great surprise that by far the majority of colluvial deposits in southern Britain date to the Neolithic and later periods.

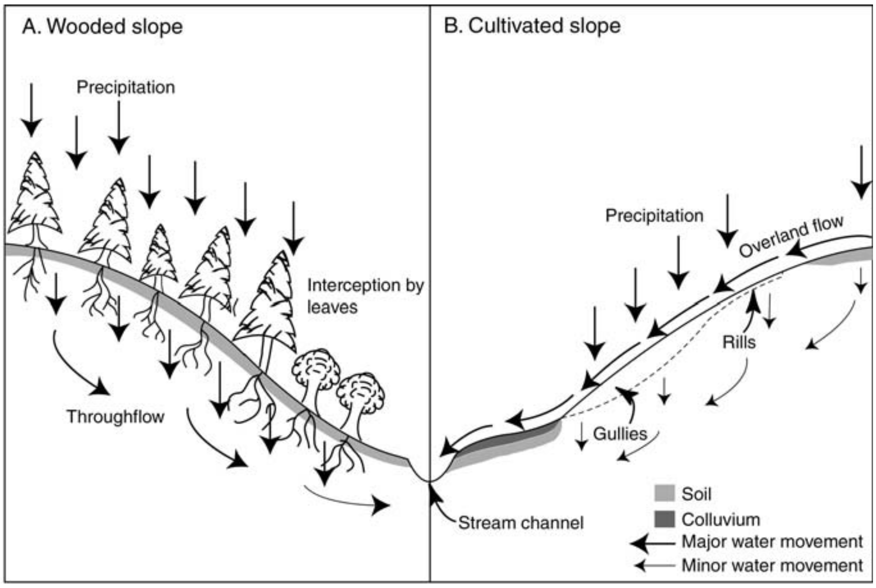


Figure 3: Runoff, infiltration and erosive processes on wooded and arable slopes (modified from Butzer 1982, figure 8.1, 124)

Processes that move soil particles downslope ['flow' and 'creep' in Waters (1992, 230-232) terminology] can be classified as a. the result of rain splash, b. the products of rill and gully erosion, and c. sheetflow (Figure 3 and 5). As is discussed further in Section 2, rain splash is a very minor cause of soil erosion on modern fields (Boardman and Bell 1992), while sheetflow is only a significant mechanism of transport for non-cohesive sandy soils (e.g. those developing on Greensand, Pleistocene and Tertiary gravels and loess) (De Ploey 1971; Morgan *et al* 1987). Elsewhere rill and gully processes are of most importance (Boardman and Bell 1992).

1.3 Basins containing colluvium

Bell and Walker (2004, 235) in their standard textbook suggest that colluvial sequences only form where there is an absence of stream activity, as such processes would otherwise rework colluvial deposits as alluvium and\or remove it from the catchment altogether. Given the definition adopted in Section 1.1, colluvium can accumulate in basins of a variety of different sizes ranging from post and stake holes found on archaeological sites up to interconnecting valley systems occupying whole regions. Sedimentary processes that lead to the infilling of relatively small archaeological features such as ditches, pits and indeed more unusual features including shafts and mines have been discussed extensively in the literature (e.g. Ashbee *et al* 1989; Bell 1990b; Crabtree 1990; Evans 1990), but as Allen (1992) notes such fills are likely to record landscape processes and events at very small spatial scales. The focus of this text is rather on colluvium accumulating in dry valley systems which are representative of activity in larger catchments, but colluvial deposits forming behind lynchets and in solution features such as dolines and swallow holes are also briefly discussed. In addition to these situations, colluvium also accumulates at the margins of river valleys where it is often reworked by stream processes and, as noted above, redeposited as alluvium (Brown 1992, 81; 1997). This last catchment is not specifically discussed in this chapter, but is mentioned when relevant case studies are examined.

1.3.1 Dry valleys

Dry valleys are characteristic geomorphological features of landscapes developed on chalk and other limestone geologies (see Figure 2 for the location of such lithologies in southern England) (Wilkinson 2003). They exhibit most of the characteristics of a low-gradient river valley except that they contain no axial drainage channel, while ephemeral flow down the valley axis is rare except during the most intense of storm events (Bull 1936). Dry valleys developing in scarp faces were termed 'coombes' by Bull (1936), although since then the use of 'coombe' has broadened. Such dry valleys are of a number of different forms, including steep sided examples in the Chilterns and South Downs and 'amphitheatre'-like features with steep slopes and flat bases in the North, South and Wessex Downs (Ballantyne and Harris 1994, 152). Dip slope dry valleys tend to be larger, have dendritic plans and are of asymmetric cross section (French 1972, 1973).

Two mechanisms have been proposed for the formation of dry valleys (Wilkinson 2003). Lewis (1949) and Sparks and Lewis (1957) suggest that until the Holocene they were the location of spring-fed streams. These streams had both incised and dissolved the chalk/limestone bedrock over timescales measured in tens to hundreds of thousands of year. However, falls in water tables during the last 11,500 years have left the valleys perched and lacking permanent streams. An alternative hypothesis was first proposed by Clement Reid (1887), but is now the most accepted view (e.g. Bull 1940; Kerney *et al* 1964; Preece and Bridgland 1998a). This holds that the impermeability of the chalk/limestone bedrock when frozen to depth by permafrost during cold stages of the Pleistocene caused spring melt water to be channelled along depressions that had originally been formed by Tertiary river systems and/or along faults. The flow eroded the bedrock by mechanical processes and thereby enlarged the existing valley. Permafrost melt at the beginning of the Holocene meant that the chalk/limestone bedrock became permeable and therefore axial flow was reduced. Williams (1980) has proposed a model that combines the two ideas. He suggests that dry valleys formed gradually during the Pleistocene due to falls in watertables during successive interglacials. This was as a result of the denudation of clay vales located adjacent to chalk and limestone ranges. According to this thesis, dry valleys in the early Pleistocene contained perennial groundwater-fed streams and these scoured out the valleys. As the water table was lowered beneath the valley floor, periglacial processes became more important in valley enlargement. Whichever is the correct explanation it is certain that dry valley systems were present across southern England by the Devensian Late Glacial as is demonstrated by ^{14}C dates of 13,500 – 9500 cal. yr BC on palaeosols sandwiched by solifluction infill of dry valleys at Brook (Kerney *et al* 1964) and Folkestone (Kerney *et al* 1980; Preece and Bridgland 1998b) in Kent (see 15 and 16 on Figure 2). It is likely, based on the occurrence of similar solifluction deposits west of Kent that dry valley systems across southern England formed at roughly the same time. However, the almost complete absence of palaeosols in solifluction deposits in Central southern and South-west England means that there is no ^{14}C chronology for dry valley solifluction in these areas and therefore the construction of exact chronologies and close correlation with the Kent sequences are both problematic.

Deposits infilling dry valleys are discussed in detail in Section 3.

1.3.2 Lynchets and other field systems

Lynchets are components of so-called Celtic field systems and are therefore characteristic of many areas of southern Britain. They comprise artificial banks that sub-divide the landscape into rectangular fields. Lynchets act as a trap for soil mobilised within the enclosed field, which over time accumulates behind the bank, forming what is known as a positive lynchet (Figure 4). Erosion of soil from the slopes of the field fronting a lynchet creates a depression down slope of that lynchet; a feature termed a negative lynchet. Bell (1981b; 1983) has suggested that lynchet construction was a response to erosion and that lynchets were therefore an overt means of soil conservation. By producing small one to two hectare-size fields, slope lengths are reduced and the banks prevent soil loss. As an illustration of the effectiveness of lynchets as a soil conservation technique, Boardman (1992) measured erosion during cultivation of a prehistoric field system at Balmer Down, East Sussex in 1990 – 1991. Erosion was found to be minimal (0.02 m^3 ha^{-1}), while the colluvium that was produced consisted entirely of organic-rich silts accumulating against the field banks. By way of comparison, an adjacent slope where prehistoric field systems had been heavily eroded by modern cultivation saw 15 m^3 ha^{-1} of soil movement. Support for Bell's hypothesis also comes from the study of a prehistoric field system and associated dry valley sequence at Eastwick Barn, Brighton. Deposits infilling the Eastwick Barn dry valley comprise flint and chalk gravels, which reflects intense erosion in the Early Iron Age and earlier periods (Wilkinson *et al* 2002). There is no later colluvium. The valley sides are characterised by a complex lynchet system dating to the Early Iron Age, but which also trapped eroded soil dating from the Iron Age and Romano-British periods (Barber *et al* 2002). Therefore it would appear that the development of the Early Iron Age lynchet system on the slopes of Eastwick Barn prevented colluvium reaching the valley bottom thereafter. Given that pre-Early Iron Age colluvial deposits in the valley bottom suggest episodes of intense erosion, it is reasonable to suggest that lynchet construction was, at least in part, a soil conservation measure.

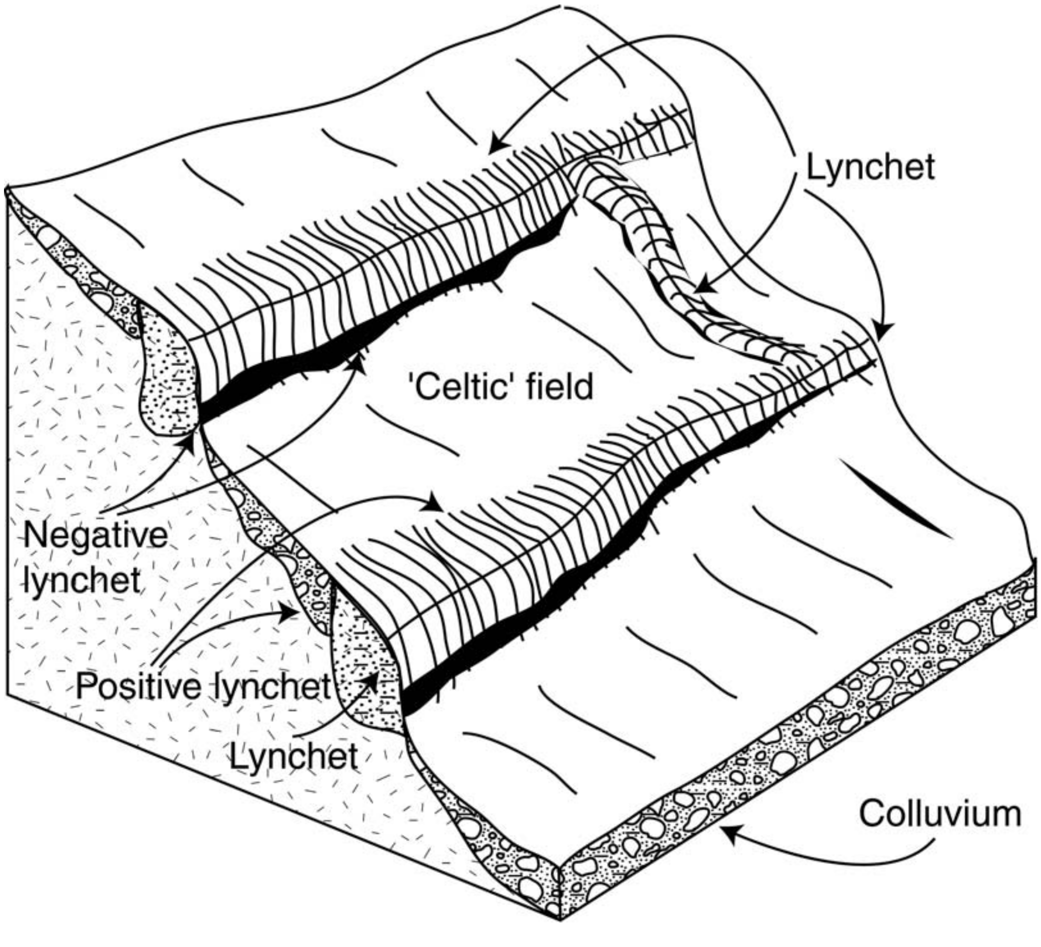


Figure 4: Block diagram of a theoretical lynchet system

1.3.3 Solution features

Dolines and swallowholes are features resulting from the collapse of chalk and occasionally limestone bedrock, into underlying caverns. They are the result of solution processes, where acidic groundwater dissolves calcareous rocks, creating channel systems below the groundwater table. Such features are well known from the Wessex Downs in particular and are concentrated in locations where Tertiary and early Quaternary lithologies lie adjacent to or above Chalk bedrock (Sperling *et al* 1976). The effect of bedrock collapse is to create a small-scale depositional basin into which soil and sediment from the immediately surrounding area are transported and deposited. Although many dolines and swallowholes are known, only a single feature of this type has been investigated in detail and that because of the presence of stratified prehistoric archaeological material in the infilling colluvial deposits. The Fir Tree Field Shaft on Cranborne Chase, Dorset was excavated in the mid-1990s (Green and Allen 1997; Allen and Green 1998; Green 2000, 40-43). It is at least 25m deep and contains a lower 23m+ thick infill of chalk-rich muds and gravels resulting from bedrock collapse. This is interspersed with dark fine-grained beds that are interpreted as soils, and which are associated with charcoal. The soils are thought to have formed in a forested environment (Allen and Green 1998). According to seven separate ^{14}C dates, the top 5m of this fill formed between 4460 and 3990 cal. BC[2], while the feature also acted as a pitfall trap for two roe deer (Green and Allen 1997). An overlying weathering cone of fine-grained colluvium seems to have formed on top of the bedrock collapse deposits between 4240 and 2030 cal. BC[3], as a result of processes akin to those operating in large ditched features (Limbrey 1975, 290-304; Bell 1990b; Evans 1990). These deposits, one unit of which seems to have been deposited deliberately, contained rich assemblages of Mesolithic microliths and Neolithic Peterborough Ware pottery.

Scott-Jackson (2000; Scott-Jackson and Winton 2001) has reported a further type of solution feature found at locations where Clay-with-Flint strata overlie Chalk. Water percolating through Clay-with-Flints is slightly acidic, and therefore dissolves the underlying Chalk. Over timescales that extend into the Middle Pleistocene, depressions are created in the Chalk bedrock by this process into which Clay-with-Flint sediment gradually subsides or is otherwise deposited as a result of low-energy colluvial processes. Scott-Jackson (2000) has argued that Lower and Middle Palaeolithic stone tool assemblages associated with such colluvially reworked Clay-with-Flint are frequently *in situ*, and therefore provide a record of hominin activity in Chalk downland landscapes that cannot be accessed from any other geomorphic context.

2. APPROACHES TO THE STUDY OF COLLUVIUM

Unlike alluvial, lacustrine and intertidal situations, which have been the subject of study by archaeologists and earth scientists since the nineteenth century, colluvial environments have a relatively short history of investigation. The potential of proxy records recovered from colluvial sediments to provide information on past environments was only recognised in the 1960s.

