QUATERNARY NEWSLETTER

No. 39 February 1983

Quaternary Newsletters are issued in February, June and November. Closing dates for submission of copy for the relevant numbers are 1st January, 1st May and 1st October. Contributions, comprising articles, reviews, notices of forthcoming meetings, news of personal and joint research projects, etc. are invited. They should be sent to the Editor of the Quaternary Research Association, Dr. D.H. Keen, Department of Geography, Coventry (Lanchester) Polytechnic, Priory Street, Coventry CV1 5FB.

THE TERMINAL PLEISTOCENE IN SUMATRA, INDONESIA

By Bernard K. Maloney

Evidence for late-glacial (terminal Pleistocene) climatic change in the tropics was reviewed by Roberts *et al* (1981) and they concluded that there was support for the view that the well documented oscillations which occurred between c.14,000 and 10,000 B.P. in temperate areas were sometimes also apparent in the tropics.

Unlike Papua-New Guinea, which Roberts *et al* mentioned, Sumatra lacks mountains high enough to have been glaciated during the Pleistocene. It does, however, possess many lake basins varying considerably in size. The largest of these, the Lake Toba depression (Fig. 1), a vast volcano-tectonic feature according to van Bemmelen (1939), has a series of lake terraces (Antevs, 1928). These were investigated by Verstappen (1964, 1973) who stated that Lake Toba was once 150m above its present c.900m level and that remnants of the high terrace discovered and other lower terraces could also be traced in the valley of the Asahan River which drains the lake. None of these terraces have been radiometrically dated and Verstappen, wisely,as the Toba area is complicated volcanically and tectonically, did not draw any palaeoclimatic conclusions from his study. Comparatively little detailed geomorphological research has been conducted in Sumatra to date and it is possible that other lakes in less volcanically complex and more tectonically stable parts of the island may have terrace sequences which could yield information about past climatic conditions, although the larger lakes lack closed basins.

The investigation of eustatic sea-level changes should not be neglected as an indirect method of establishing the world-wide nature of Pleistocene climatic variations, particularly as far as South-east Asia is concerned. The region comprising mainland South-east Asia, eastern Sumatra, northern Java and all except the east of Borneo is

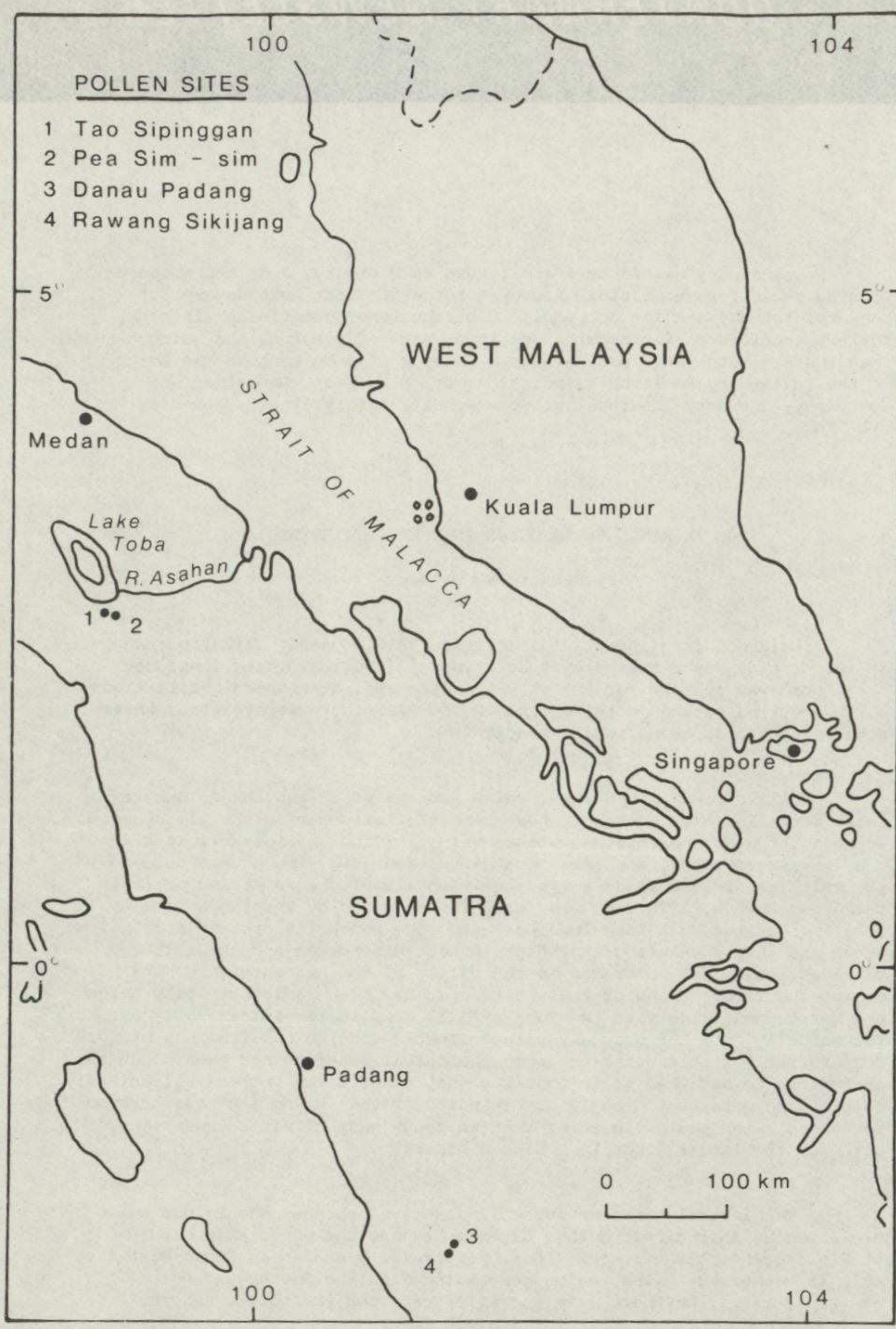


Fig. 1 Location of pollen sites mentioned in the text.

unique in the tropics because it is fringed by shallow sea. If this sea was to be dramatically lowered in level as a result of extra-tropical ice accumulation some change in the climate of neighbouring lands would be inevitable. Indeed Verstappen (1975) suggested that the effect of a considerably lowered sea-level alone would have been sufficient to bring about drier conditions, particularly in lowland areas, during glacial periods. As a lesser extent of additional land would have been exposed off the west coast of Sumatra, the amount of rainfall reaching the mountains, which stretch the length of the island a short distance in from this coast, from the south-west monsoon, may have been a greater contribution to the whole than now, and seasonal contrasts might have been more emphatic.

The recent exploration for oil and minerals has yielded much evidence about south-east Asian Pleistocene and Holocene sea-levels (cf Batchelor, 1979; Tjia, 1980). Most importantly Geyh *et al* (1979) have had a series of peat samples from the Strait of Malacca ^{14}C dated and these apparently indicate that sea-level was c.57m below its present mean level about 17,000 years ago, rising to 38.5m at c.12,000 B.P. and 33.7m around 10,500 B.P., and that it fell again to c.53.5m at the end of the Pleistocene (9,840 ± 330 B.P.). This dramatic reversal in trend might reflect the cold spell which occurred in temperate areas at the end of the late-glacial but unfortunately only a single ^{14}C date covers the period c.14,000 - 10,500 B.P. so it is not possible to say if earlier oscillations in sea-level occurred. However, Biswas (1976) claimed that the South China Sea was 75m below its present level at about 11,000 B.P. Additional recording and absolute dating of fossil shoreline features located both above and below present sea-level in south-east Asia may prove to be rewarding and, as with the Arabian Sea deposits reported upon by Van Campo *et al* (1982), pollen analysis may indicate the course of macro-regional climatic change.

Sea level seems to have recovered rapidly from its terminal Pleistocene low point reaching c.33.4m below the present mean (Geyh *et al* 1979) in the Strait of Malacca c.9,200 years ago and, as suggested by a whole series of ^{14}C determinations, it rose continuously thereafter until c.2,000 B.P.

A number of piston cores have been recovered from the Andaman Sea to the north of Sumatra and from the eastern Indian Ocean off its west coast but the most detailed palaeoclimatic reconstruction made using these (Prell *et al* (1980) only considered conditions at the last glacial maximum (23,000-14,000 B.P.) when sea-surface temperatures were estimated to have been 1-2°C below present and the monsoonal circulation slightly less intense.

Cullen (1981) however, traced changing palaeo-salinity patterns using cores from along a north-south transect located roughly 90°E and concluded that a reduction of salinity from that of full glacial times occurred between c.12,500-10,500 B.P. in the Bay of Bengal suggesting that precipitation, and therefore runoff, had increased due to an increase in intensity of the south-west monsoon. South of 10°N salinity values (? and thus precipitation) were found to be similar to at present. Duplessy (1982) discovered evidence supporting these conclusions in the oxygen-isotope record.

If temperatures were reduced by only 1-2°C in the Sumatran highlands during the terminal Pleistocene and precipitation remained at about its present level, one might not expect pollen diagrams covering this period to show much evidence of major vegetation change, but this is not the case. The pollen diagram from the Pea Sim-sim site (Maloney, 1980), which is located at 1450m altitude on the Toba Plateau, is alone so far in covering the period from the last glacial maximum to the terminal Pleistocene. Another site from the same region and a comparable altitude, Tao (Lake) Sipinggan, has a basal ^{14}C date of c.12,000 B.P. (Maloney, 1981) while Rawang Sikijang (1010 m A.S.L.), central Sumatra, has a c.11,000 year old record (Flenley, 1979) and Danau Padang (c.950m A.S.L.) nearby (Flenley, 1979; Morley, 1982) dates from c.10,000B.P. to the present. No truely lowland pollen sites have yet been analysed.

Fortunately the Pea Sim-sim and Tao Sipinggan pollen diagrams are well dated by the standards of tropical palynology, see Table 1, with four dates each from the broad terminal Pleistocene period, and three of the four Sumatran pollen diagrams contain a record which makes it possible to assess if a cold spell occurred between c.10,500 and 10,000 B.P. In fact Morley (1982) discovered a significant percentage of pollen from *Podocarpus (Dacrycarpus) imbricatus* and *Symingtonia populnea,* trees found above 1700m altitude in central Sumatra today, in the c.10,000 B.P. levels of Danau Padang, the fourth diagram, but *Lithocarpus/Castanopsis* and *Quercus*, probably from montane forest[1] at lower altitudes, were also abundant. *Dacrycarpus imbricatus* declined in importance and *Symingtonia populnea* disappeared between c.10,000 and 8,600 B.P. while *Engelhardia* and *Vernonia*, lower montane forest elements, increased. *Eugenia* was common throughout the lower part of the diagram. Flenley (1979) reported that his unpublished pollen diagram from Rawang Sikijang, which extends back to c.11,000 B.P., was broadly similar, and a depression of the vegetation zones by at least 500m at 10,000 B.P. and concomitant lowering of temperature by 2°C or more was suggested by Morley (1982) but no change in precipitation was detected.

The Pea Sim-sim and Tao Sipinggan pollen diagrams also revealed a phase when *Dacrycarpus imbricatus* and *Symingtonia populnea,* particularly the latter, were of some importance but this dated to c.16,500-12,000 B.P. and here too *Lithocarpus/Castanopsis* and *Quercus* were significant additional pollen contributors. *Eugenia* only became important at Pea Sim-sim after 13,500 B.P., however, and was less abundant between C.13,000-12,000 B.P. but thereafter increased to dominate the pollen record until c.7,000 B.P. At Tao Sipinggan some 2 km away though *Eugenia* became abundant much later, in the mid post-glacial, and *Quercus* dominated most of the early part of the diagram. *Engelhardia* was common from c.14,000-12,500 B.P. at Pea Sim-sim and in some samples from the lower levels of the Tao Sipinggan pollen diagram.

---

[1] Morley (1982) recognised three types of forest in the Padang area: Sub-montane forest at altitudes ranging between c.1000 and 1400m above sea level, montane forest I at c.1400-1800m and montane forest II at c.1800-2400m. In the absence of detailed information about the zonation of mountain vegetation in the Toba Highlands one is constrained to adopt Morley's divisions as a basis for comparison while acknowledging (cf Flenley, 1979:78) that the zonation of mountain vegetation in the Malesian mountains is very variable. As the terms montane forest I and montane forest II are rather cumbersome they are replaced by lower montane forest and upper montane forest respectively hereafter.

Errata Quaternary Newsletter 38

Bottom of P 24 (add)

3) The assumption by Burrin that "although rising base-levels may have aided peat formation and alluviation within the Vale of the Brooks, ...

Bottom of P 29 (add)

.... confused morphodynamically with those on the east coast of the U.S.A.). Coarse barriers, often solitary ridges, develop up to a limit determined by ....

Table 1. Radiocarbon dates from Pea Sim-sim and Tao Sipinggan

(a) Pea Sim-sim

Laboratory sample number	Depth (metres)	Age B.P. (statistical error one standard deviation)
SR 519	1.30-1.50	5,000 ± 130
SR 517	1.40-2.10	7,280 ± 150
SRR 1019	2.10-2.20	8,049 ± 60
SR 518	2.30-2.50	8,230 ± 150
SR 520	3.20-3.40	9,840 ± 125
SRR 1020	4.10-4.20	11,494 ± 75
SR 521	4.90-5.10	12,500 ± 140
SR 522	5.80-6.00	13,500 ± 180
SRR 1021	6.60-6.70	15,618 ± 100
SRR 864	7.15-7.25	16,212 ± 160
SRR 1022	8.15-8.25	17,722 ± 75
SR 523	8.70-8.90	17,880 ± 200
SRR 472	9.66-9.76	18,496 ± 95

(b) Tao Sipinggan

Laboratory sample number	Depth (metres)	Age B.P. (statistical error one standard deviation)
SRR 1015	2.70-2.80	1,701 ± 65
SRR 1016	5.70-5.80	4,461 ± 45
SRR 1017	7.60-7.70	9,234 ± 80
SRR 1018	8.10-8.20	10,952 ± 90
SRR 865	9.00-9.10	12,381 ± 110
SRR 473	9.15-9.22	12,116 ± 140

The general trend of both pollen diagrams indicates that lower montane forest was becoming established at c.1400m altitude as early as 12,000 B.P. but a number of the differences between them, e.g. the abundance of *Eugenia* at Pea Sim-sim and not Tao Sipinggan, are difficult to reconcile. There are also significant shifts of short duration in each pollen record, e.g. *Lithocarpus/Castanopsis*, especially, and Urticaceae/Moraceae increased dramatically between c.10,000-9,000 B.P. at Tao Sipinggan, which suggest that the vegetation was not stable. Whether or not these perturbations result from an oscillating climate remains to be demonstrated. No volcanic ash layers occurred in the stratigraphy of either site and the most recent eruption of Toba (Stauffer *et al* 1980) has been dated at c.30,000 B.P. Charcoal was present in the 8.70m sample from Tao Sipinggan, the increase of Urticaceae/Moraceae could reflect disturbance, and so could the inverted dates (inwash of old carbon) at the base of the core (if true dates).

The oldest dates from a human occupation site obtained so far (Tianko Panjang in central Sumatra) cluster around 9,000-10,000 B.P. (Bronson and Asmar, 1975) but the archaeology of Sumatra has been little studied and the recent finds made in Papua-New Guinea, summarised in Flenley (1979) must lead one to be wary of completely neglecting the anthropogenic factor in interpreting terminal Pleistocene and perhaps even earlier Sumatran pollen diagrams. Until more data have been collected an open mind is needed.

Clearly there are contrasts with diagrams from central Sumatra but it must be stressed that the lack of precise information about the altitudinal distribution and floristic and ecological composition of natural vegetation (mostly destroyed) in the mountains of north Sumatra and the range of vegetation which might be encountered on a large untouched humid tropical montane plateau hinders palaeoclimatic interpretation of the pollen record. Even if the limits of the vegetation belts were known, there is insufficient climatic data with which to construct a reliable regional lapse rate of temperature with altitude, and use of the general rate for the world may be inappropriate. As far as the water balance is concerned, thought has to be given to what a lowering of sea-level by 30-50m might do to the mean level of the groundwater table in the tropical highlands and what the reprocussions for the vegetation might be. The Toba Plateau immediately south of Lake Toba is mantled by a thick layer of volcanic tuff and the possibility that it had a perched watertable during the Pleistocene is rather less likely than for some other parts of the tropics. Theoretically water availability could have decreased without a major reduction in precipitation but as far as the pollen diagrams published to date are concerned, there is no indication of any change at the end of the Pleistocene, although more ecological data about the taxa discussed earlier are always desirable.

On the face of it lower montane forest began to be established at c.12,000 B.P. on the Toba Plateau, but 2,000 years or more later in central Sumatra despite the fact that the central Sumatran sites are at c.400m lower altitude. Had climatic change progressed at a uniform rate and direction throughout the island one might have expected upper montane forest to be present longer at 1400m altitude than lower down, but the climate of a large plateau may be rather different from isolated peaks or mountain ranges even at present and this factor may explain the anomaly.

After 12,000 B.P. the vegetation of the Toba Plateau seems to have been much as might be expected at present without human interference: lower montane forest, but upper montane forest elements persisted until c.8,600 B.P. in central Sumatra, a date which is in agreement with the claim (Frerichs, 1968), based on faunal evidence from the Andaman Sea, that the Pleistocene-Recent boundary dates to c.8,700 B.P.

It is evident that there are still problems in interpreting the causes of vegetation change during the terminal Pleistocene period in Sumatra. Analysis of more pollen sites using absolute counting procedures and more closely spaced sampling and ^{14}C dating of the sites already partly investigated may do much to resolve the problems. Nevertheless, what is needed most of all is intensive floristic and ecological investigation of Sumatra's mountain forests, while they still remain, and collection of large numbers of surface samples to assess forest pollen production, preservation and dispersal.

There is evidence which indicates that climate was becoming warmer between 14,000-8,600 B.P. A change of vegetation occurred at Tao Sipinggan from c.11,000-10,000 B.P. but not at Pea Sim-sim so the existence of a cold spell synchronous with the end of the extra-tropical late-glacial period has not been detected. Lake levels began to rise around 12,500 B.P. in East Africa (Van Campo *et al* 1982), and this phase, which reached a peak between 10,000-8,000 B.P., has been confirmed by pollen analysis but there is no support for the view that Sumatra was necessarily either drier or wetter than it is now during this period although detailed micropalaeontological and oxygen-isotope analyses of cores from the Strait of Malacca and the Sunda Shelf could clarify matters and is to be recommended.

Pollen diagrams from other sites in north (at Queen's), central (Hull) and south Sumatra (Groningen) are under construction so Sumatran palynology is healthy, if not vibrant, but there seems to be little research underway on Pleistocene geomorphology. This is a great pity as quite apart from areas where river and lake terraces, fossil shorelines and the products of vulcanicity could be studied there are others where limestone caves which could contain speleothems occur.

B.K. Maloney
Department of Geography and
The Palaeoecology Laboratory,
Queen's University,
Belfast
BT7 1NN.

References

Antevs, E. 1928. The last glaciation. *Amer. Geog. Soc. Research Series* No. 17, 292 pp.

Batchelor, B.C. 1979. Discontinuously rising Late Cenozoic eustatic sea-levels, with special reference to Sundaland, Southeast Asia. *Geol. en Mijnb.* 58, 1-20.

Bemmelen, R.W. van. 1939. The volcano-tectonic origin of Lake Toba (North Sumatra) *De Ingenieur in Ned-Indie.* No.9, 126-140.

Biswas, B. 1976. Bathymetry of Holocene foraminifera and Quaternary sea-level changes on the Sunda Shelf. *J. Foram. Res.* 6, 107-133.

Bronson, B.B. and Asmar, T. 1975. Prehistoric investigations at Tianko Panjang Cave, Sumatra. *Asian Perspectives* 18, 128-145.

Campo, E. van, Duplessy, J.C. and Rossignol-Strick, M. 1982. Climatic conditions deduced from a 150-kyr oxygen-isotope pollen record from the Arabian Sea. *Nature* 296, 56-59.

Cullen, J.C. 1981. Microfossil evidence for changing salinity patterns in the Bay of Bengal over the last 20,000 years. *Palaeogeogr., Palaeoclim., Palaeoecol.,* 35, 315-356.

Duplessy, J.C. 1982. Glacial to interglacial contrasts in the northern Indian Ocean. *Nature* 295, 494-498.