2.1 The investigation of colluvium before 1980

Geographers interested in the geomorphological evolution of southern Britain studied colluvium long before archaeologists investigated the deposits. The first investigation of a dry valley sediment sequence was by Sparks and Lewis (1957) at Pegsdon, Hertfordshire. Although the valley fills were not described in detail or dated, and while accompanying biostratigraphic investigations were rudimentary, the investigators were nevertheless able

[2] Maximum and minimum calibrations of OxA 7991, 5500±55 BP and OxA 7988, 5310±45 BP Allen Green 1998).
[3] Maximum and minimum calibrations of OxA 7987, 5275±50 BP and OxA 7985, 3775±45 BP Allen Green 1998).

to suggest that deposits overlying a palaeosol near the base of the sequence were the result of Bronze Age and later agricultural activity. Further small-scale investigations of individual colluvial sequences were undertaken in the 1960s, by which time the primary purpose had changed to obtaining samples for molluscan analysis (Sparks 1961, 1964). During the 1960s, studies developed along two separate lines that were still apparent in the 1990s (Wilkinson 2003). Firstly, Quaternary geographers and geologists focussed on the Devensian Late Glacial and Early Holocene environmental history of southern England by targeting colluvial sequences that buried Late Glacial solifluction and/or Early Holocene tufa (Kerney 1963; Kerney *et al* 1964). Secondly, archaeologists were interested in the evidence that dry valley sedimentary sequences could provide on land-use history and human impacts on the environment (Evans 1966; Evans and Valentine 1974). During the early and middle 1970s the number of studies in the former category significantly outnumbered the latter. In the late 1970s Kerney was able to develop a zonation system for the Late Glacial and Holocene based on the colonisation of Britain by terrestrial Mollusca as a result of the relatively larger number of Quaternary geological investigations that had been carried out (Kerney 1977; Kerney *et al* 1980). The later 1970s also saw an increase in the number of archaeological studies, the development of an archaeological methodology to date colluvial sequences (see Section 4), use of micromorphological techniques on colluvial deposits and the production of data that changed perceptions of past human land use of chalkland environments (Bell 1981b). Bell's research in particular demonstrated that despite the large number of Neolithic monuments known in southern England, large-scale human impact on natural geomorphic systems only occurred as a result of agricultural intensification in the later Bronze Age and during the Iron Age (Bell 1981a; 1981b; 1983). He noted that colluvial deposits dating from the historic period contained chalk granules, suggesting that by this period chalk bedrock on the valley slopes was within the depth commonly penetrated by ploughs and ards. This situation contrasted with Bronze Age, Neolithic and Mesolithic palaeosols, Bronze and early Iron Age colluvium and fills of tree throw hollows in the same locations, which lacked chalk. The implication of this discovery was that significant erosion of loessic soils on the chalkland had occurred during later prehistory.

2.2 Archaeological study of colluvium from 1980

As a direct result of the publication of Bell's studies (Bell 1981a; 1982; 1983), the potential of proxy records from dry valley colluvium for palaeoenvironmental reconstruction of chalk/limestone environments became more widely recognised by the archaeological community. Prior to Bell's work there had been no way of obtaining palaeoenvironmental data from such locations other than by the palynological examination of organic sequences located beyond the chalk/limestone margin (e.g. Thorley 1981; Scaife 1982; Waton 1982b; Waton and Barber 1987). However, pollen entering catchments such as the Rimsmoor doline, which is located only 600m from the chalk escarpment, were thought to be from many sources of which the chalk escarpment was only one (Waton 1982b). Consequently from the early 1980s onwards archaeological investigations of colluvium were carried out as part of several large landscape archaeological projects in order to provide background palaeoenvironmental data against which the archaeological finds could be compared (e.g. Bell 1990a; Richards 1990; Mercer and Healy in press).

An associated development was the use of Bell's methodology by Allen to research 15 sequences in the South Downs, Wessex and the Isle of Wight (Allen 1983; 1988; 1992; 1994). As was the case with Bell's studies, Allen used land snail analysis to assess general patterns of environmental and land use change. However, a number of new methods including mineral magnetic measurement and archaeomagnetic dating were also trialled to aid environmental reconstruction and to obtain better chronologies (Allen 1984). A particularly important find that resulted from this work was substantial evidence for Beaker period habitation in low lying locations and buried by colluvium (see Section 5 for further discussion) (Allen 1994; 2005a; 2005b; 2005c).

Since the late 1980s most investigations of colluvial sequences have been carried out as part of archaeological evaluation or mitigation prior to commercial or infrastructure development. The tight time constraints inherent in these projects on the one hand, and the comparatively generous finance on the other, changed the way that colluvial investigations were undertaken. There are several examples of colluvial investigations being carried out in such circumstances, but those undertaken in advance of construction of the Channel Tunnel in 1987 (Preece and Bridgland 1998) and the A27 Brighton bypass in 1989 – 1990 (Wilkinson 1993a, 1993b, 2003; Preece and Bridgland 1998b; Wilkinson 2002; Wilkinson *et al* 2002), are the largest published to date. The former was a Quaternary science-oriented investigation and is reviewed in Section 2.3, while the latter saw the investigation of the sequences of seven dry valleys and one lynchet on the western and northern fringes of Brighton. A key discovery of the Brighton bypass study was that the colluvial and biostratigraphic record varied considerably between different dry valley systems, suggesting that land use was highly variable on both a spatial and temporal basis (Wilkinson 1993b; 2003). Other investigations of colluvium resulting from commercial funding during this period include Allen's study (in Smith *et al* 1997) of a colluvial sequence at Middle Farm as part of archaeological works carried prior to construction of the Dorchester bypass. This study demonstrated that colluvium accumulated in a grassland environment dating from around 3710 – 3370 cal BC (4800±70 BP, OxA-2382) (Allen in Smith *et al* 1997, 177). The nearby Flagstones enclosure, also investigated during works preceding the Dorchester bypass, was found to have been used in a grassland environment at 3960 – 3630 cal BC (4960±80 BP, HAR-9161), which taken together with the Middle Farm evidence suggests a predominantly pastoral land use regime on the Late Neolithic Dorset Downs (Allen in Smith *et al* 1997, 167).

Archaeological studies of colluvium peaked in the late 1980s and early 1990s and comparatively few investigations have been carried out in southern England since that date. Indeed only 1 of the 45 investigations examined while researching this chapter was undertaken following the implementation of Planning Policy Guidance 16 (PPG 16) (Department of the Environment 1990). One reason for this post-PPG 16 decline may be the reluctance of archaeologists working for planning authorities to ask for work in 'off site' locations such as dry valleys where there is rarely a *demonstrable* archaeological resource as evidenced in Sites and Monuments Records/Historic Environments Records.

2.3 Quaternary geological studies from1980

Two of Michael Kerney's research students, Caroline Ellis and Richard Preece, used the approaches developed by their supervisor to investigate colluvial sequences in Kent, Sussex, the Isle of Wight and Dorset during the late 1970s and 1980s. Although the focus of Preece's (1978) research was the molluscan biostratigraphy of tufaceous deposits, he nevertheless investigated a number of colluvial sequences on the Isle of Wight (Preece 1980; Preece *et al* 1995). Ellis studied two dry valley sequences in East Sussex, Devil's Dyke and Asham Quarry, as part of her PhD research (Ellis 1985, 1986). The last study of this type to be published was the previously mentioned investigation in advance of construction of the Channel Tunnel at Folkestone, Kent (Preece and Bridgland 1998b). This was also the most extensive and intensive study of a colluvial sequence undertaken in Britain from a Quaternary geological perspective. Over 180 boreholes were drilled to determine the distribution and geometry of the infilling deposits and palaeosols, while seven trenches were excavated to bedrock to obtain samples for palaeoecological study (Preece 1998a). Geological works were combined with an archaeological study of the Holocene succession (Bennett 1988; Bennett *et al* 1998), with the result that the landscape changes at Holywell Coombe, Folkestone are better defined and dated than at any other dry valley site in Britain.

2.4 Studies of recent colluviation

Research on modern erosion on the limestone and particularly chalk downland environments, where colluvial sequences are so common, has been intense since the 1970s (e.g. see Boardman 2003 and references therein). Detailed studies have also taken place of modern erosion on landscapes of North-west Europe where, as with late prehistoric southern England, loess soils are cultivated (e.g. Kwaad 1977; Kwaad and Mücher 1979; Govers 1991). On the basis of data from Sussex, Boardman (1990; 1992) has argued that almost all erosion in southern England at the present day takes place in arable landscapes and has implied that the same was true of the past. He further suggests on the basis of a 10-year field experiment lasting between 1982 and 1991 that the major determining factor in the quantity of transported soil produced are the crops grown, cultivation method, field size, and magnitude and timing of rainfall events (Boardman and Favis-Mortlock 1999; Boardman 2003). Boardman's (1990; 1992; 2003) studies also demonstrate that the majority of soil eroded from modern fields in the South Downs is the result of intense storm events, these having led to the development of extensive rill and gully systems. For example in the field experiment, which was carried out on land mostly used for the cultivation of winter cereals, 72% of erosion occurred in one year (1987), and this mostly as the result of a single intense storm with an estimated return period of 25 years (Boardman 2003). Twenty three percent of soil eroded during the 10-year trial was transported in emphemeral gullies, while most of the rest was moved by rilling (Boardman 2003). Govers *et al* (1996) and Quine *et al* (1997) have studied the properties of eroded soil. They point out that the poorly sorted sequences typical of present day dry valley fills result from tillage (i.e. mixing within the plough zone) of valley bottom soils. If such an observation were applicable to the past it would have significant implications with regard to temporal resolution and contextual heterogeneity of the dry valley colluvial record.

As is discussed further in Section 3 there are obvious problems of applying modern data such as those collected by Boardman to interpret colluvial sequences exposed in dry valleys and other basins. However, archaeologists and geographers have rarely come together to discuss the interpretations of their respective datasets. Therefore, a joint Association for Environmental Archaeology and Quaternary Research Association sponsored conference in May 1991 entitled *Past and present soil erosion* (published as Bell and Boardman 1992) represented a key moment in the study of colluvium, bringing those studying colluvium from archaeological, Quaternary science and agronomic approaches together for the first time. From that point forward most archaeological studies of colluvium were conducted using present day observations as an analogue – with suitable allowances (e.g. Wilkinson 1993b; Allen 1994), while agronomists have subsequently used archaeological data to argue for the long timescales over which certain colluvial processes operate (e.g. Boardman 2003).

A final category of modern studies worth discussing is the measurement of soil erosion as a result of mechanised cultivation since World War Two using the ^{137}Cs isotopic tracer. ^{137}Cs is a fission product resulting from atmospheric atomic weapon testing, licensed discharges from nuclear reactors and nuclear accidents (Quine 1995). It is readily sorbed into clay particles within soils, and given that ^{137}Cs atoms were only released into the atmosphere from the late 1940s onwards, concentrations of the isotope in a soil profile can be used to calculate rates of erosion/deposition in the latter part of the twentieth century (Davidson *et al* 1998; Wilkinson *et al* 2006). Although archaeologically oriented studies are very few (Quine and Walling 1992), Wilkinson *et al* (2006) have employed the technique to measure post-1960 erosion rates of up 4.7mm yr^{-1} on valley slope soils overlying later Prehistoric and Romano-British archaeological sites in the Quantock Hills, Somerset, and accumulation rates of up to 3mm yr^{-1} at adjacent breaks in slope. Such investigations have an as yet unrealised potential in managing fragile archaeological resources in arable landscapes (Wilkinson *et al* 2006).

3. COLLUVIAL SEDIMENTS

Most earth and biological science approaches to archaeological problems rely on the application of uniformitarian ideas and therefore require modern analogue data (e.g. Dincauze 2000, 28-31; Wilkinson and Stevens 2003, 28-31; Branch *et al* 2005, 67-68). The study of ancient colluvium is no exception, and logically the main analogue used by most of those researching the field is the present day landscape (e.g. Allen 1992; Bell 1992). However, even though there are significant data regarding mode, timing and magnitude of erosion under different land-uses in southern England, the analogues are imperfect. Present day arable and indeed pastoral systems differ significantly from those of the ancient past in terms of the technology employed [mechanical (e.g. tractors, ploughs etc) and chemical (fertilisers, pesticides etc)], the crops grown, size of fields and nature of field boundaries, while soil properties have themselves changed as erosion has proceeded (Bell and Walker 2004, 227). Indeed the purpose of agriculture, and therefore the perception of the land by farmers, has itself shifted from a largely subsistence-oriented activity prior to the eighteenth century to the fully commercial cash-crop industry of today. In other words, although the modern analogue data recovered during erosion monitoring programmes in southern England are of value when reconstructing the mechanisms and causes of ancient colluviation, they may not explain all the phenomena that are seen in the archaeological record.

3.1 Properties of colluvium

As was noted in Section 1, colluvium forms as a result of five types of process: fall, slide, slump, flow and creep (Waters 1992, 230 – 232). Each of these processes results in the formation of colluvial sediments with characteristic morphological and geometric properties. Until the 1980s there was an assumption, based on ceramic evidence recovered from sites on the South Downs such as Kiln Combe, Itford Bottom and Ashcombe Cottom (Bell 1983; Allen 1984), that for the prehistoric period at least, colluvium built up in a slow and incremental manner as a result of creep processes. Indeed Butzer's (1982, 124 – 130) then standard textbook emphasised such a view. However, work conducted since 1980 has suggested instead that the processes that led to the deposition of colluvium were of large magnitude, but events were episodic (see Boardman and Bell 1992, 3). Boardman (Boardman and Robinson 1985; 1990; 1992) in particular has argued for the role of rills and gullies in the deposition of present day colluvium.

Several authors have attempted to relate colluvial sediments seen in dry valley sequences to distinct erosion and transport processes visible at the present day using uniformitarian principles (Allen 1991; 1992; Wilkinson 2003). Using Boardman's (1990; 1992) and his own modern analogue data, Allen recognises two groups of colluvial sediments: fine-grained deposits which are deposited 'gradually and rhythmically' and coarse-grained sediments that are emplaced 'rapidly and infrequently' (Figure 5) (Allen 1991, 41). According to Allen (1991; 1992) fine-grained [granule – clay size classes on the Wentworth (1922) scale] deposits form as a result of processes of creep, namely rain splash, soil creep, tillage and surface casting of soil particles by animals, as well as by sheetwash. The kinetic impact of a raindrop or the detachment of soil particles by either plough or microfauna is the mechanism of erosion, while transport is by gravity or low-energy flow. Such processes produce moderately or poorly sorted deposits characterised by silts, sand and chalk/limestone granules (the latter a result of the low specific gravity of chalk and oolitic limestone and the tendency of such lithologies to erode to form near-spherical granular-sized particles) (Allen 1991). The majority of colluvial sediments retained behind lynchets are of this type (Allen 1992), but fine-grained deposits in dry valleys may occasionally contain well-sorted, banded beds indicating pulsed sedimentation. Occasionally fine-grained colluvial deposits are both homogeneous and entirely free of gravel-sized particles, a situation that Macphail (quoted in Allen 1992, 44) interprets as either the result of worm sorting during pedogenesis or a calcareous slurry produced by intense cultivation of a rendzina soil (but see Carter and Davidson (1998) for a critique of the latter hypothesis).