Flenley, J.R. 1979. *The equatorial rainforest : a geological history.* Butterworths, London.

Frerichs, W.E. 1968. Pleistocene - Recent boundary and Wisconsin glacial biostratigraphy in the Northern Indian Ocean. *Science* 159, 1456-1458.

Geyh, M.A., Kudrass, H-R and Streif, H. 1979. Sea-level changes during the late Pleistocene and Holocene in the Strait of Malacca. *Nature* 278, 441-443.

Maloney, B.K. 1980. Pollen analytical evidence for early forest clearance in North Sumatra. *Nature,* 287, 324-326.

Maloney, B.K. 1981. A pollen diagram from Tao Sipinggan, a lake site in the Batak highlands of North Sumatra, Indonesia. *Mod. Quaternary Res. S.E. Asia,* 6, 57-76.

Morley, R.J. 1982. A palaeoecological interpretation of a 10,000 year pollen record from Danau Padang, Central Sumatra, Indonesia. *J. of Biogeog.* 9, 151-190.

Prell, W.L., Hutson, W.H., Williams, D.F., Bé, A.W.H., Geitzenauer, K. and Molfino, B. 1980. Surface circulation of the Indian Ocean during the last glacial maximum, approximately 18,000 yr B.P. *Quat. Res.* 14, 309-336.

Roberts, N., Street-Perrott, A. and Perrott, A. 1981. The "Late-glacial" in the tropics. *Quat. Newsl.* No. 35, 1-5.

Stauffer, P.H., Nishimura, S. and Batchelor, B.C. 1980. Volcanic ash in Malaya from a catastrophic eruption of Toba, Sumatra, 30,000 years ago. In Nishimura, S. (ed) *Physical geology of Indonesian island arcs.* Kyoto University, pp. 156-164.

Tjia, H.D. 1980. The Sunda Shelf, South east Asia. *Zeitsch. f. Geomorph.* 24, 405-427.

Verstappen, H. Th. 1964. The geomorphology of Sumatra. *J. Trop. Geog.* 18, 184-191.

Verstappen, H. Th. 1973. *A geomorphological reconnaissance of Sumatra and adjacent islands (Indonesia)*. Wolters-Noordhoff, Groningen.

Verstappen, H. Th. 1975. On palaeoclimates and landform development in Malesia. *Mod. Quaternary Res. S.E. Asia* 1, 3-35.

A CLOSER LOOK AT THE MERSTHAM WIND GAP

By D.S. Peake

The mode of origin of the Merstham gap through the North Downs south of Croydon has been the topic of much discussion throughout the century. If it originated as a gap formed by a southern tributary to the drainage of the London basin, comparable to other rivers of the western North Downs, the concept has implications for the early Pleistocene transport of material from the Weald across the line of the present Thames. An established Wealden river would also have played a more significant part in landscape dissection in the central part of the London basin than would a smaller stream heading in downland. It has been suggested (Peake 1982) that the diagonal breaching of the structural axis of the Hampstead Heath - Epping Forest ridge may have been affected from the south by a Wealden Wandle, superimposed from the Pebble Gravels level on to bedrock.

In attempting to discern whether the present wind gap at Merstham once carried the headstream of the River Wandle from the Weald, or is merely a dry downland valley beheaded in the recession of the Chalk escarpment, a study of the gap's environment provides some interesting findings. The Merstham valley differs from local beheaded dry valleys in three important respects:-

Firstly, the altitude of the Merstham col (134m O.D.) is considerably lower than that of the Caterham col (171m O.D.), the latter being the lowest example of the cols of several beheaded dry valleys in the area.

Secondly, in contrast to those of the cols in the Caterham area, the long profile of the Merstham valley shows a gradual dipslope climb, without the marked uphill increase in gradient which characterises the original steep head of a downland dry valley (Fig 1). Furthermore, a shoulder of Middle Chalk at the southern end of the Merstham valley (S in Figs 1 and 2), has the position, elevation and morphology of an eroded remnant of an earlier through-valley floor. The direct route northward from the shoulder over the col, shown in Fig 2 as the probable line of the original Wandle, roughly aligns with the Merstham north-south fault in the Cretaceous (Dines and Edmunds 1933). The shatter belt of the fault is likely to have facilitated the erosion of a depression along its length.

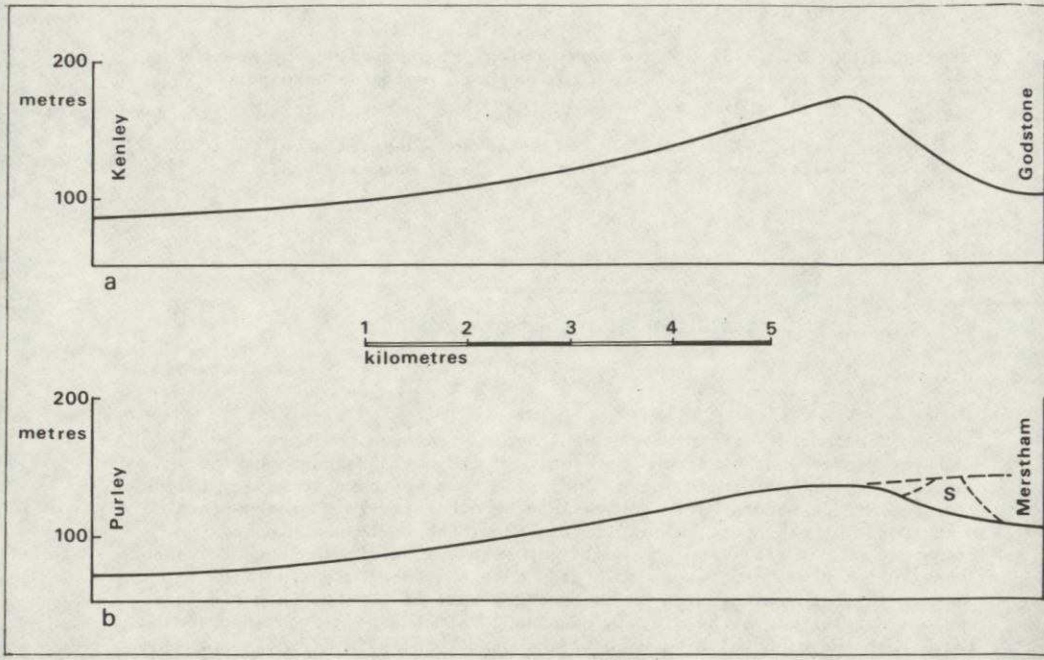


Fig. 1. Long profile of (a) the Caterham valley and (b) the Merstham valley.

Fig 2 shows that the southern end of the Merstham valley narrows rapidly into an incised more ravine-like valley, which curves eastwards round the Middle Chalk shoulder, below the steep south west face of the Chalk escarpment in the Merstham embayment. In 1972 a gas main trench across the Merstham valley south of Harps Oak (285546), and more recently the deep motorway cutting for M23, exposed a great thickness of coombe rock along the foot of the Chalk escarpment here, extending up the eastern flank of the ravine to the vicinity of the Merstham col. The cause of marked asymmetry of this type in Chalk valleys was studied in the Chilterns by Ollier and Thomasson (1957). They concluded that uniclinal lateral shifting of periglacial streams results from greater frost shattering and solifluction on sunnier south and south west-facing Chalk slopes than on north and north east-facing slopes. During cold periods the latter remain more permanently frozen and retain their protective snow covering. The initiation and development of the Merstham ravine appears therefore to have been related to rapid periglacial erosion along the foot of the

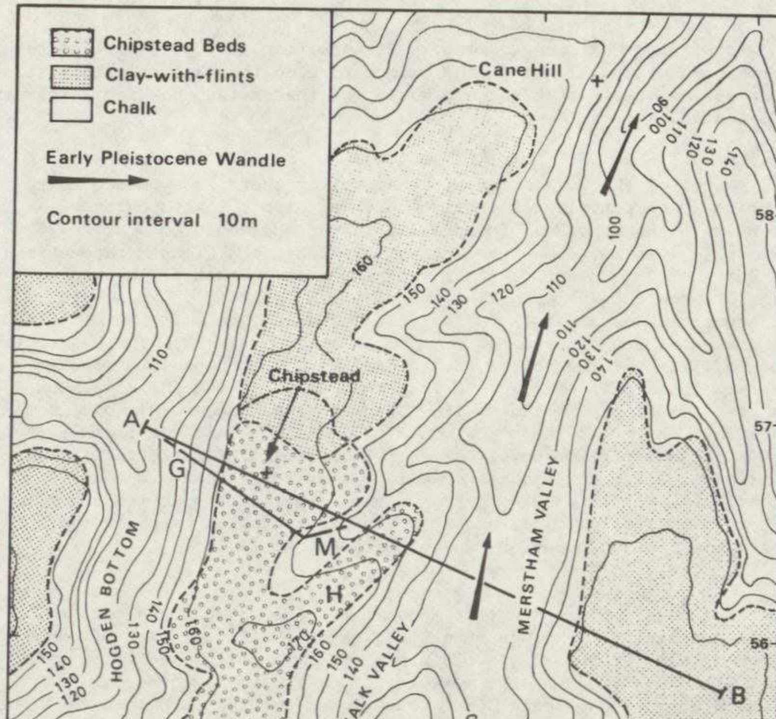


Fig. 2. Map showing the relationship of the Chipstead Beds to the Merstham valley.

south west-facing Chalk escarpment. Preservation of a palaeosol of the Windermere Interstadial within the coombe rock on the eastern valley side (Peake 1982) suggests that the excavation of the ravine occurred mainly in the Devensian.

North of the col in the Merstham valley there is evidence that much of the deep periglacial erosion here was also a late occurrence. The remains of *Hippopotamus* (Moodie 1913) are recorded from a site (293585) at Cane Hill (Fig 2), 33m above the valley floor. Skeletal fragments, tusks and teeth of an adult animal were found at a depth of 1m in sands filling a large cup-shaped hollow in the Upper Chalk of the Cane Hill spur, which separates the Merstham valley from Chipstead Bottom. Unidentified shell fragments and the remains of mammoth also occurred. The description of the infilling of the hollow with clean sharp sand containing broken flints and chalk pellets suggests that the pocket in the Chalk was not the usual deep solution pipe lined with Clay-with-flints *sensu stricto*, but a water-eroded cavity, perhaps the mouth of a doline. If the site at that time was at valley floor level, as seems most likely for fluviatile erosion to have taken place in a downland valley, the indications are that the Merstham valley at this point may have been shallower by at least 30m in the Ipswichian Interglacial, and that the marked valley deepening here is attributable to the Devensian, as in the Merstham ravine.

Less erosion of this type appears to have taken place across the Merstham col itself. It was suggested (Peake 1982) that much of the dry valley deepening in the Wandle basin was effected periglacially in the corrasion of the floors by the movement of coarse valley gravels. A minimum of corrasive material would have moved across the col in the Devensian, transport in either direction to the north and south appearing already to have been initiated. Were it not for the late incision of the curving Merstham ravine into the valley floor immediately to the south of the col (Fig 2), there would be a well-graded gentle northward slope across the col from the Merstham shoulder (Fig 1). Such a slope accords with the profile of a former through-valley rather than with that of a beheaded dry valley.

Thirdly, ferruginous sands and gravels mapped by Dines and Edmunds (1933) at Chipstead (277554) had been claimed by Wooldridge (1927) to be Diestian sediments occurring on the western edge of the Merstham valley. Later (1960) he re-assigned the group of high-level marine sediments to which the Chipstead Beds belong to the Calabrian, Red Crag fossils in them at Netley Heath having been given a Waltonian age, at the base of the Pleistocene. The presumed Calabrian deposits in the western North Downs occur at Netley Heath, Ranmore, Headley and Upper Gatton Park extending to Chipstead. By mineral analysis Davies (1915-1916) had shown that the beds are similar in composition and distinct from Eocene formations. Also recognised as correlatives by John (1980), these eroded remnants of once widespread sands and gravels rest directly on Upper Chalk at localities along the apparent upper margin of the zone of marine deposition, their elevation in general being a little above 180m O.D.

Bedded on Upper Chalk and partially covered with Clay-with-flints, the Chipstead Beds are the northward extension of the Upper Gatton Park deposit (Fig 2). In the North Downs they are the sole example of a linear extension of the marine deposits down the dipslope. From the Chalk escarpment the narrow belt of sand and gravel, 4km in length, falls gently to Chipstead village at 166m O.D. In 1968 a gas main trench across the ridge south of Chipstead (G-M in Fig 2), revealed an estimated 4m of mainly undisturbed stratified sand and basal gravel resting on Chalk, with an irregular but clearly defined junction. Dark flint pebbles of Blackheath Beds type, pale part-rounded flint cobbles, more angular broken flint and chalk pellets occurred in the sandy basal gravel, but the higher strata consisted of alternating fine chestnut-brown, orange and buff sand, the lighter beds sometimes being coarser in texture. Thin ferruginous horizons were common throughout the upper sands, but pebbles and flints were rarely seen. The sequence resembles that of the marine deposits described and correlated with it by Wooldridge (1927) and John (1980) at Netley Heath and Headley.

The relationship of the marine beds to the Merstham valley is shown in Fig 2. At Upper Gatton Park they cap the steep western slope of the Markedge valley in the Chalk escarpment. Northwards they are on the western edge of the Broadwalk dry valley, and beyond this they extend alongside the Merstham valley. The main body of the deposit is thus preserved on the narrow interfluve between these three aligned valleys to the east and the long dry valley, Hogden Bottom, to the west. In the vicinity of Chipstead however a sloping ridge of Upper Chalk, the Hogscross Lane spur (H in Fig 2), descends from the main ridge north eastwards into the Merstham valley. Along its narrow crest a lateral extension of the Chipstead Beds falls more steeply than the gentle northward inclination of the deposit on the main interfluve. Whereas its base extends below the 150m contour, the eastward sloping base of the marine beds on the main Chipstead ridge is in general some 10m higher (Figs 2 and 3).

A portion of the western side of a former wide shallow channel in the Upper Chalk (Fig 3) is thus preserved north of Merstham, lined with

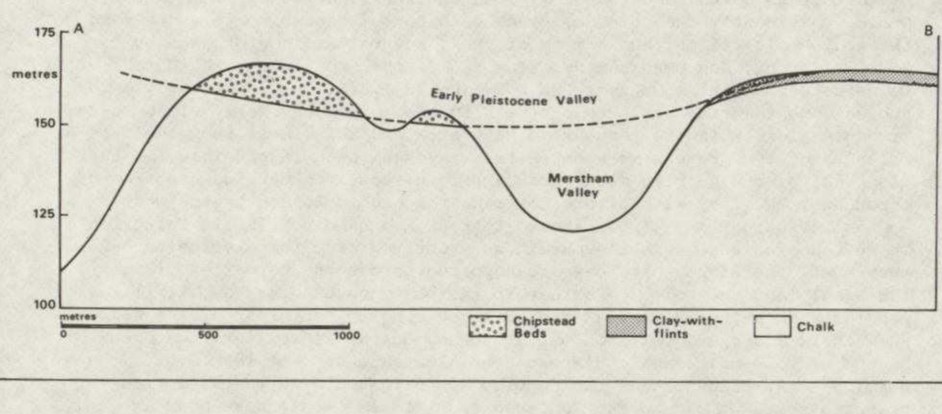


Fig. 3. Cross section of the Merstham valley on line AB in Fig 2.

marine shingle and sand which probably would have been widespread on estuarine flats to either side. Fine sand and remanié blocks of tabular ironstone are common in the Clay-with-flints immediately to the east of the Merstham gap in the vicinity of Alderstead Heath (303553), suggesting the persistence for some time of the ferruginous marine deposits along the eastern flank of the valley, as well as to the west (Dines and Edmunds 1933). It is reasonable to suppose that an established Wealden river, entering the Calabrian sea from the south along the line of the present Merstham valley, presaged the development of the River Wandle, which came into being on the downland dipslope as the sea level began to fall.

South of Croydon the crest of the Botley Hill ridge of high ground, falling northwards, forms the present watershed between the Ravensbourne and the Wandle drainage basins, respectively to east and west. Significantly it marks a divide of some antiquity in that Lower Greensand material, present in the Clay-with-flints on the downs of the Ravensbourne catchment (Dines *et al* 1969), and similarly on the downs west of the deep Caterham valley in the Wandle basin, is absent from the Clay-with-flints cover on the high terrain of Botley Hill (Dines and Edmunds 1933). Resulting from the Wealden uplift, but before the development of the Chalk escarpment, the downhill drift of Lower Greensand material across younger outcrops to the north seems therefore from the first to have been channelled into distinct belts, with the implication that initial fluviatile transport from the southern uplift was deflected to east and west of Botley Hill. The picture emerges of this ridge of high ground becoming the North Downs early Pleistocene divide between eastern Wealden rivers probably flowing to an eastern estuary, and the original four western Wealden rivers, Blackwater, Wey, Mole and Wandle, which were tributary to the proto-Thames flowing north eastwards on the Chiltern border.

In the main syncline of the London basin the central section of the southern limb is the area where outcrops of the Tertiary marine sands and gravels, the Blackheath Beds, extend from the Medway westward to the Wandle. Up to 12m in thickness, they consist in the main of well rounded flint pebbles compacted in a quartzose sandy matrix; secondary ferruginous cementation has hardened them locally into conglomerates. Hilly outcrops occur south of the line of the Thames, but the pebble beds reach the highest areas of the downs as disturbed outliers, partly piped into the Chalk. Evidently the original Blackheath Beds extended up to and beyond these high elevations, but a mass of them, several km in width and over 20km in extent, has been removed from the flatter zone along the North Downs between about 150m and 200m O.D. (Peake 1982). This strongly suggests that marine currents of the Pliocene, or of the early Pleistocene transgression, which is thought to have attained this level when the Calabrian sands and gravels were deposited, may have been responsible for the dispersal of the pebbles much farther afield; derived pebbles are present throughout the Clay-with-flints cover on the high downland to the west. John's investigations (1980) showed that pre-rounded pebbles in Calabrian shingle as far west as Netley Heath were derived from the Blackheath Beds: they must, therefore, have been transported across the estuaries of both the Wandle and the Mole. Farther to the west, beyond the Wey, similar pebbles are scattered through the soil covering on the crest of the Hogs Back Chalk ridge at over 150m O.D., and beyond the Blackwater they occur in the gravels of the Hale plateau near Aldershot at over 183m O.D. John surmises that transport of the pebbles was effected by a westward transgressing sea, but widespread long-shore drift also would have been in operation throughout the marine phases.

When sea level in the London basin began to fall below the Calabrian, deposits at the Pebble Gravels level in Hertfordshire were at first still marine, but with the land's emergence the deposits became increasingly fluviatile (Hey *et al.* 1971), as was probably the case elsewhere. Along the North Downs the gradual cessation of widespread transport by marine action brought restriction of sediment source to individual river catchments. As the basins of the Wealden rivers west of Botley Hill developed, that of the most easterly, the Wandle, alone of the four remained the recipient of pebbles from the western fringe of the Blackheath Beds *in situ*, the subaerial erosion of which was often to be intensified under periglacial conditions. Therefore, quantities of the mainly dark pre-rounded flint pebbles characterise all the Wandle terraces, decreasing proportionately as frost action and corrosion in the downland valley system excavated more deeply into the Upper Chalk, providing more angular flint.

While the Merstham gap operated as a river valley the Wandle gravels also contained an appreciable proportion of Lower Greensand material. 10% of chert was recorded in the three high sand and gravel deposits in the vicinity of Norwood, brought from the Weald through the downland gap (Dewey and Bromehead 1921, p.44), and up to 35% of chert was recorded in gravels at Deptford (Nunn 1982). It has been shown that the deep Pool River valley east of the Norwood ridge in south London was probably excavated from Croydon northwards by the Anglian Wandle (Peake 1982). The hogsback ridge of London Clay developed along the north east - south west axis of the Crystal Palace syncline (Barrow and Wills 1913). Erosive power of the Pool River may have been increased by a gradient steepened to a lowered sea level, and aided by minor slipping and solifluction of the London Clay along the flank of the Norwood ridge, beneath its pervious capping of Claygate Beds and Pleistocene sand and gravel. Land slipping on the steepened upper slopes has continued into the present century (Dewey and Bromehead 1921), extensive head deposits masking the lower slopes (Berry and Rollin 1981). It is unlikely that a downland bourne or even periglacial flow, heading in the Chalk, could have achieved the deep downcutting evident in the Pool River valley. A Wealden Wandle flowing through the Merstham gap under perigalcial conditions is more likely to have been in operation.