Coarse deposits form the majority of colluvial infills in dry valleys, but are rare in sediment sequences retained behind lynchets (Allen 1992). They form as a result of flow during exceptional storm events when intense overland flow becomes concentrated in rills and gullies. Granular and pebble-sized stone particles have been noted accompanying sand and silt-size material in ephemeral rills (Allen 1991, 1992), while partly because gullies cut into the bedrock, gravel fans containing rocks of boulder size have been noted at the mouths of such features (Stammers and Boardman 1984). Given that deposition in rills and gullies is akin to that in small stream channels and on alluvial fans, the sediments produced can be crudely bedded and moderately sorted. As has previously been noted, Boardman (1992) suggests that on the present day South Downs, rill and gully erosion accounts for the majority of soil erosion and sheetwash causes limited erosion, while soil movement as a result of creep and rain splash is insignificant.

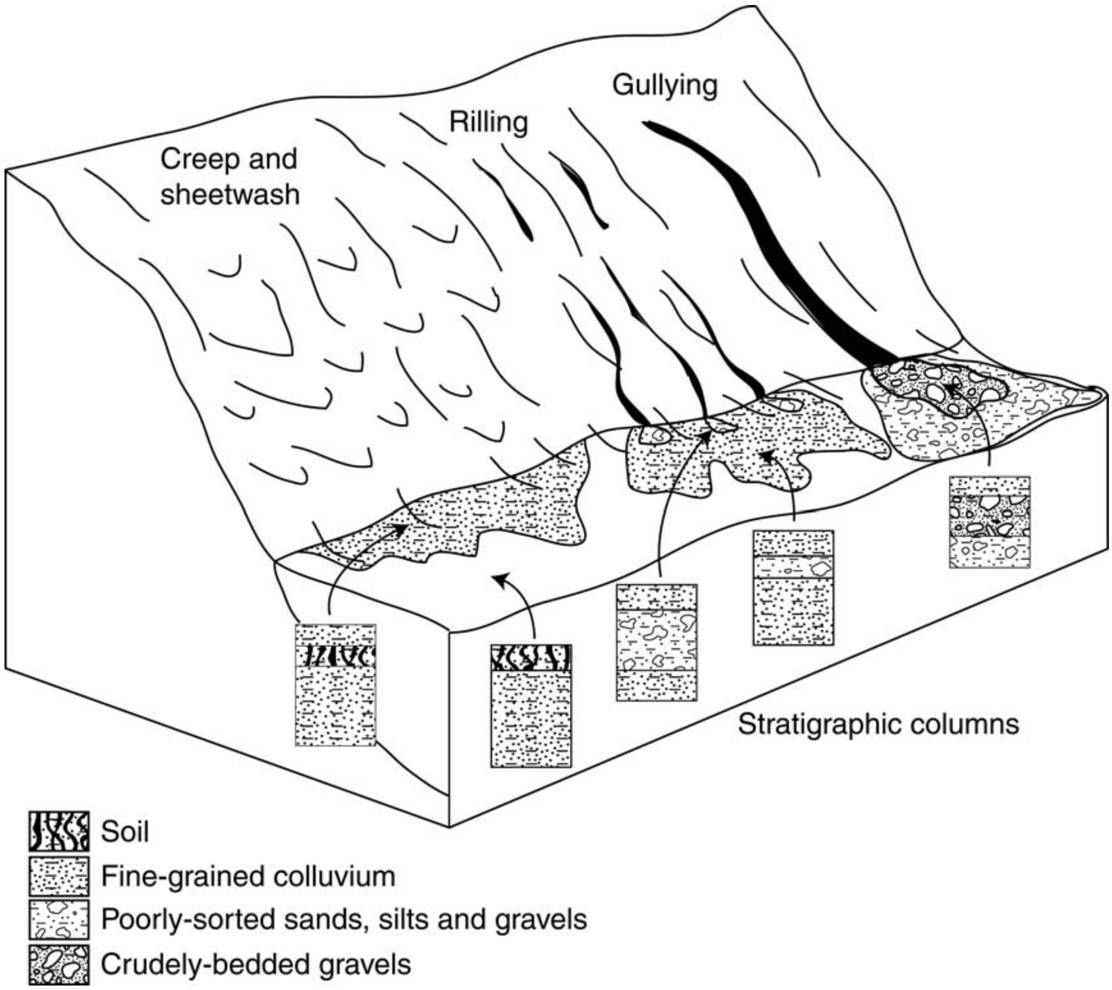


Figure 5: Block diagram showing the mechanisms of erosion and sediment transport in a dry valley environment and the deposits/sequences produced

In addition to the sediments discussed above, the other significant category of colluvium found in southern England is the result of mass wasting in periglacial environments. According to Ballantyne and Harris (1994, 114 – 120) there are three categories of periglacial slope sediments that were deposited in lowland Britain during Pleistocene cold stages: solifluction, mass movement and slopewash. These terms can be equated with Waters' (1992) terminology outlined in Section 1.1 whereby solifluction is a creep and flow deposit, mass movement forms flow-, slump- and slide-derived sediments, and flow deposits are also formed by slopewash. Deposits resulting from periglacial mass wasting are collectively called 'head' – a term first used by De la Beche (1839) for unsorted 'rubble-drift' of South-west England (Ballantyne and Harris 1994, 121) – in the geological literature (e.g. Young and Lake 1988; Green 1992). Solifluction deposits are formed by processes of frost heave through seasonal ice formation and subsequent melt, leading to movement of particles (frost creep) and gelifluction[4]. Deposits produced by frost creep and gelifluction are indistinguishable in the stratigraphic record (Harris 1987), and in southern English limestone and chalk situations comprise a chalk or limestone marl of sub-angular rock fragments and rock flour. Mass movement is an exaggerated form of gelifluction and occurs as a result of rapid thaw caused by summer rainfall, unusually warm weather or fires that destroy vegetation cover (Ballantyne and Harris 1994, 118). There are several types of mass movement: skinflow, where the surficial layer *flows* downslope above the permafrost table (McRoberts and Morgenstern 1974); active-layer detachment glides, where the whole supra-permafrost layer *slides* en bloc (Lewkowicz 1990), and ground ice slump, where both the non-permafrost active layer and permafrost layers move en masse on a rotational axis (Harris 1987). Deposits produced by these processes in chalk and limestone situations are broadly similar to those caused by solifluction processes. Slopewash deposits are formed by processes of overland flow where vegetation cover is minimal (Lewkowicz 1988), but according to French and Lewkowicz (1981), slopewash produces two orders of magnitude less sediment than solifluction in modern arctic environments. Slopewash sediments are fine grained, sorted and often stratified (Ballantyne and Harris 1994, 120). Of all these periglacial slope processes, Harris (1987) considers that solifluction was the most important in non-argillaceous geologies of Southern Britain.

Head deposits forming both in chalkland dry valleys and as aprons extending beyond the chalk escarpment into the coastal plain are sometimes termed Coombe rock (Evans 1968). On the West Sussex coastal plain, head deposits date to the Anglian and Devensian cold stages; the Anglian head deposits contain Lower Palaeolithic artefacts (Bates *et al* 1998). In dry valleys, head deposits are of Devensian Late Glacial age.

3.2 Associated sediments and palaeosols

Colluvial deposits have been found associated with both buried palaeosols and non-colluvial sediments. The former are of two types: buried remnants of soils dating from prior to the deposition of colluvium and which are found at the base of the colluvial stratigraphy, and buried palaeosols developing within colluvial deposits. The latter are indicative of episodes of stasis subsequent to the deposition of colluvial sediments when the catchment was not subject to erosion or where sedimentation into a basin was at such a slow rate that pedogenesis was able to keep pace. Buried palaeosols developing in solifluction debris and dating to the Devensian Late Glacial fall into the second category. Two of these soils, thought to correspond to the Devensian Late Glacial interstadial (formerly the Bølling and Allerød interstadials) on the basis of ^{14}C chronology have been found from sites in Kent (e.g. Dover Hill, Castle Hill and Holywell Coombe, Folkestone; Brook, Holborough and Broadstairs) (Kerney 1963, 1965; Preece and Bridgland 1998b), but are rare from colluvial situations elsewhere in southern England, having been found only at Pitstone, Buckinghamshire (Evans and Valentine 1974), Watcombe Bottom, Isle of

[4] Gelifluction occurs during the melting of permafrost when the liquid limit of the regolith is exceeded and a slow viscous flow is initiated.

Wight (Preece *et al* 1995) and Horsecombe Vale, Bath (Chandler *et al* 1976). More common are buried palaeosols developing within the Holocene colluvial successions and which are commonly thought to be characteristic of changes from arable to other land uses. Palaeosols of this type have been investigated in detail at a number of sites in Sussex. At Ashcombe Bottom, East Sussex, a palaeosol buried by c 0.7m of colluvium contained ceramic evidence for a Beaker settlement (Allen 1984; 2005b), while similar buried palaeosols at Kiln Combe and Itford Bottom, East Sussex also contained evidence for Beaker activity[5] (Bell 1983). Indeed a palaeosol developing in fine-grained colluvium and dating between 2900 and 2250 cal. BC (OxA 3077, 4020±90 BP) and 1690 to1400 cal. BC (OxA 3080, 3260±70 BP) at Toadeshole Bottom East, East Sussex was also associated with human activity (but lacked diagnostic ceramics) dated to 2040 – 1730 cal. BC[6] (Figure 6a) (Wilkinson *et al* 2002). Somewhat different interpretations have been made of three separate buried palaeosols within the Holocene colluvium at Holywell Combe, Kent (Preece *et al* 1998). Detailed investigations of the soils suggest that the earliest developed in colluvium over millennial timescales, but that it was subsequently buried by tufa (Catt and Staines 1998). The middle soil formed in colluvium between 4960 and 4320 cal. BC (OxA 2091, 5620±90 BP) and 3370 – 2900 cal. BC (OxA 3224, 4470±90 BP), while the youngest dates to around 2040 – 1630 cal. BC (OxA 2090, 3515±80 BP) (Catt and Staines 1998). The latter two palaeosols are thought to represent episodes of stability following deforestation and cultivation (Catt and Staines 1998).

Buried palaeosols developing in non-colluvial parent material and predating deposition of Holocene colluvial deposits are known from several sites. For example a clay-rich Bt horizon was encountered during borehole drilling and trenching of the Piddinghoe dry valley, East Sussex where it was preserved in pockets in the underlying chalk and as a 0.1m thick layer (Swindle *et al* 2004). A truncated Bt horizon of almost identical properties to that at Piddinghoe was found at Sweetpatch Bottom, East Sussex and associated fine charcoal recovered from mollusc samples was ^{14}C dated to 2140 – 1690 cal. BC (OxA 2995, 3560±80 BP) (Wilkinson 2002). A basal palaeosol with similar characteristics to Sweetpatch but from Chalton, Hampshire, was examined using micromorphological techniques by Macphail (in Bell 1983). Clay and silt translocation were both identified, while the presence of matri-argillans containing fine charcoal in the palaeosol was interpreted as indicating cultivation (see Section 4.2.1 for a discussion of micromorphological evidence for cultivation). In particular geomorphological circumstances more complete soil profiles have survived, as for example at Whitesheet Quarry, Wiltshire, where both A and B horizons survived in the lea of a break in slope (Rawlings *et al* 2004). In complete contrast to palaeosol preservation at Whitesheet Quarry are the vestiges of Middle Holocene pedogenesis surviving from Toadeshole Bottom East. Mollusc shells from an assemblage attributable to Kerney's (1977; Kerney *et al* 1980; Preece 1998b) zone d^2 (c. 6650 – 4320 BC), were found in gradually declining numbers within the top 0.2m of a periglacial marl (Wilkinson 1993b). Although vestiges of a Middle Holocene soil were otherwise only found from a tree throw hollow (see below), these molluscan data are evidence of the redistributive action of earthworms in a woodland environment and of the presence of a palaeosol developed in solifluction deposits.

[5] Dated to 2500 – 1750 cal. BC (BM 1545, 3720±120 BP, combined age on 113 separate charcoal fragments) at Itford Bottom.
[6] A combined age on OxA 3078 (3560±80 BP) and OxA 3079 (3550±90 BP).

Colluvium in Kent has occasionally been found to bury Early Holocene tufas, a sure indication that valley systems were formerly the loci of streams and/or springs. The best known example is Holywell Combe, Kent where up to 3.5m of fossiliferous micritic spring tufa dating from after 9450 – 8800 cal. BC (Q 2721, 9760±100 BP) to before 4960 – 4320 cal. BC (OxA 2091, 5620±90 BP) were investigated (Preece *et al* 1998). However, other tufas buried by colluvium have also been investigated at Brook and Wateringbury, Kent (Kerney *et al* 1964), and Cherhill, Wiltshire (Evans and Smith 1983). In most of these instances the tufa is associated with perched springs forming above the boundary between the base of the (permeable) Chalk and underlying (impermeable) Gault clay and run off from those springs (Pedley 1998).

Another type of Early to Middle Holocene deposit commonly associated with colluvial basins are the fills of tree throw hollows. These comprise depressions in the chalk or limestone bedrock that were once occupied by tree roots. Following the death and fall or removal of the tree the void left was infilled by the erosion products of contemporary soils (Evans 1971). Such hollows have been noted at many sites, including Ashcombe Bottom (Allen 2005b), Itford Bottom, from which coniferous charcoal (probably pine) has been dated to 8250 – 7600 cal. BC (BM 1544, 8770±85 BP) (Bell 1983), and Toadeshole Bottom East, where the hollow dates from before 2900 – 2250 cal. BC (OxA 3077, 4020±90 BP) (Wilkinson *et al* 2002). In the case of the Itford Bottom and Toadeshole Bottom East examples, associated mollusc assemblages indicate that the infilling sediment was derived from soils developing in woodland environments.

3.3 Diagenesis of colluvial sequences

Assuming firstly that non-periglacial colluvial sequences associated with lynchets and dry valleys are emplaced as a result of cultivation and secondly that the surrounding slopes and the valley bottom are cultivated, it is highly likely that transported sediment will mixed by ploughing. In other words, the properties of colluvial sequences are the result, not only of the sedimentation process, but subsequent land use too. Only when depositional rates are so high that the thickness of a new sediment unit exceeds plough depth will primary sedimentary features be preserved (Allen 1992). Even where deposition is into a basin that is not subject to ploughing, some mixing of newly deposited sediment with underlying soil and sedimentary material will occur as a result of bioturbation – particularly given that most limestone and chalkland soils in southern England have high levels of micro/macro faunal activity – and other pedogenic processes. Frequently the product of such diagenesis is homogeneous, poorly sorted colluvium from which the original depositing process is difficult to reconstruct.