Acknowledgement

The author wishes to thank Miss Anne Bennett for redrawing the illustrations.

Mrs D.S. Peake,
Rosewall,
Portley Wood Road,
Whyteleafe,
Surrey
CR3 OBP

References

Berry, F.G. and Rollin, K.C. 1981. South London, Sheet 270(D) *Geol. Surv. G.B.*

Barrow, G. and Wills, L.J. 1913. Records of London wells. *Mem. geol. Surv. G.B.*

Davies, G.M. 1915-16. The rocks and minerals of the Croydon Regional Survey Area. *Proc. Croydon nat. Hist. scient. Soc.* 8, 53-96.

Dewey, H. and Bromehead, C.E.N. 1921. The geology of south London. *Mem. geol. Surv. G.B.*

Dines, H.G., Buchan, S., Holmes, S.C.A. and Bristow, C.R. 1969. Geology of the country around Sevenoaks and Tonbridge. *Mem. geol. Surv. G.B.*

Dines, H.G. and Edmunds, F.H. 1933. The geology of the country around Reigate and Dorking. *Mem. geol. Surv. G.B.*

Hey, R.W., Krinsley, D.H. and Hyde, P.J.W. 1971. Surface texture of sand grains from the Hertfordshire Pebble Gravels. *Geol. Mag.* 108, 377-82.

John, D.T. 1980. The soils and superficial deposits on the North Downs of Surrey. In *The shaping of southern England*, ed. D.K.C. Jones, Inst. British Geographers Spec. Pubn. No. 11, 101-30.

Moodie, J.M. 1913. Animal remains and Saxon burials found near Coulsdon. *Surrey archaeol. Collect.* 26, 139-40.

Nunn, P.D. 1982. High level river terraces in south London. *Quaternary Newsletter.* 36, 9-15.

Ollier, C.D. and Thomasson, A.J. 1957. Asymmetric valleys of the Chiltern Hills. *Geogr. J.* 123, 71-80.

Peake, D.S. 1982. The ground upon which Croydon was built; a reappraisal of the Pleistocene history of the River Wandle and its basin. *Proc. Croydon nat. Hist. scient. Soc.* 17, 89-116.

Wooldridge, S.W. 1927. The Pliocene Period in the London basin. *Proc. Geol. Ass.* 38, 49-132.

Wooldridge, S.W. 1960. The Pleistocene succession in the London basin. *Proc. Geol. Ass.* 11, 113-129.

A PROBLEM OF DEFINITION IN SEA-LEVEL RESEARCH METHODS

By I. Shennan

It has been clearly shown (e.g. Shennan 1980, 1982a, b, Tooley 1982) that the terms "transgression" and "regression" have led to numerous problems in sea-level research due to the lack of precise definitions. As a result, it has not been possible to easily correlate between the results of different research workers and subsequently the identification of regionally significant changes in sea-level, associated processes and the accurate estimation of rates of crustal movements are not possible. A series of terms have been recommended (Shennan 1982a, b, Tooley 1982) which will allow reliable comparisons between different authors' work if the terms are applied correctly. However a recent review paper (Kidson 1982) and a recent summary of research (Jennings & Smyth 1982) indicate that while attempts have been made to use the terminology they have been in an incorrect manner. The purpose of this article is to set out clearly the meanings of various terms since their misuse may have been the result of inexplicit original definitions by Shennan and Tooley.

<u>Trangression</u> and <u>regression</u> are seldom defined and have been applied as chronostratigraphic units, lithostratigraphic units and as processes (see the disucsion in Shennan 1980, 1982a, b, Tooley 1982). These terms must not be used in any formal sense or correlation scheme if the inconsistencies of the past are to be avoided. They remain most widely used as indicating processes, but even then their precise meaning should be defined. Perhaps it would be better to use alternative phrases to avoid further problems of comparison.

<u>Transgressive overlap</u> and <u>regressive overlap</u> should be used as lithostratigraphic descriptive terms in which no process is implied (Shennan 1982a, Tooley 1982). The statement by Kidson (1982: 141-142) "Tooley (1982) now accepts the terms transgressive and regressive overlap as alternatives to presumed rises and falls of sea level" is thus erroneous. Jennings and Smyth (1982: 17) first use the terms correctly".... the upper peat layer is overlain either by a silt and sand or by a stiff orange stained silty clay .... The date of this transgressive overlap is....". In the next paragraph, however, they state "The upper deposit of silt and sand at the Vale of Brooks has been interpreted by Jones (1981) as representing a period of marine incursion - a transgressive overlap. This was preceded by a removal of the marine influence - a regressive overlap - ...". <u>Transgressive and regressive overlap</u> are terms describing a change in sediment type, the <u>interpretation</u> of this change is the next stage of analysis and neither this interpretation or the designation of a chronological unit, "a period of marine incursion", is the correct usage.

While interpretations of sea-level data will vary between authors the original data must not be suppressed. Different terms must be applied at each stage of analysis to make everything clear. Transgressive overlap and regressive overlap are just two types of <u>sea-level index points.</u> The IGCP Project 61 guidelines (van de Plassche & Preuss 1978, van de Plassche 1982) developed the useful concepts of indicative meaning and reference water level of sea-level index points. An individual sea-level index point is unlikely to show unequivocally a regionally significant process such as a rise or fall in sea level. By comparing all available lines of evidence, e.g. radiocarbon dated sea-level index points, undated sea-level index points, lithologic changes, archaeological and palaeobotanical evidence; the processes operating on a wider scale may be interpreted in terms of the dominant tendency of sea-level movement. Therefore, following the analysis of stratigraphic sections and the assessment of errors relating to the age, altitude and meaning of numerous sea-level index points, the accumulated evidence of the local sea-level index points can be interpreted in terms of the dominant local sea-level tendency. A positive tendency of sea-level movement is defined as an apparent increase in the marine influence and a negative tendency of sea-level movement is the apparent decrease of the marine influence. It is a further, and often the most difficult, stage to show that tendencies of sea-level movement inequivocally indicate changes in the altitude of a particular sea-level, or tide-level, through time. The comment of Kidson (1982: 141;142) equating transgressive and regressive overlaps with positive and negative tendencies of sea-level movements needs a little clarification since this may not be the only possible interpretation. For example, a regressive overlap need not always indicate a negative tendency of sea-level movement since the altitudinal variation of the overlap may show that it was formed at that specific location while the regional direction of change was an increase in the marine influence. In an example discussed by Shennan et al (in prep.) the regressive overlap formed during a period of increasing sea-level.

To summarize, firstly there should be the identification and accumulation of sea-level index points. Transgressive and regressive overlaps are just two types. Secondly these sea-level index points are assessed jointly to identify a wider scale process, the tendency of sea-level movement. The next stages will vary according to the research topic; e.g. the development and comparison of local chronologies of sea-level tendencies, the development of regional chronologies and, perhaps, the estimation of altitudinal changes of sea-level or real "rises and falls of sea-level". Tendencies are not synonyms for altitudinal changes.

I. Shennan
Department of Geography
Science Laboratories
University of Durham
South Road
Durham DH1 3LE

References

Jennings, S. and Smyth, C. 1982 - A preliminary interpretation of coastal deposits from East Sussex. *Quaternary Newsletter* 37: 12-19

Kidson, C. 1982 - Sea level changes in the Holocene. *Quaternary Science Reviews* 1: 121-151

Shennan, I. 1980 - *Flandrian sea-level changes in the Fenland.* Unpublished Ph.D. Thesis. University of Durham.

Shennan, I. 1982a. - Interpretation of Flandrian sea-level data from the Fenland, England. *Proc. Geol. Assoc. London* 93: 53-63.

Shennan, I. 1982b. - Problems of Correlating Flandrian sea-level changes and climate. In, Harding, A.F. (ed) *Climatic change in later prehistory.* Edinburgh, University Press. pp. 52-67

Shennan, I. in press. - Flandrian and Late Devensian sea-level changes and crustal movements in England and Wales. In, Smith, D.E. and Dawson, A.G. (eds) *Shorelines and Isostasy.* London, Academic Press.

Shennan, I., Tooley, M.J., Davis, M.J. and Haggart, B.A. in prep. The analysis and interpretation of Holocene sea-level data.

Tooley, M.J. 1982. - Sea-level changes in Northern England. *Proc. Geol. Assoc. London* 93: 43-51

van de Plassche, O. 1982. - *Sea-level change and water level movements in the Netherlands during the Holocene.* Amsterdam, Free University.

van de Plassche, O. and Preuss, H. 1978. - *IGCP Project 61. Explanatory guidelines for completion of the computer form for sample documentation.* Unpublished typescript. Amsterdam/ Hannover.

UNITED KINGDOM CONTRIBUTION TO THE INTERNATIONAL GEOLOGICAL CORRELATION PROGRAMME; PROJECT 24, QUATERNARY GLACIATIONS OF THE NORTHERN HEMISPHERE.

National Correspondent Professor F.W. Shotton. Report by a working group, chaired by Professor F.W. Shotton, with the following membership:

A.J. Sutcliffe (Convenor and secretary), D.Q. Bowen, A.P. Currant, G.R. Coope, R. Harmon, N.J. Shackleton, C.B. Stringer, C. Turner, R.G. West and J. Wymer. It represents a consensus view, with occasional minority reservations on certain points. The paper was presented by Professor Shotton at the 9th and final meeting of Project 24 in Paris, in September 1982, and will be issued as one of a series of reports published by I.G.C.P. Permission is kindly granted by Project 24 Leader, Professor V. Sibrava, for advance publication of this report in *Quaternary Newsletter*.

INTERGLACIALS AFTER THE HOXNIAN IN BRITAIN

In 1973 the Geological Society of London issued its Special Report No.4 on the correlation of British Quaternary deposits (Mitchell et al 1973). The stages recognized in the Middle and Upper Pleistocene and Holocene follow below, with their names based on British stratotypes and their rough equivalents in the European stages indicated.

HOLOCENE	Flandrian	
UPPER PLEISTOCENE	Devensian = Weichselian	Gl.
	Ipswichian = Eemian	I.Gl.
MIDDLE PLEISTOCENE	Wolstonian = Saalian	Gl.
	Hoxnian = Holsteinian	I.Gl.
	Anglian = Elsterian	Gl.
	Cromerian = Voigstedtian	I.Gl.