Boardman (1992) has highlighted the frequency of unconformities seen in the colluvial record preserved in dry valley sequences. Valley bottom palaeosols are, despite the tenor of the review above, rarely preserved (Allen 1992), while, with the exception of sequences from the North Downs of Kent, evidence for pre-Bronze Age sediments is usually restricted to the fills of hollows found in the bedrock. In other words, there is evidence for the operation of erosion and transport processes along the valley axis as well as perpendicular to it. For example, Swindle, Green and Branch (2004) found an axial channel in the Piddinghoe dry valley, Peacehaven, East Sussex during a borehole investigation, while Bell (1992) notes that at a dry valley at Bascombe, Chalton, Hampshire there were no deposits dating before the medieval period and that prior deposits were probably removed by stream action. Allen (1992) has also suggested that extensive but buried spreads of gravel noted along dry valleys such as Folly Bottom, Amesbury, Wiltshire may have been emplaced by ephemeral streams. Modern studies suggest that ephemeral gullies (*sensu* Foster 1990) form in valley bottoms where slope gradients are ≥ 3.6° (Patton and Schumm 1975), and that these remove fine-grained deposits. Nevertheless, ephemeral gullies of the type that are active in present day dry valleys would not have had the capacity to remove complete Early Holocene sediment sequences/soil profiles of the type thought to have resided in the valleys (Boardman and Bell 1992). Modern features are in this case a poor analogue, even if it is argued that prior to slope erosion valley axes gradients may have been steeper.

The net result of incremental but slow deposition over a whole valley system as a result of creep, rapid point deposition by flow, axial erosion in ephemeral gullies, bioturbation and mixing by ploughing, is highly complex sediment sequences that vary in character in different parts of dry valley systems. For example Allen (in Smith *et al* 1997) notes that in Fordington Bottom, Dorchester, Dorset, the total thicknesses of colluvium varied between 1.2m and 2.3m over a distance of 250m, while at Holywell Coombe, Folkestone, Kent, colluvium of variable date and thickness infilled topographic hollows in underlying strata that are not visible today (Preece *et al* 1998). As is discussed further in the concluding section, spatial variation of this type has profound implications when considering the most appropriate methods for investigating dry valleys.

3.4 Colluvial and associated facies

Unlike alluvial, marine marginal and aeolian environments (e.g. Reineck and Singh 1980; Boggs 1987; Reading and Levell 1997; Miall 2000), Earth scientists have been reluctant to discuss colluvial facies, but instead have grouped all such sediments, irrespective of the depositional sub-environment in which they formed, under such umbrella terms as 'slope deposits'. In part this may be a factor of the problems of using modern analogues to reconstruct precise environments of deposition of colluvial sediments. However, such deposits are also relatively unimportant in the geological record, while problems resulting from complex diagenesis associated with human activity means that slope deposits are difficult to study. Nevertheless Wilkinson (2003), using modern analogue data and Allen's (1991; 1992) archaeological observations, has described characteristic colluvial lithofacies of dry valley environments using a similar approach to that taken by Miall (1977; 1996) for fluvial deposits (Table 1). These lithofacies were used to analyse the stratigraphy of seven dry valley sequences in the Brighton area and suggested that from the base upwards, the typical facies succession is Fi→Gfu→Gcu→Fcu/Fnu/Fs→Modern soil (Wilkinson 2003). Although not all facies were present in every valley, the data nevertheless suggest that in the Brighton area, depositional environments changed from a stable unfarmed landscape as represented by a truncated palaeosol (Fi), through episodes of major instability caused by woodland clearance and initial agriculture as manifested by the deposition of fan gravels (Gfu,Gcu), to an agricultural environment in which fine-grained colluvium formed (Fcu, Fnu, Fs).

Table 1: Colluvial lithofacies found in dry valley environments (modified from Wilkinson 2003, table II, 733)

Code	Lithofacies	Depositional environment and diagenesis
Fi	Well sorted, red brown structureless, non-calcareous clays	Clays washed from local soils into bedrock hollows; non-calcareous residue of chemically weathered chalk; remnant Bt horizons
Fcu	Poorly sorted, unstratified calcareous silts containing small quantities of chalk granules	Diagenetically/plough-modified sheetwash and rill-derived sediment, originating from thin chalk soils on cultivated fields adjacent to the valley bottom; product of tillage of valley bottoms or immediately adjacent slopes
Fnu	Poorly sorted, unstratified non-calcareous silt/clays with small quantities of angular flint granules	Diagenetically/plough-modified sheetwash and rill-derived sediment originating from Brown-Earth soils or soils developing on Clay-with-Flint lithologies
Fs	Crudely stratified, thinly, or thickly bedded calcareous and non-calcareous silt/clays alternating with thinly bedded (chalk or flint) granular sands	Pulsed input of sediment derived from successive sheetwash/rill erosion of adjacent arable fields, or sediment deposited through low-energy alluvial processes along the valley axis. The presence of bedding structures indicates rapid burial and isolation from the plough soil
Gfu	Thinly bedded, unstratified granular and pebble-sized chalk and/or flint in silt matrix	Products of high-energy rill erosion of gravel-rich soils
Gcu	Thick beds of crudely stratified flint gravels of cobble to pebble-sized clasts, oriented perpendicular to valley sides	Sediments washed out of gullies and larger rills to form 'fans' in valley bottoms
Mu	Unstratified calcareous granular-rich marls	Periglacial sediments liberated from slopes by solifluction and mass-movement processes

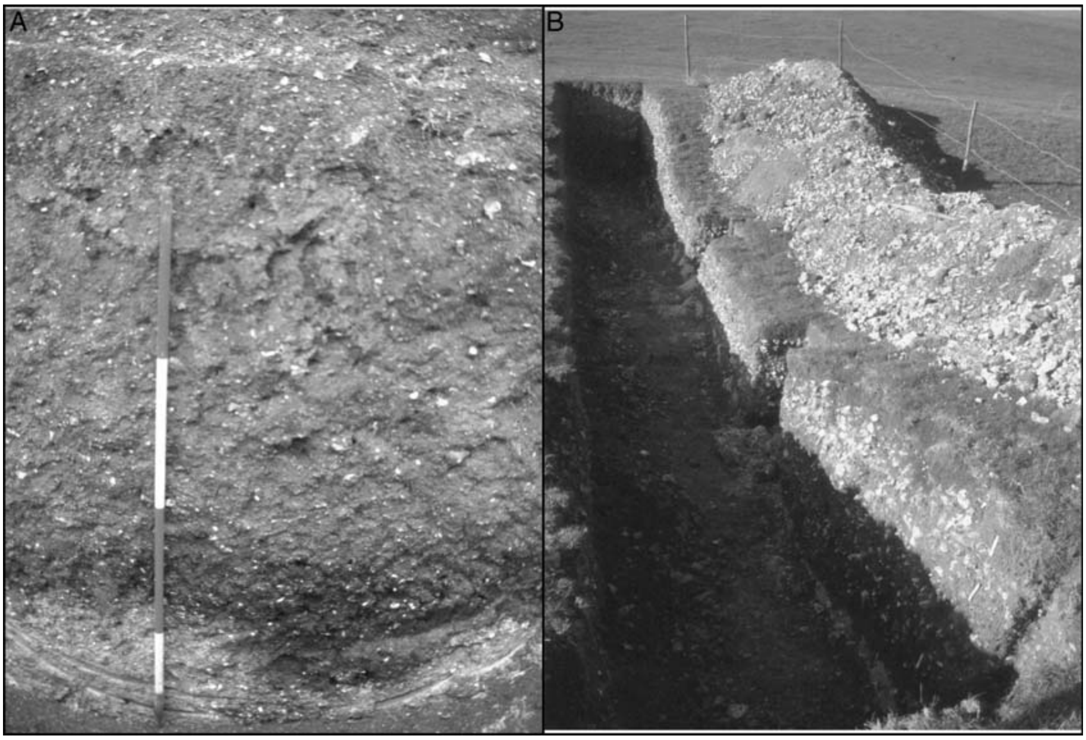


Figure 6: a. Fine-grained lithofacies and a subsoil hollow exposed in section at Toadeshole Bottom East, Brighton, East Sussex, and b. Coarse-grained lithofacies from Eastwick Barn valley bottom, Brighton, East Sussex

4. METHODS OF INVESTIGATION

4.1 Field methodologies

The field methodologies by which colluvial sequences have been investigated have varied depending upon the disciplinary background of the relevant researchers, the purpose of the investigation, and from the late 1980s onwards, on whether the investigation was as part of a commercial archaeological project or not.

Field investigation of dry valley sequences undertaken in the 1980s mainly followed the methodology developed by Bell (1981b; 1983) for his examination of sequences at Itford Bottom, East Sussex; Kiln Combe, East Sussex and Chalton, Hampshire (Figure 7). This approach consisted of machine excavating a 2 – 3m wide trench, cut perpendicular to the valley axis from the valley centre and extending up one of the slopes. The trench was dug to bedrock, one section face was hand cleaned and drawn, and descriptions were made of the strata exposed. Either one or two columns of samples for molluscan analysis were then taken through the entire stratigraphic sequence using the methods of Evans (1972, 41-44). Once sampling was complete, a 1 – 2m wide strip parallel to the cleaned trench edge was hand excavated to bedrock to recover artefacts and charcoal for ^{14}C dating. The three-dimensional locations of all recovered artefacts were recorded, while all excavated sediment was dry sieved to recover smaller artefacts. Allen (1983) employed a similar methodology in his investigations of dry valley sequences conducted in the 1980s in Sussex and the Isle of Wight, but in addition, samples for flotation processing, magnetic susceptibility measurement and micromorphological study[7] were also taken. Investigations conducted for purely Quaternary geological reasons during the same period were either sampling exercises of existing upstanding sections [e.g. Asham, East Sussex (Ellis 1985, 1986), Watcombe Bottom, Isle of Wight (Preece *et al* 1995)] or of test pits [e.g. Devil's Dyke, East Sussex (Ellis 1985, 1986)].

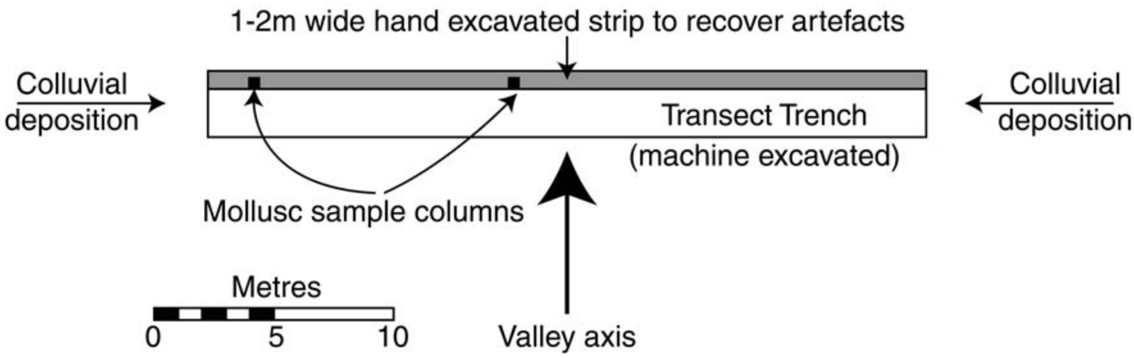


Figure 7. Schematic representation of Bell's (1981b; 1983) method of field investigation for dry valley deposits

Since the late 1980s, most investigations of colluvial sequences have been undertaken as part of projects preceding commercial or infrastructure development. The methods used by Bell and Allen in the early to mid-1980s were both time consuming and labour intensive, and were therefore unrealistic in a commercial situation, particularly where several colluvial sequences had to be investigated in rapid succession. As a result, studies conducted since the late 1980s have lacked hand excavated strips – previously the longest lasting aspect of fieldwork – and a greater emphasis has instead been placed on the use of ^{14}C dating [by this time, the accelerator mass spectrometry (AMS) method enabled smaller organic fragments to be dated] in providing a chronology [e.g. Dorchester bypass (Smith *et al* 1997), A27 Brighton bypass (Wilkinson 2002; Wilkinson *et al* 2002)]. In the case of the Brighton bypass example, the 1m wide strip was reduced to three 1m by 0.5m hand-excavated areas, but otherwise trenching and sampling techniques remained the same as those developed by Bell and Allen. It is worth noting that dry valley transect trench excavations post-dating 1997 are not mentioned in the published or grey literature, suggesting that this form of investigation is not part of recent archaeological field strategy.

A development of the 1990s and the present decade has been the use of borehole survey to examine the spatial distribution of dry valley sediments. During the 1980s, Allen (1983; 1994) had used boreholes to locate suitable locations for transect trenches, but subsequently he used manual borehole techniques to investigate and sample a Beaker age buried soil at Pyecombe, West Sussex (Allen 2005c). Preece (1998a) also employed boreholes at Holywell Coombe, both to plan trench locations, but also to model the stratigraphy infilling the valley. A total of 180 holes along nine transects was drilled with a

[7] As previously noted in Section 3.2, Bell (1983) had taken micromorphological samples from his site at Chalton.

petrol-powered percussion auger, and the data were used to map the extent of Late Glacial interstadial soils, Early Holocene tufa-filled channels and fossil landslips (Preece *et al* 1998). Swindle, Green and Branch (Swindle *et al* 2004; C.P. Green *et al* 2005) have also employed boreholes to investigate dry valley sediments in a similar manner to Preece. They drilled 113 boreholes through the upper Piddinghoe dry valley at Peacehaven, East Sussex, using an Eijkelkamp mechanical auger, in order to model sub-surface colluvial deposits prior to construction of a water treatment works.

4.2 Analytical methodologies

4.2.1 Sedimentological and pedological techniques

Descriptive data from colluvial sequences examined by archaeologists and geographers alike have been acquired exclusively in the field and, with the exception of kubiena boxes for micromorphological examination, cohesive undisturbed samples (e.g. 'monoliths') have rarely been obtained. However, columns of bulk samples taken primarily for molluscan analysis have been used for various sedimentary tests with the intention of fleshing out field descriptions. Bell (1981b; 1983), for example, used the hydrometer technique (Bouyoucos 1927), to determine grain size properties of the <2mm fraction. These data demonstrated that pre-medieval colluvium and palaeosols at Kiln Combe and Chalton were comprised of >70% silt, most of which was coarse, while later deposits and buried soils contained lower proportions of silt and a higher proportion of sand. Wilkinson (1993b) also carried out grain size tests on <2mm fraction of bulk samples of a Beaker/Middle Bronze Age palaeosol and Late Bronze Age/Early Iron Age colluvium from Toadeshole Bottom East, using the pipette technique and a laser granulometer. The resulting grain size distributions were dominated by silt-size particles (>60%), while the laser granulometer enabled a modal distribution in the 15 – 25µm (medium silt) size range to be identified. Both Bell (1983) and Wilkinson (2003) interpreted the results as indicating that later prehistoric palaeosols developed in loess, while colluvium of the same period was the product of erosion of loessic soils. An optical study of the mineralogy of the silt-size fraction was undertaken in the case of the Itford Bottom samples, demonstrating that the quantity of chlorite and hornblende is similar to that from loess in eastern Kent rather than that found in Sussex (Catt in Bell 1983).