It was never intended that this correlation was sacrosanct and immutable and in recent years, since the publication of the deep sea deposits Oxygen isotope record, with attempts to correlate its stages and substages with land deposits (Shackleton 1969, Shackleton & Opdyke 1973) there has been a growing body of opinion that there must be more climatic oscillations than have hitherto been recognized in our continental deposits. Accordingly the Royal Society's INQUA subcommittee set up a working group to report on the number of interglacials after the Hoxnian. After three years of intermittent work, a report is now presented to the final session of IGCP Project 24, Glaciations of the Northern Hemisphere.

The stratotype of the Ipswichian is Bobbitshole at the margin of the alluvium of the River Orwell at Ipswich, Suffolk. It is virtually at the same level as the alluvium and less than a metre above sea level, whereas the Hoxnian Interglacial deposits of the type area, only 35 Km to the north but not on the same river, fill a hollow cut into a plateau of Anglian till at about 35m above sea level. Gladfelter (1975) has pointed out that erosion of this plateau, with clear evidence of strong frost action, can most logically be credited to the Wolstonian cold period and that the deep incision of the East Anglian rivers down to the Ipswichian level makes those interglacial deposits much later than the Hoxnian.

West (1957) described the pollen zone succession and Sparks (1957) described the mollusca. Coope (1974) subsequently examined the coleoptera. Of the four stages which any interglacial passes through between two enveloping glaciations (Turner and West 1968), West only recognized the first two at Bobbitshole and he defined palynologically Zones Ip.I, Ip.IIa and Ip.IIb.

Since the Ipswichian was thus defined, numerous other deposits have been credited to the same interglacial, from London through Essex and Suffolk to Norfolk, on the south English coast, in terrace deposits of the Midlands and in English and Welsh caves. Between them they have provided the additional pollen zones III and IV but it is important to note that the full sequence from Zone I to Zone IV had not been found at a single site until Hall (1980) described such at Wing in Leicestershire. In view of the strong possibility that different interglacials will nevertheless produce vegetation successions that are broadly similar, it is clearly possible that parts of more than one warm period may have been credited to a single interglacial and called Ipswichian.

The one important faunal element virtually missing from Bobbitshole was the mammalia, but mammals have been found at many other sites accorded the title of Ipswichian. A key site where correlation of a mammal-bearing deposit with Bobbitshole may be attempted, using more than one discipline, was in the excavation for Uganda House in Trafalgar Square, London. As at Bobbitshole, the interglacial level was very close to O.D. Its mammal fauna included *Hippopotamus* and *Dicerorhinus hemitoechus* but lacked *Equus*. Franks (1960) demonstrated a close similarity of the pollen spectrum to Ip.IIb. The beetle assemblages closely paralleled those of Bobbitshole, being dominated at both sites by the same Scarabaeids, making them unique amongst British deposits. Coope (1974) has little doubt that the two deposits are of the same age. Trafalgar Square thus becomes a critical site in that it provides a mammal fauna from beds which, from other biological evidence, must be Ipswichian *sensu stricto*. The same fauna, very rich in species, occurs in Joint Mitnor Cave, Buckfastleigh, Devonshire (Sutcliffe 1960). The ossiferous layer is underneath unfossiliferous cave earth which is presumed to be of cold climate origin and to belong to part, at least, of the Devensian. Similar faunas occur at several other cave or river terrace sites in England and up to the present they consistently lack *Equus*. At Swanton Morley in Norfolk, *Hippopotamus* occurs in early Ip.III, after which it has not been recorded from the British scene.

There are, however, a number of British sites which are demonstrably post-Hoxnian, which have pollen assemblages broadly similar to those of the Ipswichian, but which for a variety of reasons appear to fit better into an older warm period. The arguments for this are not always the same. Obviously the ideal situation would be that of two interglacial deposits separated by a cold period in a single succession and all demonstrably post-Wolstonian. The available evidence is rarely so accommodating but there are certainly a number of British sites which go well towards fulfilling most of these requirements. It is unfortunate that much of this information is not yet published, as is apparent in the critical sites which are discussed below.

<u>Aveley, Essex.</u> (Personal communication from A.J. Sutcliffe and A.P. Currant).

A richly fossiliferous interglacial sequence has been attributed on palynological grounds to pollen zones IIb and III of the Ipswichian (West 1969). The mammal fauna, however, is at odds with this interpretation, since the lower part of the sequence attributed to pollen zone Ip.IIb, has a mammal fauna with *Palaeoloxodon* but none of the other elements of the "Hippopotamus fauna". In view of the wide geographical range of this fauna, its absence from here is not easily dismissed. In Zone III there is a marked change to a fauna with *Mammuthus*, contrasting with Zone III at Swanton Morley where elements of the Hippopotamus fauna still persist. In addition, the beetle remains, although fragmentary, do not compare with those from Ipswichian II of Bobbitshole or Trafalgar Square. There is also little similarity with the beetles from the Hoxnian of Hoxne itself or of Nechells in Birmingham (Shotton & Osborne, 1965) though in any case few would suggest such a correlation in view of the relation of Aveley to the Thames terraces.

Marsworth, Buckinghamshire. (Personal communication from A.P. Currant and J. Wymer).

A channel deposit characterised by *Mammuthus* and *Equus* and including a small wolf and a large form of lion is covered by a cryoturbated gravelly coombe rock indicative of very cold conditions. Into these has been cut a second channel with deposits carrying a classic Ipswichian Hippopotamus fauna. Thus, according to the communicators, two interglacial periods are separated by a very cold interval. Turner however, suggests from pollen evidence that the earlier period may be of interstadial rather than interglacial status. Strict stratigraphical proof that both are post-Wolstonian has not yet been produced.

Stanton Harcourt (alternatively known as Linch Hill) near Oxford.

The large gravel pit now being worked is on an extensive outcrop of terrace gravel shown on the latest edition of geological sheet 237 of the Institute of Geological Sciences as Terrace 2,3. Other terrace spreads of the same height above the Thames floodplain are given as Terrace 2 only, i.e. the Summertown-Radley Terrace, with No.3, the Wolvercote Terrace, clearly separated at a higher level. Although levels on the top of the Stanton Harcourt spread range from 69 to 75m, in its southern part it is about 7m above the Thames floodplain and in its northern part still about the same distance above the tributary of the Thames, the Windrush, which the terrace adjoins. So there is no reason to regard the deposits about to be described as other than those of the Summertown - Radley Terrace. This is younger than the Wolvercote Terrace gravels, which are Wolstonian (Bishop 1958) and still younger than the Hanborough Terrace which is no older than Hoxnian and may be in part early Wolstonian (Briggs and Gilbertson 1973). So there is no doubt about the post-Wolstonian age of the Summertown - Radley Terrace.

The main deposit being worked is gravel, with strong intra-formational cryoturbation and ice-wedge pseudomorphs. It is clearly a deposit of a very cold period. Channels cut into bedrock below the gravel are filled with silt and yield a *Mammuthus* - *Equus* vertebrate fauna together with many *Corbicula fluminalis*, often with joined valves. Obviously an interglacial climate is indicated, a conclusion reinforced by Coope's study of the coleoptera (personal communication).

Older accounts of working the gravels of the terrace (Sandford 1924) stress the 'cold' nature of the main mass of gravel but make frequent reference to hippopotamus remains from the top. So here there is a good case for two separate interglacials, the later one being Ipswichian *sensu stricto* and both post-Wolstonian.

Terraces of the Warwickshire Avon

Work over the past decade by Whitehead and Shotton has resulted in the following sequence of events after the type Wolstonian glacial sequence and before the sediments under No.2 Terrace which are Mid-Devensian with a mammoth, woolly rhinoceros, reindeer, horse and musk ox fauna

a. Terrace No.5 gravels between 36 and 42m above alluvium level. Whitehead has for the first time found a fauna (molluscs, ostracods, *Equus* and *Cervus elaphus)* and flora in these deposits which are at least temperate.

b. Erosion from No.5 level to a maximum depth of 30m. Nothing to represent this time interval, which must be long.

c. Aggradation of deposits formerly called "No.3 Terrace" to a thickness of at least 13m. These deposits appear to fill a large channel but not as widespread as the subsequent No.4 Terrace. Fauna includes *Hippopotamus, Palaeoloxodon antiquus, Bison, Corbicula, Belgrandia marginata* and *Potamida littoralis*. *Hippopotamus* is known from four localities, *Corbicula* from one only and so far they have not been found together.

d. Lateral erosion followed by deposits of No.4 up to 6m thick. The mammal fauna, mollusc fauna and the flora are all markedly 'cold'. Derived Acheulian and Levalloisian implements are numerous. Ascribed to the early Devensian.

This again seems to be another case of two interglacials of post-Wolstonian date, the later one with the Hippopotamus fauna. Unfortunately, the mammal fauna from the early No.5 Terrace is scanty.

Other localities with alleged Ipswichian deposits (John Wymer).

Of the many sites which have been put into the Ipswichian, those known by the names of Stoke Tunnel, Maidenhall, Stutton and Harkstead (sites near to Bobbitshole) and Brundon, Suffolk, are described as geomorphologically discordant to Bobbitshole, as having a *Mammuthus-Equus* fauna and lacking the *Hippopotamus* fauna. Wymer thus regards these sites as pre-Ipswichian.

The possibility of a critical separation based on beetle species.

Coope has commented on the occurrence of a small, easily recognisable staphilinid beetle, *Anotylus gibbulus*, in British deposits. This insect now lives in the Caucasus but is not a present day British species. It occurs, often as the dominant species, in the interglacial deposits at Aveley, Marsworth earlier channel, Stanton Harcourt basal channel and Stoke Goldington (another alleged Ipswichian site). It is not restricted to deposits of this age, for it occurred sparingly in the Mid-Devensian of Upton Warren (Coope, Shotton and Strachan 1961) and at Seisdon (Morgan 1973) in a very small fauna from a channel deposit which West tentatively put in the Hoxnian because of high *Hippohäe*. More significantly, however, it appears to be absent from those deposits which are as accepted as Ipswichian *sensu stricto*. Coope therefore believes that the presence or absence of this species serves to distinguish an earlier post-Hoxnian interglacial from a later one which is the true Ipswichian of Bobbitshole.