Micromorphological studies of kubiena samples were carried out as part of Bell's studies at Chalton (Macphail in Bell 1983). However, Macphail also examined thin sections prepared from kubiena samples taken during Allen's investigations of Ashcombe Bottom (Allen 1984, 2005b), Bourne Valley (Macphail *et al* 1987) and Strawberry Hill, Wiltshire (Allen 1992, 1994), and also from a colluvial sequence at Brean Down (Macphail 1990), while Catt and Staines (1998) investigated thin sections from Holywell Coombe. In all cases the studies have enabled extra interpretive detail to be added to that provided from field description. For example Catt and Staines' (1998) analysis demonstrates that the 'Bølling' buried palaoesol at Holywell Coombe reflected stability for less than a century following an episode of waterlogging, while 'Allerød' buried palaeosols at the same site formed over longer timescales in seasonally waterlogged environments. Macphail's (1992) studies suggest that palaeosols developing within colluvium (e.g. Ashcombe Bottom) contain micromorphological evidence of cultivation in the form of vestiges of surface crusts formed in ard furrows, burnt soil fragments and charcoal, suggesting the ploughing in of chaff and manure. However, those at the base of colluvial sequences [e.g. Brean Down, (Macphail 1990)] appear to be vestiges of Brown Earths, which have secondary features resulting from cultivation. More recently Carter and Davidson (1998) have argued that micromorphological techniques cannot be used to *identify* past cultivation in colluvial deposits and palaeosols, but rather should be used to *explain* the impact of cultivation on soils which have been identified as having been cultivated by other means. The basis for their argument is that many micromorphological features cited in the literature as having resulted from arable agriculture (e.g. 'agricutans', mixed soil fabrics etc), form under other land-usage too, or are particular to soils of distinct grain-sizes and organic contents (Carter and Davidson 1998). Macphail (1998) has strenuously countered these arguments and suggests that an experienced researcher can identify cultivation on the basis of multiple micromorphological criteria. However, Usai (2001) (admittedly for a study area – Hadrian's Wall - outside the Southern Region) has firmly demonstrated that agricutans form in both cultivated and uncultivated soils.

Allen (Allen and Macphail 1987; Allen 1988; 1990; 1994), Wilkinson (1993b; Wilkinson *et al* 2002) and Sharp and Dowdeswell (1998) have all employed mineral magnetic techniques in their investigations of colluvial sequences. Wilkinson (1993b) and Sharp and Dowdeswell (1998) used magnetic studies in a conventional manner to assist in the interpretation of the sedimentary record by reconstructing weathering histories, confirming the presence and maturity of buried soils and assessing human impact (Dearing 1998). For example Sharp and Dowdeswell's (1998) frequency-dependent susceptibility data confirm Catt and Staines' (1998) thesis that Holywell Coombe's valley side 'Allerød' soil has undergone a greater degree of pedogenesis than any other Late Glacial buried soil in north-west Europe. Wilkinson's (1993b; Wilkinson *et al* 2002) low frequency magnetic susceptibility data from the base of a buried palaeosol at Toadeshole Bottom East on the other hand demonstrate *in situ* burning in a Middle Bronze Age palaeosol during a probable clearance episode. Allen (1988), on the other hand, has used magnetic susceptibility data as a proxy for past land use and environment. Based on over 1000 low-frequency magnetic readings from known present day environments in Sussex, he proposed magnetic parameters for arable, pasture and two types of woodland and then used these data as an analogue against which samples taken from dry valley sequences could be compared.

4.2.2 Biostratigraphic techniques

Given that dry valleys are features of chalk and limestone environments, colluvium that forms within them is commonly calcareous. Consequently, because of the good preservation of shell, mollusc analysis has been the preferred technique of palaeoenvironmental reconstruction. Indeed, as was discussed in Section 2.1, the reason for examining dry valley sediment sequences in the 1970s and 1980s was the lack of suitable pollen sampling locations in southern Britain (Kerney 1977; Bell 1981a, 1983; Ellis 1985, 1986). Therefore land snail data from colluvium have been *the* proxy used to reconstruct past environments of the chalkland until the very recent past. Distinct molluscan assemblages found in dry valley deposits and sediments trapped behind lynchets have demonstrated that unsorted, calcareous colluvium is associated with arable land use (Allen 1992), which in turn is one of the originators of the argument that colluvium is a product of cultivation (see Section 3.1). Nevertheless molluscan data from sites such as Figheldean, Wiltshire; Fordington Bottom, Dorchester, Dorset and Newbarn

Combe, Isle of Wight indicate that the dry valley slopes may have been used for more than one purpose at any one time (Allen 1992). Similarly molluscan data from sediments trapped behind lynchets and dry valley fills along the route of the Brighton bypass suggest that a mosaic of arable and pastoral environments existed in this Sussex downland during most archaeological periods from the Late Bronze Age onwards (Wilkinson *et al* 2002). Only at Turkdean, Gloucestershire (Wilkinson unpublished data) have assemblages of predominantly shade-loving molluscs been recovered from dry valley colluvium.

Small vertebrates and charred plant macro remains are the only other proxies to have been examined during archaeological work on colluvial sequences. Charred cereal grains were recovered from colluvial dry valley fills by Wilkinson (Wilkinson 2002), Allen (2005b) and Green *et al* (2005) during flotation or wet sieving of column samples taken from transect trenches. The presence of cereal remains in dry valley colluvium has been taken to be a further indication of the deposition of colluvium as a result of cultivation of the surrounding slopes (Green *et al* 2005), although the mechanism by which such macrofossils have entered the colluvial record is unclear. Wilkinson (2002) has suggested for charred macro botanical remains from Sweetpatch Bottom, East Sussex that they may have been a product of stubble burning. However, it is more likely, given the dominance of spikelets and other chaff in the assemblages, that the remains were incorporated in domestic debris spread on the fields (Wilkinson 2002). Nevertheless it is notable that in all cases where charred plant macro remain recovery from dry valley colluvium has been attempted, the macro fossil density is low. Despite processing over 1300 litres of sediment at Ashcombe Bottom, East Sussex, only one barley seed was recovered (Allen 2005b), while c 20 macrofossils were recovered from the c 800 litres processed from Sweetpatch Bottom (Wilkinson 2002). Small vertebrates have only been recovered in any great quantity from colluvium at Beer Head, Dorset (Wilkinson and Stewart in Tingle 1998), although they have been recorded from the Devil's Kneadingtrough site in Kent (Carreck in Kerney *et al* 1964). The prevalence of moderate quantities of bank vole (*Clethriomomys glariolus*) bones at Beer Head is somewhat contradictory to the interpretation made on the basis of the accompanying molluscan data, as it suggests that the Beer Head colluvium was deposited in a partially wooded environment (Wilkinson and Stewart in Tingle 1998).

Those examining colluvial basins from a Quaternary geological perspective have placed even greater emphasis on molluscan data as a means of palaeoenvironmental reconstruction. Shells from tufas buried by colluvial sediments in dry valleys in Kent have provided good palaeoenvironmental evidence for Early and Middle Holocene wooded marshes (Kerney *et al* 1964; Kerney *et al* 1980; Preece 1998b). Fine-grained solifluction deposits and buried soils of Devensian Late Glacial age have similarly been examined. The restricted, but distinctive molluscan assemblages found from this time interval have enabled a picture to be built up of cold, damp, treeless grassland environments in south-eastern England and Wessex during the Devensian Late Glacial stadial and interstadial(s) (Kerney 1963; Evans 1968; Kerney *et al* 1980; Preece 1998b; Wilkinson *et al* 2002). Despite the focus of Quaternary geologists on Mollusca as a palaeoenvironmental proxy, this has nevertheless been the only group to regularly employ other biostratigraphic techniques in investigating colluvial basins. Chandler (Kerney *et al* 1964) and Turner (Kerney *et al* 1980) examined pollen from samples taken from Devensian Late Glacial and Early Holocene contexts at Brook, Holywell Coombe and Wateringbury (all in Kent) as part of investigations of those sites in the 1960s. However, in the most detailed study of its type, Preece and Bridgland (1998b) engaged specialists in palynology, wood, mosses, fungal spores, insects, ostracods and vertebrates to investigate waterlogged Devensian Late Glacial and Early Holocene deposits buried by colluvium at Holywell Coombe. Nevertheless these same methods have not been applied to colluvial deposits themselves due to the poor preservation of these proxies in such oxidised and calcareous environments.

5. CHRONOLOGICAL REVIEW

In the first edition of their textbook, Bell and Walker (1993, 193) suggest that there are commonalities in the properties of colluvium found in dry valley environments. Firstly, colluvium frequently buries hollows that are cut into the chalk/limestone and that are thought, on the basis of morphology and molluscan analysis, to be fossil tree hollows of Early to Middle Holocene date (Bell 1981b; 1983; Wilkinson *et al* 2002). Secondly, the earliest colluvial layers are non-calcareous and are largely of re-worked loess and flint, and finally, later colluvium contains a higher stone content, the lithology of which is largely chalk/limestone. These second two phenomena are interpreted as resulting from initial erosion of soils developing in loess and later (Iron Age to post-Medieval) erosion of thin chalk/limestone rendzinas. The change in morphology of colluvial deposits occurs in the Bronze and Iron Ages, and is suggested by Bell and Walker (2004, 236) as being a result of an intensification of arable regimes associated with the introduction of autumn sowing of cereals (Jones 1981). The vast majority of the dry valley data obtained over the last half century supports these generalisations. The chronological implications are as follows: colluvial deposition did not commence until the Neolithic, it accelerated in the Bronze Age to peak in the Romano-British period, erosion rates then declined in the medieval and post-medieval periods, only to increase following mechanisation in the 20th century. However, there are enough exceptions to argue against the application of any universal model.

Evidence of Holocene erosion prior to the Neolithic is rarely found in the colluvial record and the only published example to date, other than infill of the Fir Tree Farm shaft discussed in Section 1.3.3, is Unit 5b at Holywell Coombe, Kent (Preece *et al* 1998). This 0.38m thick Mesolithic sequence is only found in one of the many sections investigated at the site and is therefore undoubtedly a local phenomenon. Also, a soil developed in Unit 5b (the palaeosol is Unit 5a), which, micromorphological characteristics suggest, evolved over a relatively long period of time (Catt and Staines 1998), perhaps indicating that deposition of Unit 5b was a brief event. Nevertheless the very presence of a colluvial deposit predating 4960 – 4320 cal. BC (OxA 2091, 5620±90 BP) suggests that colluvium did accumulate in Holocene climates in southern England as a result of non-anthropogenic processes. It is possible that some of the colluvium investigated by Tingle at Beer Head, Dorset also dates from the Mesolithic on the basis of mollusc assemblages that are comparable to Kerney's (1977) Middle Holocene zone d^2 and the presence of small vertebrates characteristic of woodland environments (Tingle 1998). However, there are no absolute dates for the site, while flint artefacts found in the sequence would appear to be of Neolithic date. As has been outlined in Section 3.2, in all other dry valleys that have been examined to date, the Mesolithic period is represented by palaeosols, fills of tree-throw hollows and tufa. Given that palaeosols suggest stable landscapes, that tree throw hollows normally form by natural processes in woodland environments, and that tufa formation is a deposit formed as a result of climate processes, this evidence attests to the lack of impact of Mesolithic people on the geomorphology of southern Britain.

There is more evidence for deposition of colluvium in the Neolithic and Beaker periods than for the Mesolithic. However, perhaps surprisingly given the number of monumental structures such as causewayed enclosures, longbarrows, cursae and henges in southern England from 3000 BC onwards, this evidence is not widespread. Writing in 1992, Allen documented four dry valleys sites containing Neolithic colluvium: Middle Farm, Dorset; Strawberry Hill, Wiltshire; Redcliff and Newbarn Combe, both on the Isle of Wight. To these can be added Ashcombe Bottom (Allen 2005b), Toadeshole Bottom East and Sweetpatch in East Sussex (Wilkinson 2002; Wilkinson *et al* 2002), and perhaps Holywell Coombe, Kent (Preece *et al* 1998). The colluvial deposits of Neolithic/Beaker age forming in these dry valleys have several commonalities, namely:
a. The deposits are relatively thin (<0.35m);
b. A palaeosol has usually developed in the colluvium;
c. The colluvium is usually of facies Fnu (Table 1), although stone content is often low and mollusc shell preservation is commonly poor;
d. Where absolute dates have been obtained (almost always of charcoal in the palaeosols), they indicate that soil formation and sediment deposition relate to the second half of the Neolithic or the Beaker period [e.g. 2140 – 1690 cal. BC (OxA 2995, 3560±80 BP) at Sweetpatch (Wilkinson 2002) and 2900 – 2250 cal. BC (OxA 3077, 4020±90 BP) at Toadeshole Bottom East (Wilkinson *et al* 2002)]. Similarly artefacts recovered from the colluvial sequences are usually of Late Neolithic or Beaker Age.

Taken together, the evidence of Neolithic colluvium from dry valleys in southern England suggests a minimal impact of people on natural geomorphological processes in the Early Neolithic. Such a conclusion is perhaps of little surprise given that molluscan evidence suggests that early to middle fourth millennium BC causewayed enclosures were either built in woodland clearings (Thomas 1982; Evans and Rousse in Sharples 1991, 119 – 120) or species-rich grassland scrub (Fishpool in Whittle *et al* 1999, 127), and may lend support to those who argue that cereal cultivation was undertaken on a relatively small scale and for ritual rather than subsistence purposes (e.g. Fairbairn 2000). Despite a lack of evidence for charred cereals in the latter part of the Neolithic (C. Stevens, personal communication, 2006), this is the period when people seem to have begun to have an effect on depositional processes. Nevertheless the small quantities of colluvium of this date found in dry valleys and the fact that there is evidence of soil formation in most deposits of this period, argue for small scale and localised impact.

Dry valleys would appear to have been of particular significance in the Beaker period. Archaeological work undertaken on chalk and limestone 'uplands' has generally failed to locate settlement of Beaker age, even though monumental sites such as henges are well known, while burials have also been found both in and outside barrows. However, as noted in Section 2.2, Allen (1994; 2005c) has suggested that dry valleys were used for settlement during the this period in preference to the surrounding hills. His evidence is >12 sites where Beaker finds have been buried beneath colluvium, including two sites (Kiln Combe and Ashcombe Bottom, East Sussex) where more than 50 Beaker sherds were found (Allen 2005c). Allen (2005c) argues that in the Beaker period, soils on the slopes of dry valleys would have been both thick and fertile, primarily because little erosion had occurred, and therefore these areas were cultivated, while the valley bottoms were used for settlement and pasture.

While evidence from dry valleys suggests that deposition of colluvium during the Neolithic and Beaker period was on a small scale, the situation appears to change dramatically during the Bronze Age. What little palynological evidence there is from areas adjacent to chalk and limestone hills in southern England suggests widespread woodland clearance and cultivation of the cleared landscapes during the Middle and Later Bronze Ages (e.g. Thorley 1981; Scaife 1982; Waton 1982b; Waller and Hamilton 2000). There are many other indicators of significant social and economic changes during the Bronze Age which suggest a more stratified society with a greater reliance on cultivated and reared food (Champion 1999). These changes are reflected in the dry valley records: substantial Middle and Late Bronze Age colluvial deposits are found in dry valley deposits, suggesting that a key environmental threshold must have been crossed around this time. Allen (1988; 1991) has suggested, on the basis of data produced by Jones (1981) and Reynolds (1981), that the prompt for erosion was the introduction of autumn-sown cereals. Indeed Boardman (2003) argues that such winter cereals are a major cause of erosion on the South Downs at the present day. However, as the palynological data indicate, it was probably also the case that new areas of woodland were opened up to provide more land for food production [i.e. the 'extensification' of Wilkinson and Stevens (2003, 145)].

It has been suggested that the combination of agricultural intensification, extensification and the introduction of winter-grown cereals not only increased the quantity of colluvial sediments that were input into dry valleys, but also led to changes in the character of those deposits (Wilkinson 2003). For example gravel strata that are indicative of high-energy deposition at gully mouths [i.e. facies Gfu and Gcu (Table 1)] were found underlying finer Bronze Age colluvium in five of the seven dry valleys investigated on the route of the A27 Brighton Bypass (Wilkinson *et al* 2002; Wilkinson 2003). Even though Allen (1992) suggests that such gravel strata were not deposited during any one chronological period, he presents data for two further dry valleys in Dorset (Middle Farm and Fordington Bottom), where Bronze Age gravels have been found. It is therefore possible that human modification of the landscape in the second half of the Bronze Age resulted in intense episodes of erosion that are very rarely seen in the post-Bronze Age stratigraphic record (Wilkinson 2003)[8]. Nevertheless in volume terms most colluvial deposits forming prior to the Late Bronze Age date are finer grained and of facies Fnu, suggesting that colluvium in the second millennium BC was largely derived from Brown Earth soils that had developed in loess.

During the Late Bronze Age and Early Iron Age the lithology of gravel clasts incorporated in fine-grained colluvium changed from predominantly flint (facies Fnu) to chalk (facies Fcu) (Allen 1992; Wilkinson 2003). Favis-Mortlock *et al* (1997) have used these data to argue that soils developed in loess on valley sides must have been removed by the Late Bronze Age. There is little trace of the 2m of loess that Catt (1978) suggests once carpeted southern Britain as it is certainly not all locked up in the relatively meagre Middle

[8] Gravel strata post-dating the Bronze Age are not found in the dry valleys along the route of the A27 Brighton Bypass, but Allen (1992) notes gravel fans of Roman date at Duxmore and medieval date at Newbarn Combe, both on the Isle of Wight.

Bronze Age and earlier dry valley deposits, although as previously noted it may have been reworked into rivers.

The Iron Age and Romano-British periods are characterised by continuing deposition of fine-grained (facies Fcu and Fs) colluvial sediments into dry valleys, and indeed in many basins deposits of this age are the thickest Holocene fills. Allen's (1992, table 4.1, 40 – 41) survey of colluvial stratigraphy suggests that palaeosols of Iron Age and Romano-British date are rare in dry valley sequences (only Strawberry Hill in Wiltshire and Newbarn Combe on the Isle of Wight), suggesting that dry valley erosion occurred too frequently during this time frame for pedogenesis to occur. Indeed, as was discussed in Section 1.3.2, the development of Celtic field systems of lynchets from the Late Bronze Age onwards may have been partly to counter problems of soil loss (Bell 1981b, 1983). Wilkinson (1993b; 2003) has noted that mollusc assemblages associated with Romano-British colluvium in particular are characterised by high frequencies of *Pupilla muscorum*, a species that is associated with dry, exposed and disturbed grassland at the present day (Kerney 1999, 103). The dry valley record therefore suggests that chalk downland (and probably oolitic limestone hills too) was intensively exploited during the Iron Age and Romano-British periods, that arable cultivation was intense and that intensity of exploitation increased under Roman administration.

Whereas colluvium of Romano-British date is ubiquitous in dry valleys where lynchets have not intervened, colluvial deposits of medieval age occur on a more variable and localised basis (Wilkinson 2003). Several dry valleys investigated by Allen (1992; 1994) contained thin colluvial layers dating to the medieval period, most of which were located in the top 0.5m of the stratigraphy, hence forming the parent material for present day soils. All three of Bell's (1981b; 1983) dry valley sites contained medieval colluvial deposits, which in the case of Chalton and Itford Bottom were thin and form the parent material for the present day soil. Only at Kiln Combe were more extensive medieval deposits noted, and this because the dry valley trench was located adjacent to a deserted medieval settlement (Drewett 1982; Bell 1983). Wilkinson (2002; 2003) has argued on the basis of data from the A27 Brighton Bypass that in contrast to the Romano-British period, mosaic environments of arable, pasture and woodland characterised the South Downs in the early medieval period and that consequently depositional processes varied between different valley systems. The molluscan record relating to deposits of the later Middle Ages in the Brighton area suggests a greater vegetation cover and is perhaps therefore evidence for the well known change in economy on the South Downs and elsewhere to commercial sheep rearing for the wool trade (c.f. Pelham 1934).

Perhaps surprisingly, given the review of Section 2.5, there is very little evidence for post-medieval and recent deposition of colluvial sediments in dry valleys. Where it has been possible to collect artefacts during dry valley excavations, those of post-medieval date are usually mixed with medieval ceramics [e.g. Itford Bottom and Chalton (Bell 1983)]. These data suggest that the present plough soil, which is on average 0.25 – 0.30m thick, is developing in medieval and post-medieval strata, suggesting that the latter must be <0.30m thick. In exceptional cases discrete sedimentary events are preserved in the colluvial record, as for example is the case at Cockroost Bottom, East Sussex where a palaeosol developed in Late Bronze Age/Early Iron Age colluvium is buried by 0.10m of fine-grained colluvium that resulted from a single storm in October 1987 (Wilkinson *et al* 2002).

6. CONCLUSIONS

In much the same way as seriation depicts the chronology of an artefact type as a 'battleship curve' (Brainerd 1951; Robinson 1951), the history of archaeological studies of colluvium can be viewed in the same way and the present situation (2007) corresponds to the extreme end of the stern. In other words, as the dates of citations in the previous pages make obvious, current archaeological investigations of colluvium in southern England are few. As was noted in Section 2.2, one reason for the decline in dry valley studies is the changes in how, when and where archaeological works are carried out that took place following the introduction of PPG 16 in the early 1990s. In most cases, dry valleys are blank areas on archaeological distribution maps [as for example represented by Historic Environment Records], and given that the distribution and nature of known sites is a major determinant in deciding archaeological strategies in advance of development, it is unlikely that dry valleys would be seen as a priority. The reason that this state of affairs has impacted on dry valley investigations so noticeably is that archaeological works in advance of development comprise over 90% of the archaeological fieldwork that is carried out in England at the present day. There are, however, other reasons for the decline in the number and scope of investigations of colluvial deposits. One factor, which is also related to the changing nature of British archaeology in the 1990s, is expense. A team of perhaps half a dozen people working for a couple of weeks or more is required in order to undertake fieldwork of sufficient scope to record and sample a colluvial sequence. Post-fieldwork assessment and analysis is again extremely time consuming if the most informative data are to be obtained. In other words the investigation of a single dry valley sequence may cost several tens of thousands of pounds when undertaken commercially (and indeed in academic institutions too, given recent changes in research funding). Also, some of the optimism that appeared in the wake of Bell's investigations of the 1970s and 1980s and which foresaw dry valley sequences as providing detailed evidence of past land use and environment evidence in areas in which palynology did not work, has now dissipated. In part this was because of the realisation that, except in exceptional circumstances, such as where multiple palaeosols are preserved, chronological control is always likely to be of low resolution (Wilkinson 1993a, 2003). However, it is also the case that molluscs, the biological proxy most used in investigating dry valley colluvium, are only useful for palaeoenvironmental reconstruction at a local scale, while snail shell data are not a proxy evidence for past vegetation except in the most general terms (see Wilkinson and Stevens 2003, 111 – 126). Lastly, since the 1980s, palynologists have developed a renewed interest in downland environments and this has spurred a new series of investigations that have resulted in detailed vegetation histories for certain downland catchments (e.g. Thomas and Rackham 1996; Waller and Hamilton 2000).

Despite the arguments made above, dry valley sequences do provide an important archaeological record. As has been discussed in Sections 2 and 5, dry valley colluvium is an extremely useful proxy for past erosion. Indeed Boardman (2003) has used the dry valley colluvial data collected by Allen, Bell and Wilkinson as a scale against which modern erosion on the South Downs can be compared, but also as warning with regard to the sustainability of the present soil resource. The dry valley colluvial record is, then, extremely sensitive to land use changes that occur on its surrounding slopes, while the fact that the colluvial sequences of dry valleys are so different reflects variation of erosion and therefore land use history (Wilkinson and Stevens 2003). As has pointed out in Section 3.3, even over the short distances between sites along the Brighton bypass, no two dry valley sequences were identical, while there was also considerable stratigraphic variation within individual dry valleys (Wilkinson 2003). This makes the study of dry valley sequences extremely useful in any landscape archaeological project, as their study is often the only way of determining *where* the different cultivation and stock rearing activities seen in other proxies took place, and indeed what affect the different activities had on the landscape. Allen's (1994; 2005c) work on Beaker settlements located in dry valleys also demonstrates that archaeological sites do occur in colluvial sequences in such locations and indeed that during this period dry valley sites were preferentially selected for settlement. These data give the lie to the statement made in the first paragraph of this section that dry valleys are archaeological blanks. Given that burial of Beaker sites is often beneath >1m of colluvium, these settlements are unlikely to be detectable by any conventional methods of archaeological prospection (aerial photography, magnetometry, resistivity and fieldwalking) (Allen 1991, 2005c). However, Beaker sites are not unique in this respect and Bronze Age, Romano-British and even medieval sites have been found buried beneath colluvium in dry valleys (Bell 1983; Wilkinson 2002; Wilkinson *et al* 2002). The implications therefore of not investigating dry valley sequences are obvious: these areas will remain blanks, will therefore not be archaeologically tested prior to development, and so on. The question then is not so much whether dry valleys should be investigated, but rather how. In this respect the staged approach used at the Piddinghoe dry valley near Peacehaven (Green *et al* 2005; Swindle *et al* 2004) may provide a way out of this vicious circle.

7. BIBLIOGRAPHY

Allen, M J 1983 *Sediment analysis and archaeological data as evidence of the palaeo-environments of early Eastbourne: the Bourne Valley excavation*. Unpublished BSc Dissertation, Institute of Archaeology, University of London: London.

Allen, M J 1984a 'Ashcombe Bottom excavations'. *Sussex Archaeological Society Newsletter* 44, 406.

Allen, M J 1984b *Ashcombe Bottom excavations, AB 84: first interim report.* Lewes Archaeological Group: Lewes.

Allen, M J 1988 'Archaeological and environmental aspects of colluviation in South East England', in Groenman van Waateringe, W and Robinson, M (eds) *Man made soils*, 67-92. Oxford: British Archaeological Reports International Series 410

Allen, M J 1990 'Magnetic susceptibility', in Bell, M G (ed) *Brean Down: excavations 1983-1987*, 197-202. London: English Heritage Archaeological Report 15

Allen, M J 1991 'Analysing the landscape: a geographical approach to archaeological problems', in Schofield, A J (ed) *Contributions to ploughzone archaeology*, 39-57. Oxford: Oxbow Monograph 4

Allen, M J 1992 'Products of erosion and Prehistoric land-use of the Wessex chalk', in Bell, M G and Boardman, J (eds) *Past and present soil erosion: archaeological and geographical perspectives*, 37-52. Oxford: Oxbow Monograph 22

Allen, M J 1994 *The land-use history of the southern English chalklands with an evaluation of the Beaker period using environmental data: colluvial deposits as environmental and cultural indicators*. Unpublished Ph.D thesis, Department of Archaeology, University of Southampton: Southampton

Allen, M J 1995 'The prehistoric land-use and human ecology of the Malling-Caburn Downs'. *Sussex Archaeological Collections* 133, 19-43

Allen, M J 2000 'Piggledene Bottom: dry valley', in Fowler, P J (ed) *Landscape plotted and pieced: landscape history and local archaeology in Fyfield and Overton, Wiltshire*, 209-211. London: Society of Antiquaries

Allen, M J 2005a 'Beaker and Early Bronze Age activity, and a possible Beaker valley entrenchment in Cuckoo Bottom, near Lewes, East Sussex'. *Sussex Archaeological Collections* 143, 35-45

Allen, M J 2005b 'Beaker occupation and development of the downland landscape at Ashcombe Bottom, nr Lewes, East Sussex'. *Sussex Archaeological Collections* 143, 7-33.

Allen, M J 2005c 'Beaker settlement and environment on the chalk downs of southern England'. *Proceedings of the Prehistoric Society* 71, 219-246

Allen, M J 2005d 'Considering prehistoric environmental changes on the Marlborough Downs', in Brown, G, Field, D and McOmish, D (eds) *The Avebury landscape: aspects of the field archaeology of the Marlborough Downs*, 77-86. Oxford: Oxbow

Allen, M J and Green, M 1998 'The Fir Tree Field Shaft: the date and archaeological and palaeoenvironmental potential of a chalk swallowhole feature'. *Proceedings of the Dorset Natural History and Archaeology Society* 120, 25-37

Allen, M J and Macphail, R I 1987 'Micromorphology and magnetic susceptibility studies: their combined role in interpreting archaeological soils and sediments', in Fedoroff, N, Bresson, L M and Courty, M-A (eds) *Soil micromorphology*, 669-678. Paris: L'Association Français pour l'Etude du Sol

Ashbee, P, Bell, M G and Proudfoot, E 1989 *Wilsford Shaft: excavations 1960-62*. London: English Heritage Archaeological Report 11

Avery, B W 1980 *Soil classification for England and Wales (higher categories)*. Harpenden Soil Survey of England and Wales

Ballantyne, C K and Harris, C 1994 *The periglaciation of Great Britain*. Cambridge: Cambridge University Press

Barber, L, Gardiner, M and Rudling, D 2002 'Excavations at Eastwick Barn', in Rudling, D (ed) *Downland landscape and settlement: the archaeology of the Brighton by-pass*, 107-140. London: University College London Field Archaeology Unit Monograph 1

Bates, M R, Parfitt, S A and Roberts, M B 1998 'Palaeolithic archaeology and Quaternary stratigraphy of the West Sussex coastal plain', in Murton, J B, Whiteman, C A, Bates, M R, Bridgland, D R, Long, A J, Roberts, M B and Waller, M P (eds) *The Quaternary of Kent and Sussex*. Field guide, 165-167. London: Quaternary Research Association

Bell, M G 1981a 'Valley sediments and environmental change', in Jones, M and Dimbleby, G W (eds) *The environment of man: the Iron Age to Anglo-Saxon period*, 75-91. Oxford: British Archaeological Reports British Series 87

Bell, M G 1981b *Valley sediments as evidence of Prehistoric land-use: a case study based on dry valleys in south-east England*. Unpublished Ph.D thesis, Institute of Archaeology, University of London

Bell, M G 1982 'The effects of land-uses and climate on valley sedimentation', in Harding, A F (ed) *Climatic change in later prehistory*, 127-147. Edinburgh University Press: Edinburgh.