It is always dangerous to base a conclusion on negative evidence but the presence or absence of *Anotylus gibbulus* is an argument of the same kind as the claimed mutual exclusiveness of *Equus* and *Hippopotamus* in the period between the Wolstonian and Devensian glaciations.

Absolute dating of the various deposits.

Although the majority of the working party would certainly favour two interglacials where previously only the Ipswichian has been recognised, an expected confirmation by absolute dating is not yet conclusive.

All the sequences in question are beyond the range of radiocarbon dating. Using the Uranium series, the Hippopotamus fauna of Victoria Cave, Settle, Yorkshire, has been firmly dated at 120 10 Ka (Gascoyne, Currant & Lord 1981), thus dating the Ipswichian *sensu stricto* and correlating it with Sub-stage 5e of the Oxygen isotope record.

Similar figures on speleothems have been obtained at Belle Hougue Cave in Jersey, 121 Ka (Keen, Harmon and Andrews, 1981) and at Bacon Hole in South Wales, 122 Ka, but the vertebrate fauna at these sites has yet to yield *Hippopotamus*. At Bacon Hole, other associated animals have been found, whilst Belle Hougue is clearly interglacial as judged by the marine mollusca.

There are numerous measurements (many of them still unpublished) on speleothems with no biotal associations which give dates consistent with a warm period at isotope Stage 7. This cannot be the true Ipswichian and is unlikely to be the Hoxnian, but we still await a U/Th date firmly associated with the *Mammuthus* - *Equus* fauna.

Bowen has embarked upon the measurement of amino acid racemization ratios and where these are made upon the marine limpet *Patella* in raised beaches or sea caves, there is a reasonable consistency in the results. However, most of the discussed sections are non-marine in origin and in such cases fresh water molluscs such as *Corbicula*, *Pisidium* or *Lymnaea* have to be used and these give values different from those of *Patella* and even different amongst themselves. Although preliminary figures suggest that the sites once all considered to be Ipswichian do divide into two groups, Bowen considers that more measurements and repetition of those already made, are necessary before authorative statements can be given. It is possible that by the time this paper is published, more definite conclusions will be available.

References

Bishop, W.W. 1958. The Pleistocene geology and geomorphology of three gaps in the Midland Jurassic Scarp. *Phil. Trans. R. Soc. London* B 241, 255-305.

Briggs, D.J. & Gilbertson, D.D. 1973. The age of the Hanborough Terrace of the River Evenlode, Oxfordshire. *Proc. Geol. Assoc. London* 84, 155-173.

Coope, G.R. 1974. Interglacial coleoptera from Bobbitshole, Ipswich, Suffolk. *Jl. Geol. Soc. London* 130, 333-340.

Coope, G.R., Shotton, F.W. & Strachan, I. 1961. A Late Pleistocene fauna and flora from Upton Warren, Worcestershire. *Phil. Trans. R. Soc. London* B 244, 379-421.

Franks, J.W. 1960. Interglacial deposits at Trafalgar Square, London. *New Phytol.* 59, 145-152.

Gascoyne, M., Currant, A.P. & Lord, T.C. 1981. Ipswichian fauna of Victoria Cave and the marine palaeoclimatic record. *Nature, London* 294, 652-654.

Gladfelter, B.G. 1975. Geomorphological meaning of a type locality: an example from the British Pleistocene. *Proc. Ass. Amer. Geogr.* 7, 76-79.

Hall, A.R., 1980. Late Pleistocene deposits at Wing, Rutland. *Phil. Trans. R. Soc. London* B 289, 135-164.

Keen, D.H., Harmon, R.S. & Andrews, J.T. 1981. U series and amino acid dates from Jersey. *Nature, London* 289, 162-164.

Mitchell, G.F., Penny, L.F., Shotton, F.W. & West, R.G. 1973. A correlation of Quaternary deposits in the British Isles. *Geol. Soc. London* Special Report No. 4. 99pp.

Morgan, A.V. 1973. The Pleistocene geology of the area north and west of Wolverhampton, Staffordshire, England. *Phil. Trans. R. Soc. London* B 265, 233-297.

Sandford, K.S. 1924. The river gravels of the Oxford district. *Q. Jl. Geol. Soc. London,* 80, 113-179.

Shackleton, N.J. 1969. The last interglacial in the marine and terrestrial record. *Proc. R. Soc. London* B 174, 135-154.

Shackleton, N.J. & Opdyke, N.D. 1973. Oxygen isotope and palaeomagnetic stratigraphy of Equatorial Core V28-238. *Quat. Res.*3, 39-55.

Shotton, F.W. & Osborne, P.J. 1965. The fauna of the Hoxnian interglacial deposits of Nechells, Birmingham. *Phil. Trans. B. Soc. London* B 248, 353-378.

Sparks, W.B. 1957. The non-marine mollusca of the interglacial deposits at Bobbitshole, Ipswich. *Phil. Trans. R. Soc. London* B 241, 33-44.

Sutcliffe, A. 1960. Joint Mitnor Cave, Buckfastleigh. *Trans. Torquay Nat. Hist. Soc.* XIII pt.1, 1-28.

Turner, C. & West, R.G. The subdivision and zonation of interglacial periods. *Eiszeit. u. Gegenw.* 19, 93-101.

West, R.G. 1957. Interglacial deposits at Bobbitshole, Ipswich. *Phil. Trans. R. Soc. London* B 241, 1-33.

West, R.G. 1969. Pollen analyses from interglacial deposits at Aveley and Grays, Essex. *Proc. Geol. Assoc. London* 80, 271-282.

FLANDRIAN BARRIER BEACHES OFF THE COAST OF SUSSEX AND SOUTH-EAST KENT.

By J. Eddison

Recent contributions to Quaternary Newsletters Nos. 37 and 38 (Jennings and Smyth, 1982; Burrin, 1982; Carter, 1982) have discussed Flandrian sediments which accumulated in the Sussex coastal lowlands, probably behind hypothetical barrier beaches, and also the possible mechanism of breaching those barriers.

Perhaps a further comment on the barrier beaches themselves is appropriate, in the light of evidence from the barrier beaches which remain in the area east of Fairlight and of the mechanics of shingle movement in that area.

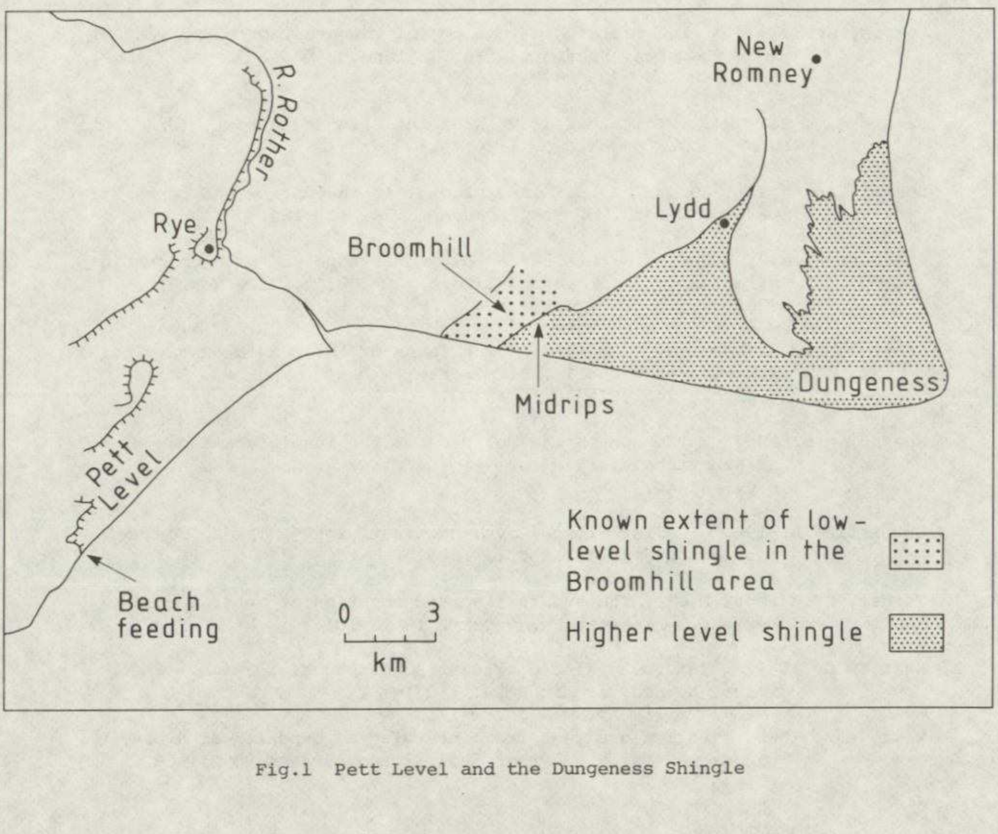


Fig.1 Pett Level and the Dungeness Shingle

Eastward littoral drift is an all-important component of shingle movement east of Selsey Bill. In an attempt to maintain stability of coastline, the Southern Water Authority is beach-feeding 29,300 cu.m. p.a. (1979 figures) at Pett Level (Fig.1) to compensate for an equivalent volume being removed annually by littoral drift towards the mouth of the Rother. The eastward littoral drift indicates not only the likely destination of beach material which formerly constituted the barrier beaches off Sussex: it must also be taken into account when discussing the mechanics of those hypothetical barriers.

Evidence from the Dungeness shingle mass (Eddison, 1983) could be most helpful. Low-level shingle, with the top of north-east-trending ridges at approximately 1.5 m. O.D., is evident in sewers, lying beneath later marsh deposits in the area of Broomhill Farm (TQ 987 184) and at two other points further north-east across the Romney Marsh embayment.

These are probably fragments of a very early low-level barrier beach system which dates from a time when sea level (assuming the present tidal range) was over four metres lower than it is today. There may be even lower precursors of this barrier system (the shingle beneath Lydd town is at least 16 m. thick) but they have not been identified.

The whole of the Dungeness shingle mass accumulated subsequently outside this low-level barrier, apparently banked up against it. Lewis and Balchin (1940) showed a gradual rise in the level of the shingle ridges from the Midrips to Dungeness itself, which illustrates a gradual rise in sea level.

It appears (Eddison, 1983) that shingle was entering the Romney Marsh area from the south-west by at least 5,500 B.P. By A.D. 1,000 the supply was diminishing, and by the 1940s it had virtually ceased (Lewis, 1932).