Bell, M G 1983 'Valley sediments as evidence of Prehistoric land-use on the South Downs'. *Proceedings of the Prehistoric Society* 49, 119-150

Bell, M G 1990a *Brean Down excavations 1983-1987*. London; English Heritage Archaeological Report 15

Bell, M G 1990b 'Sedimentation rates in the primary fills of chalk-cut features', in Robinson, D E (ed) *Experimentation and reconstruction in environmental archaeology*, 237-248. Oxford: Oxbow

Bell, M G 1992 'The prehistory of soil erosion', in Bell, M G and Boardman, J (eds) *Past and present soil erosion: archaeological and geographical perspectives*, 21-36. Oxford: Oxbow Monograph 22

Bell, M G, Allen, M J, Smith, R W and Johnson, S forthcoming 'Mollusc and sedimentary evidence for the environment of Hambledon Hill and its surroundings', in Mercer, R and Healy, F (eds) *Hambledon Hill*. Swindon: English Heritage

Bell, M G and Boardman, J (eds) 1992 *Past and present soil erosion*. Oxford: Oxbow Monograph 22

Bell, M G, Caseldine, A, Caseldine, C, Crabtree, K, Maguire, D and Maltby, E 1984 'Environmental archaeology in South-west England', in Keeley, H C M (ed) *Environmental archaeology: a regional review* (Occasional Paper 6), 131-151. London; Directorate of Ancient Monuments and Historic Buildings, Department of the Environment

Bell, M G and Walker, M J C 1993 *Late Quaternary environmental change: human and physical perspectives*. First Edition. London: Longman

Bell, M G and Walker, M J C 2004 *Late Quaternary environmental change: human and physical perspectives*. Second Edition. London: Pearson Prentice Hall

Bennett, P 1988 'Archaeology and the Channel Tunnel'. *Archaeologia Cantiana* 106, 1-24

Bennett, P, Ouditt, S and Rady, J 1998 'The prehistory of Holywell Combe', in Preece, R C and Bridgland, D R (eds) *Late Quaternary environmental change in north-west Europe: excavations at Holywell Coombe, south-east England*, 263-314. London: Chapman & Hall

Boardman, J 1990 'Soil erosion on the South Downs: a review', in Boardman, J, Foster, I D L and Dearing, J A (eds) *Soil erosion on agricultural land*, 87-105. Chichester: John Wiley

Boardman, J 1992 'Current erosion on the South Downs: implications for the past', in Bell, M G and Boardman, J (eds) *Past and present soil erosion: archaeological and geographical perspectives*, 9-20. Oxford: Oxbow Monograph 22

Boardman, J 2003 'Soil erosion and flooding on the South Downs, southern England 1976-2001'. *Transactions of the Institute of British Geographers* 28, 176-196

Boardman, J and Bell, M G 1992 'Past and present soil erosion: linking archaeology and geomorphology', in Bell, M G and Boardman, J (eds) *Past and present soil erosion: archaeological and geographical perspectives*, 1-8. Oxford: Oxbow Monograph 22

Boardman, J and Favis-Mortlock, D T 1999 'Frequency-magnitude distributions for soil erosion, runoff and rainfall - a comparative analysis'. *Zeitschrift für Geomorphologie* Supplementband, 115, 51-70

Boardman, J and Robinson, D A 1985 'Soil erosion, climatic vagary and agricultural change on the Downs around Lewes and Brighton, autumn 1982'. *Applied Geography* 5, 243-258

Boggs, S 1987 *Principles of sedimentology and stratigraphy* Second. New Jersey: Prentice-Hall

Bouyoucos, G J 1927 'The hydrometer as a new method for the mechanical analysis of soils'. *Soil Science* 23, 343-353

Brainerd, G W 1951 'The place of chronological ordering in archaeological analysis'. *American Antiquity* 16, 301-313

Branch, N P, Canti, M, Clark, P and Turney, C 2005 *Environmental archaeology: theoretical and practical approaches*. London: Hodder Arnold

Bronk Ramsey, C 2005 *OxCal 3.10*. Research Laboratory for Archaeology, University of Oxford

Brown, A G 1992 'Slope erosion and colluviation at the floodplain edge', in Bell, M G and Boardman, J (eds) *Past and present soil erosion: archaeological and geographical perspectives*, 77-87. Oxford: Oxbow Monograph 22

Brown, A G 1997 *Alluvial geoarchaeology: floodplain archaeology and environmental change*. Cambridge: Cambridge University Press

Bull, A J 1936 'Studies on the geomorphology of the South Downs'. *Proceedings of the Geologists' Association* 47, 99-129

Bull, A J 1940 'Cold conditions and landforms in the South Downs'. *Proceedings of the Geologists' Association* 51, 63-71

Butzer, K W 1982 *Archaeology as Human Ecology*. Cambridge: Cambridge University Press

Carter, S P and Davidson, D A 1998 'An evaluation of the contribution of soil micromorphology to the study of ancient arable agriculture'. *Geoarchaeology* 13, 535-547

Catt 1978 'The contribution of loess to soils in lowland Britain', in Limbrey, S and Evans, J G (ed) *The effect of man on the landscape: the lowland zone*, 12-21. London: Council for British Archaeology Research Report 21

Catt, J A and Staines, S J 1998 'Petrography of sediments and buried soils', in Preece, R C and Bridgland, D R (eds) *Late Quaternary environmental change in north-west Europe: excavations at Holywell Coombe, south-east England*, 69-86. London: Chapman and Hall

Champion, T 1999 'The later Bronze Age', in Ralston, I and Hunter, J (eds) *The archaeology of Britain: an introduction from the Upper Palaeolithic to the Industrial Revolution*, 95-112. London: Routledge

Chandler, R J, Kellaway, G A, Skempton, A W and Wyatt, R J 1976 'Valley slope sections near Bath, Somerset'. *Philosophical Transactions of the Royal Society of London* A 283, 527-556

Crabtree, K 1990 'Experimental earthworks in the United Kingdom', in Robinson, D E (ed) *Experimentation and reconstruction in environmental archaeology*, 225-236. Oxford: Oxbow

Davidson, D A, Grieve, I C, Tyler, A N, Barclay, G J and Maxwell, G S 1998 'Archaeological sites: assessment of erosion risk'. *Journal of Archaeological Science* 25, 857-860

De la Beche, H T 1839 *Report on the geology of Cornwall, Devon and west Somerset*. London: Memoirs of the Geological Survey

De Ploey, J 1971 'Liquefaction and rainwash erosion'. *Zeitschrift für Geomorphologie* 15, 491-496

De Ploey, J 1984 'Hydraulics of runoff and loess loam deposition'. *Earth Surface Processes and Landforms* 9, 533-539

Dearing, J A 1998 'Magnetic susceptibility', in Walden, J, Oldfield, F and Smith, J P (eds) *Environmental magnetism: a practical guide*, Technical Guide 6, London: Quaternary Research Association

Department of the Environment 1990 *Archaeology and planning*. London: Department of the Environment Planning and Policy Guidance 16

Dincauze, D F 2000 *Environmental archaeology: principles and practice*. Cambridge: Cambridge University Press

Drewett, P 1982 *The archaeology of Bullock Down, Eastbourne, East Sussex: the development of a landscape*. Lewes: Sussex Archaeological Society Monograph 1

Ellis, C 1985 'Flandrian mollusc biostratigraphy and its application to dry valley infill deposits in East Sussex', in Fieller, N R J, Gilbertson, D D and Ralph, N G A (eds) *Palaeobiological investigations: research design, methods and data analysis*, 157-166. Oxford: British Archaeological Reports International Series 266

Ellis, C 1986 'The Post glacial molluscan succession of the South Downs dry valleys', in Sieveking, G d and Hart, M B (eds) *The scientific study of flint and chert*, 175-184. Cambridge: Cambridge University Press

Evans, J G 1966 'Late glacial and post glacial sub-aerial deposits at Pitstone, Buckinghamshire'. *Proceedings of the Geologists' Association* 77, 347-364

Evans, J G 1968 'Periglacial deposits in the Chalk of Wiltshire'. *Wiltshire Archaeological and Natural History Magazine* 63, 12-27

Evans, J G 1971 'Habitat change on the calcareous soils of Britain: the impact of Neolithic man', in Simpson, D D A (ed) *Economy and settlement in Neolithic and early Bronze Age Britain and Europe*, 1-26. Leicester: Leicester University Press

Evans, J G 1972 *Land snails in archaeology*. London: Seminar Press

Evans, J G 1990 'Notes on some late Neolithic and Bronze Age events in long barrow ditches in southern and eastern England'. *Proceedings of the Prehistoric Society* 56, 111-116

Evans, J G, French, C and Leighton, D 1978 'Habitat change in two Late-glacial and post-glacial sites in southern Britain: the molluscan evidence', in Limbrey, S and Evans, J G (eds) *The effect of man on the landscape: the lowland zone*, 63-75. London: Council for British Archaeology Research Report 21

Evans, J G and Smith, I F 1983 'Excavations at Cherhill, North Wiltshire, 1967'. *Proceedings of the Prehistoric Society* 49, 43-118

Evans, J G and Valentine, K W G 1974 'Ecological changes induced by Prehistoric Man at Pitstone, Buckinghamshire'. *Journal of Archaeological Science* 1, 343-351

Fairbairn, A S 2000 'On the spread of plant crops across Neolithic Britain, with special reference to southern England', in Fairbairn, A S (ed) *Plants in Neolithic Britain and beyond* (Neolithic Studies Group Seminar Papers 5), 107-121. Oxford: Oxbow

Favis-Mortlock, D T, Boardman, J and Bell, M G 1997 'Modelling long-term anthopogenic erosion of a loess cover, South Downs, UK'. *The Holocene* 7, 79-90

Foster, G R 1990 'Process-based modelling of soil erosion by water on agricultural land', in Boardman, J, Foster, I D L and Dearing, J A (eds) *Soil erosion on agricultural land*, 420-445. Chichester: John Wiley

French, H M 1972 'Asymetrical slope development in the Chiltern Hills'. *Biuletyn Peryglacjalny* 21, 51-73

French, H M 1973 'Cryopediments on the chalk of southern England'. *Biuletyn Peryglacjalny* 22, 149-156

French, H M and Lewkowicz, A G 1981 'Periglacial slopewash investigation, Banks Island, Western Arctic'. *Biuletyn Peryglacjalny* 28, 33-45

Govers, G 1991 'Rill erosion on arable land in central Belgium: rates, controls and predictability'. *Catena* 18, 133-155

Govers, G, Quine, T A, Desmet, P J J and Walling, D E 1996 'The relative contribution of soil tillage and overland flow erosion to soil redistribution on arable land'. *Earth Surface Processes and Landforms* 21, 929-946

Green, C P, Swindle, G E, Branch, N P, Palmer, A P, Vaughan Williams, A, Austin, P and Keen, D H 2005 *A reconstruction of the environmental history of a dry valley at Peacehaven, East Sussex, UK*. Unpublished report, Archaeoscape, Department of Geography, Royal Holloway, University of London

Green, G W 1992 *British Regional Geology: Bristol and Gloucester region*. London: Her Majesty's Stationary Office

Green, M 2000 *A landscape revealed. 10,000 years on a chalkland farm*. Stroud:Tempus

Green, M and Allen, M J 1997 'An early prehistoric shaft on Cranborne Chase'. *Oxford Journal of Archaeology* 16, 1-32

Harris, C 1987 'Solifluction and related periglacial deposits in England and Wales', in Boardman, J (ed) *Periglacial processes and land-forms in Britain and Ireland*, 209-224. Cambridge: Cambridge University Press

Jones, M K 1981 'The development of crop husbandry', in Jones, M K and Dimbleby, G W (eds) *The environment of man: the Iron Age to the Anglo-Saxon period*, 95-127. Oxford: British Archaeological Reports British Series 87

Keeley, H C M (ed) 1984 *Environmental archaeology: a regional review*. London: Directorate of Ancient Monuments and Historic Buildings, Department of the Environment

Keeley, H C M (ed) 1987 *Environmental archaeology: a regional review*. Volume II. London: Historic Buildings and Monuments Commission for England

Kerney, M P 1963 'Late glacial deposits on the chalk of south-east England'. *Philosophical Transactions of the Royal Society of London* B 246, 203-254

Kerney, M P 1965 'Weichselian deposits in the Isle of Thanet, east Kent'. *Proceedings of the Geologists' Association* 76, 269-274

Kerney, M P 1977 'A proposed zonation scheme for Late-glacial and Postglacial deposits using land Mollusca'. *Journal of Archaeological Science* 4, 387-390

Kerney, M P 1999 *Atlas of the land and freshwater molluscs of Britain and Ireland.* Chichester: Harley Books

Kerney, M P, Brown, E H and Chandler, T J 1964 'The Late-glacial and Postglacial history of the chalk escarpment near Brook, Kent'. *Philosophical Transactions of the Royal Society of London* B 248, 135-204

Kerney, M P, Preece, R C and Turner, C 1980 'Molluscan and plant biostratigraphy of some late Devensian and Flandrian deposits in Kent'. *Philosophical Transactions of the Royal Society of London* B 291, 2-43

Kwaad, F J P M 1977 'Measurement of rainsplash erosion and the formation of colluvium beneath deciduous woodland in the Luxembourg Ardennes'. *Earth Surface Processes* 2,161-173

Kwaad, F J P M and Mücher, H J 1979 'The formation and evolution of colluvium on arable land in northern Luxembourg'. *Geoderma* 17, 1-37

Lewis, W V 1949 'The Pegsdon dry valleys'. *Compass: the Magazine of the Cambridge University Geography Society* 1, 53-70

Lewkowicz, A G 1988 'Slope processes', in Clark, M G (ed) *Advances in periglacial geomorphology*, 325-370. Chichester: Wiley

Lewkowicz, A G 1990 'Morphology, frequency and magnitude of active layer detachment slides, Fosheim Peninsula, Ellesmere Island, NWT', in Burgess, M M, Harry, D G and Sego, D C (eds) *Proceedings of the 5th Canadian Permafrost Conference.* Québec: Université Laval

Limbrey, S 1975 *Soil science and archaeology* London: Academic Press

Macphail, R I 1987 'A review of soil science in archaeology in England', in Keeley, H C M (ed) *Environmental archaeology: a regional review.* Volume II, 332-379. London: Historic Buildings and Monuments Commission for England

Macphail, R I 1990 'Soil history and micromorphology', in Bell, M G (ed) *Brean Down: excavations 1983-1987*, 187-196. London: English Heritage Archaeological Report 15

Macphail, R I 1992 'Soil micromorphological evidence of ancient soil erosion', in Bell, M G and Boardman, J (eds) *Past and present soil erosion: archaeological and geographical perspectives*, 197-215. Oxbow: Oxbow

Macphail, R I 1998 'A reply to Carter and Davidson's "An evaluation of the contribution of soil micromorphology to the study of ancient arable agriculture"'. *Geoarchaeology* 13, 549-564

Macphail, R I, Romans, J C C and Robertson, L 1987 'The application of micromorphology to the understanding of Holocene soil development in the British Isles; with special reference to Holocene cultivation in the British Isles', in Fedoroff, N, Bresson, L M and Courty, M-A (eds) *Soil micromorphology*, 647-656. Paris: L'Association Français pour l'Etude du Sol

McRoberts, E C and Morgenstern, N R 1974 'The stability of thawing slopes'. *Canadian Geotechnical Journal* 11, 447-469

Mercer, R and Healy, F (eds) in press *Hambledon Hill*. Swindon: English Heritage

Miall, A D 1977 'A review of braided-river depositional environments'. *Earth Science Review* 13, 1-62

Miall, A D 1996 *The geology of fluvial deposits: sedimentary facies, basin analysis and petroleum geology*. Berlin: Springer-Verlag

Miall, A D 2000 *Principles of sedimentary basin analysis*. Third Edition. Berlin: Springer

Morgan, R P C, Martin, L and Noble, C A 1987 *Soil erosion in the United Kingdom: a case study from mid-Bedfordshire*. Cranfield, Bedfordshire: Silsoe College, Cranfield Institute of Technology

Patton, P C and Schumm, S A 1975 'Gully erosion, northwestern Colorado: a threshold phenomena'. *Geology* 3, 88-90

Pedley, H M 1998 'Petrology of tufa sediments', in Preece, R C and Bridgland, D R (eds) *Late Quaternary environmental change in north-west Europe: excavations at Holywell Coombe, south-east England*, 85-86. London: Chapman and Hall

Pelham, R A 1934 'Distribution of sheep in Sussex in the early fourteenth century'. *Sussex Archaeological Collections* 75, 129-135

Preece, R C 1978 *The biostratigraphyof Flandrian tufas in southern Britain*. Unpublished PhD Thesis, Department of Geology, Imperial College, University of London

Preece, R C 1980 'The biostratigraphy and dating of a Postglacial slope deposit at Gore Cliff, near Blackgang, Isle of Wight'. *Journal of Archaeological Science* 7, 255-265

Preece, R C 1998a 'Introduction', in Preece, R C and Bridgland, D R (eds) *Late Quaternary environmental change in north-west Europe: excavations at Holywell Coombe, south-east England*, 1-14. London: Chapman and Hall

Preece, R C 1998b 'Mollusca', in Preece, R C and Bridgland, D R (eds) *Late Quaternary environmental change in north-west Europe: excavations at Holywell Coombe, south-east England*, 158-212. London: Chapman and Hall

Preece, R C and Bridgland, D R 1998a 'Environmental background', in Preece, R C and Bridgland, D R (eds) *Late Quaternary environmental change in north-west Europe: excavations at Holywell Coombe, south-east England*, 15-30. London: Chapman and Hall

Preece, R C and Bridgland, D R (eds) 1998b *Late Quaternary environmental change in north-west Europe: excavations at Holywell Coombe, south-east England*. London: Chapman and Hall

Preece, R C, Bridgland, D R and Sharp, M J 1998 'Stratigraphical investigations', in Preece, R C and Bridgland, D R (eds) *Late Quaternary environmental change in north-west Europe: excavations at Holywell Coombe, south-east England*, 33-68. London: Chapman and Hall

Preece, R C, Kemp, R A and Hutchinson, J N 1995 'A Late-glacial colluvial sequence in Watcombe Bottom, Ventnor, Isle of Wight'. *Journal of Quaternary Science* 10, 107-121

Quine, T A 1995 'Estimation of erosion rates from Caesium 137 data: the calibration question', in Foster, I D L, Garrett, A M and Webb, B W (eds) *Sediment and water quality in river catchments*, 307-329. Chichester : John Wiley

Quine, T A, Govers, G, Walling, D E, Zhang, X, Desmet, P J J and Zhang, Y 1997 'Erosion processes and landform evolution on agricultural land - new perspectives from caesium-137 data and topographic-based erosion modelling'. *Earth Surface Processes and Landforms* 22, 799-816

Quine, T A and Walling, D E 1992 'Patterns and rates of contemporary soil erosion derived using caesium-137: measurement, analysis and archaeological significance', in Bell, M G and Boardman, J (eds) *Past and present soil erosion*, 185-196. Oxford: Oxbow

Rawlings, M, Allen, M J and Healy, F 2004 'Investigation of the Whitesheet Down environs 1989-90: Neolithic causewayed enclosure and Iron Age settlement'. *Wiltshire Archaeological and Natural History Magazine* 97, 144-196

Reading, H G and Levell, B K 1997 'Controls on the sedimentary rock record', in Reading, H G (ed) *Sedimentary environments: processes, facies and stratigraphy*, 5-36. Oxford: Blackwell Science

Reid, C 1887 'On the origin of dry Chalk valleys and of Coombe Rock'. *Quarterly Journal of the Geological Society of London* 43, 364-373

Reimer, P J, Baillie, M G L, Bard, E, Bayliss, A, Beck, J W, Bertrand, C, Blackwell, P G, Buck, C E, Burr, G, Cutler, K B, Damon, P E, Edwards, R L, Fairbanks, R G, Friedrich, M, Guilderson, T P, Hughen, K A, Kromer, B, McCormac, F G, Manning, S, Bronk Ramsey, C, Reimer, R W, Remmele, S, Southon, J R, Stuiver, M, Talamo, S, Taylor, F W, van der Plicht, J and Weyhenmeyer, C E 2004 'IntCal04 terrestrial radiocarbon age calibration, 0-26 cal. kyr. BP'. *Radiocarbon* 46, 1029-1058

Reineck, K E and Singh, I B 1980 *Depositional sedimentary environments*. New York: Springer-Verlag

Reynolds, P J 1981 'New approaches to familiar problems', in Jones, M K and Dimbleby, G W (eds) *The environment of man: the Iron Age to the Anglo-Saxon period*, 19-49. Oxford: British Archaeological Reports British Series 87

Richards, J C 1990 *The Stonehenge Environs Project*. London: English Heritage Archaeological Report 16

Robinson, W S 1951 'A method for chronologically ordering archaeological deposits'. *American Antiquity* 16, 293-301

Scaife, R G 1982 'Late Devensian and early Flandrian vegetation changes in southern England', in Bell, M G and Limbrey, S (eds) *Archaeological aspects of woodland ecology*, 57-74. Oxford: British Archaeological Report International Series 146

Scott-Jackson, J E 2000 *Lower and Middle Palaeolithic artefacts from deposits mapped as Clay-with-Flints. A new synthesis with significant implications for the earliest occupation of Britain*. Oxford: Oxbow

Scott-Jackson, J E and Winton, V S 2001 'Recent investigations at Dickett's Field, Yarnhams Farm, Holybourne, Hants', in Milliken, S and Cook, J (eds) *A very remote period indeed.* Papers on the Palaeolithic presented to Derek Roe, 214-222. Oxford: Oxbow

Sharp, M J and Dowdeswell, J A 1998 'Mineral magnetic properties of valley-fill sediments: implications for provenance and weathering history', in Preece, R C and Bridgland, D R (eds) *Late Quaternary environmental change in north-west Europe: excavations at Holywell Coombe, south-east England*, 86-105. London: Chapman and Hall

Sharples, N M 1991 *Maiden Castle*. Excavations and field survey 1985-6. London: English Heritage

Smith, R J C, Healy, F, Allen, M J, Morris, E L, Barnes, I and Woodward, P J 1997 *Excavations along the route of the Dorchester by-pass, Dorset, 1986-8*. Salisbury: Wessex Archaeology

Sparks, B W 1961 'The ecological interpretation of Quaternary non-marine Mollusca'. *Proceedings of the Linnean Society* 172, 71-80

Sparks, B W 1964 'Non-marine Mollusca and Quaternary ecology'. *Journal of Animal Ecology* 33, 87-98

Sparks, B W and Lewis, W V 1957 'Escarpment dry valley near Pegsdon, Herts.' *Proceedings of the Geologists' Association* 68, 26-38

Sperling, C H B, Goudie, A S, Stoddart, D R and Poole, G G 1976 'Dolines of the Dorset Chalklands and other areas in South Britain'. *Transactions of the Institute of British Geographers* NS 2, 205-223

Stammers, R L and Boardman, J 1984 'Soil erosion and flooding on Downland areas'. *The Surveyor* 164, 8-11

Swindle, G E, Green, C P and Branch, N P 2004 *A borehole survey within a dry valley at Peacehaven, East Sussex, UK.* Unpublished report, Archaeoscape, Department of Geography, Royal Holloway, University of London

The Wolds Research Project 2004 The Wolds Research Project http://www.york.ac.uk/depts/arch/Wolds/index.html (Accessed 11 November 2007)

Thomas, C and Rackham, D J 1996 'Bramcote Green, Bermondsey: a Bronze Age trackway and palaeoenvironmental sequence'. *Proceedings of the Prehistoric Society* 61, 221-253

Thomas, K D 1982 'Neolithic enclosures and woodland habitats on the South Downs, England', in Bell, M G and Limbrey, S (eds) *Archaeological aspects of woodland ecology*, 147-167. Oxford: British Archaeological Reports International Series 146

Thorley, A J 1981 'Pollen analytical evidence relating to the vegetational history of the chalk'. *Journal of Biogeography* 8, 93-106

Tingle, M 1998 *The prehistory of Beer Head: field survey and excavations at an isolated flint source on the south Devon coast*. Oxford: British Archaeological Reports British Series 270

Usai, M R 2001 'Textural pedofeatures and pre-Hadrian's wall ploughed paleosols at Stanwix, Carlisle, Cumbria, UK'. *Journal of Archaeological Science* 28, 541-553

Waller, M P and Hamilton, S 2000 'Vegetation history of the English chalklands: a mid-Holocene pollen sequence from the Caburn, East Sussex'. *Journal of Quaternary Science* 15, 233-272

Waters, M R 1992 *Principles of geoarchaeology: a North-American perspective*. Tucson: University of Arizona Press

Waton, P V 1982a 'Land snail evidence of post-glacial environmental change on the Hertfordshire chalklands'. *Hertfordshire Natural History Society Transactions* 28, 63-75

Waton, P V 1982b 'Man's impact on the chalklands: some new pollen evidence', in Bell, M G and Limbrey, S (eds) Archaeological aspects of woodland ecology, 75-91. Oxford: British Archaeological Reports International Series 146

Waton, P V and Barber, K E 1987 'Rimsmoor, Dorset: biostratigraphy and chronology of an infilled doline', in Barber, K E (ed) *Wessex and the Isle of Wight*. Field guide, 75-80 Cambridge: Cambridge University Press

Wentworth, C K 1922 'A scale of grade and class terms for clastic sediments'. *Journal of Geology* 30, 377-392

Whittle, A, Pollard, J and Grigson, C 1999 *The harmony of symbols: the Windmill Hill causewayed enclosure*. Oxford: Oxbow

Wilkinson, K N 1993a 'The effects of colluvial erosion on Holocene archaeological landscapes: case studies from the chalklands of southern England'. *Procesos Postdeposicionales*. Arqueologia Espacial 16-17, 57-74

Wilkinson, K N 1993b *The influence of local factors on palaeoenvironment and land-use: evidence from dry valley fills in the South Downs*. Unpublished Ph.D Thesis, Institute of Archaeology, University of London

Wilkinson, K N 2002 'Appendix 1: Sweetpatch Valley Bottom', in Rudling, D (ed) *Downland landscape and settlement: the archaeology of the Brighton by-pass*, 259-266. London: University College London Field Archaeology Unit Monograph 1

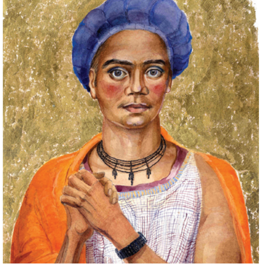
Wilkinson, K N 2003 'Colluvial deposits in dry valleys of southern England as proxy indicators of paleoenvironmental and land-use change'. *Geoarchaeology* 18, 725-755

Wilkinson, K N, Barber, L and Bennell, M 2002 'The examination of six dry valleys in the Brighton area: the changing environment', in Rudling, D (ed) *Downland landscape and settlement: the archaeology of the Brighton by-pass, 203-238*. London: University College London Field Archaeology Unit Monograph 1

Wilkinson, K N and Stevens, C J 2003 *Environmental archaeology: approaches, techniques and applications*. Stroud: Tempus

Wilkinson, K N, Tyler, A, Davidson, D and Grieve, I 2006 'Quantifying the threat to archaeological sites from the erosion of cultivated soil'. *Antiquity* 80, 658-670

Young, B and Lake, R D 1988 *Geology of the country around Brighton and Worthing.* London: British Geological Survey



ENGLISH HERITAGE RESEARCH DEPARTMENT

English Heritage undertakes and commissions research into the historic environment, and the issues that affect its condition and survival, in order to provide the understanding necessary for informed policy and decision making, for sustainable management, and to promote the widest access, appreciation and enjoyment of our heritage.

The Research Department provides English Heritage with this capacity in the fields of buildings history, archaeology, and landscape history. It brings together seven teams with complementary investigative and analytical skills to provide integrated research expertise across the range of the historic environment. These are:

- *Aerial Survey and Investigation*
- *Archaeological Projects (excavation)*
- *Archaeological Science*
- *Archaeological Survey and Investigation (landscape analysis)*
- *Architectural Investigation*
- *Imaging, Graphics and Survey (including measured and metric survey, and photography)*
- *Survey of London*

The Research Department undertakes a wide range of investigative and analytical projects, and provides quality assurance and management support for externally-commissioned research. We aim for innovative work of the highest quality which will set agendas and standards for the historic environment sector. In support of this, and to build capacity and promote best practice in the sector, we also publish guidance and provide advice and training. We support outreach and education activities and build these in to our projects and programmes wherever possible.

We make the results of our work available through the Research Department Report Series, and through journal publications and monographs. Our publication Research News, which appears three times a year, aims to keep our partners within and outside English Heritage up-to-date with our projects and activities. A full list of Research Department Reports, with abstracts and information on how to obtain copies, may be found on www.english-heritage.org.uk/researchreports

For further information visit www.english-heritage.org.uk

ENGLISH HERITAGE