It is, therefore, suggested that the hypothetical barrier beaches off the coast of Sussex consisted of flint shingle, which was <u>en route</u> by means of vigorous beach drifting to Dungeness. Their height O.D. kept pace with rising sea level over several thousand years.

Each valley on the Sussex coast with a significant river flow must have had an outlet through the barrier beach. These outlets would almost certainly have become inlets for tidal waters (since by definition a shingle barrier beach is thrown up by the waves higher than the marsh sediments behind it). Although the regular tidal flow would have helped to keep the inlets constant, each individual break in the barrier would have been mobile, would have had a tendency to migrate eastwards, and may have been short-lived.

However, shingle evidently continued to move eastwards across the mouths of these inlets. This may have been achieved partly by means of an intensely mobile bar at low water (as it is today at the mouth of the Cuckmere), and partly by the westward transfer of inlets resulting from the closure of one breach in the east and the development of a new breach further west. The latter process has been witnessed in much more recent times at the mouths of both the Adur and the Ouse (Steers, 1964).

Unfortunately the evidence of the breaching of the Fairlight - Broomhill barrier beach has been completely lost through erosion, but the evidence available on the behaviour of the storm beach in the neighbourhood of the Galloways Road Look-Out Post south-east of Lydd may be instructive in projecting breach-mechanisms. There the storm beach is backed by much older shingle ridges, which vary between 2 and 3 m. lower than it. But very seldom is the storm beach over-topped. The principal weakening movement occurs as a result of seepage. At high spring tides, and especially when they coincide with an on-shore wind, tidal water seeps through the storm beach, appearing on the landward side some 1 - 2 m. below tide level. Shingle is washed down gullies away from, and therefore weakening, the storm beach. Dips appear from time to time in the crest of the beach as a result of this seepage, but are self-healing, quickly repaired with material supplied naturally by littoral drifting. The net result is that the storm beach is retreating northwards. In hypothetical situations likely to have occurred in Sussex, where a river might well have been flowing along behind the barrier, diverted by the eastward drift of shingle, it appears likely that a new breach could result very quickly.

The aim of this short note has been to draw attention of the relevance of information from the area east of Fairlight when considering the early barrier beaches off the present coast of Sussex. The evidence from Dungeness strongly suggests that flint shingle was travelling east along the then Sussex coast for much of the past 6,000 years, and that for the earlier part of that time it was at levels considerably below the present sea level.

Jill Eddison
Langley Farm
Bethersden
Ashford
Kent TN26 3HF

References

Burrin, P.J., 1982. The Coastal Deposits of the Southern Weald, *Quaternary Newsletter* 38, 16-24.

Carter, R.W.G., 1982. Barrier Breaching. *Quaternary Newsletter* 38, 29-32.

Eddison, Jill, 1983. The Evolution of the Barrier Beaches between Fairlight and Hythe, *Geogr. J.* 149, (in press).

Jennings, S. and Smyth, C., 1982. A Preliminary Interpretation of Coastal Deposits from East Sussex. *Quaternary Newsletter* 37, 12-19.

Jennings, S. and Smyth, C., 1982. A Reply to The Coastal Deposits of The Southern Weald. *Quaternary Newsletter* 38, 24-29.

Lewis, W.V., 1932. The formation of the Dungeness Foreland. *Geogr. J.* 80, 309-324.

Lewis, W.V. and Balchin, W.G.V., 1940. Past sea-levels at Dungeness. *Geogr. J.* 96, 258-285.

Steers, J.A., 1964. *The Coastline of England and Wales* (2nd edition) Cambridge University Press.

ON THE COASTAL DEPOSITS OF EAST SUSSEX: A FURTHER COMMENT

By P.J. Burrin

The recent reply by Jennings and Smyth (1982a) to my earlier remarks (Burrin 1982a) regarding the coastal deposits of the southern Weald must be welcomed in that (i) they clarify a number of previously vague and unsubstantiated points; (ii) they confirm that there are similarities in the general coastal zone lithostratigraphy encountered by both commercial and more specific research boreholes in the southern Weald, despite some significant local variations, e.g. in the extent of peat formation; (iii) they accept that the presence or role of coastal barriers in episodes of coastal sedimentation in East Sussex, other than late Flandrian, can only be suggested rather than proven in many cases on the basis of current evidence; and finally (iv) they agree that diatom and similar analyses, together with radiocarbon and other dating techniques, will considerably aid our understanding and evolution of these deposits. There are, however, two points which merit further brief discussion.

First, their comment regarding the probability of reworked loessal-derived sediments within both floodplain and coastal zone valley tracts of the southern Weald is surprising for it ignores both Catt's (1978) and Jones's (1981) comments regarding loess within this area as well as the evidence and arguments produced by Burrin (1981, 1982b). Consequently, the point made (Burrin 1982a) that loessal-derived sediments may probably be found within the more downstream valley deposits in the southern Weald is still valid.

Second, confusion appears to have arisen in attempting to interpret and correlate the lithostratigraphies and depositionary environments of the coastal zone tracts of southern Weald rivers, with the sequences found in broader expanses of coastal alluvium, such as Pevensey Levels. My original remarks concerning this problem (op. cit. 1982a) appear to have been somewhat misconstrued in that they were concerned with first, the mis-interpretation of the coastal zone lithostratigraphy in the lower Ouse valley, the latter which was constructed largely on the basis of research (Jones 1971), and not commercial, borehole logs as incorrectly inferred by Jennings and Smyth (1982a, p.26); and second, as subsequently acknowledged by these authors (op. cit.), with the lack of evidence provided for their conclusions concerning the apparent evolution of this valley, and neighbouring coastal, deposits. The nature of the Willingdon

Levels and Combe Haven sedimentary depositionary environments was questioned because a number of unsupported statements were made. New evidence has subsequently been produced (Jennings and Smyth 1982a), from which it now appears more probable that the bluish-grey Lottbridge Drove silts were deposited under brackish or marine conditions, although similar argillaceous deposits found within the adjacent lower river valleys are more likely to be freshwater in origin for reasons given in Burrin (1982a). This, and the later establishment of salt-marsh conditions in Willingdon Levels suggests an environment protected to some degree by offshore barriers or spits, as originally suggested but previously unsupported by Jennings and Smyth (1982b). However, the development, and importance of, coastal barrier-breaching in explaining sedimentation in more inland coastal zone valley sites (such as the Vale of the Brooks) appears unfounded, particularly in light of the recent pertinent and interesting comment by Carter (1982).

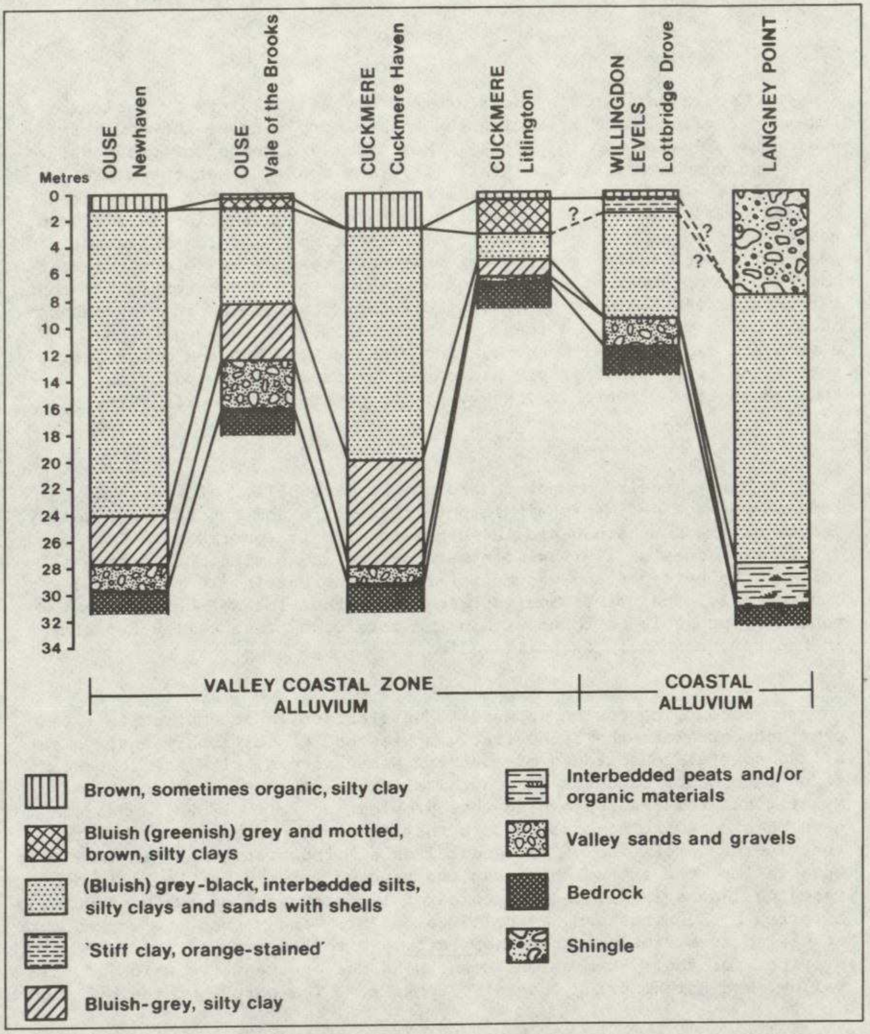


Fig.1: Revised, possible correlation of southern Weald valley coastal zone and coastal alluvial sequences (modified from Burrin 1982a)

On the basis of the more recently provided evidence, a revised correlation is required for the Lottbridge Drove coastal lithostratigraphy with those encountered in the lower coastal zones of neighbouring river valleys (Burrin 1982a; fig. 2). A tentative correlation of the lower bluish-grey silts found at the former site with the (bluish-) grey or black estuarine sands and silts encountered within the lower valleys in this area might be suggested (fig. 1), although it is evident that further research is required before this can be substantiated or otherwise. As such, the forthcoming results mentioned by Jennings and Smyth are awaited with interest.

Paul J. Burrin
Department of Geography
Goldsmiths' College
University of London
New Cross
London.

References

Burrin, P.J., 1981. Loess in the Weald. *Proc. Geol. Assoc. London* 92, 87-92.

Burrin, P.J., 1982a. The coastal deposits of the southern Weald. *Quaternary Newsletter* 38, 16-24.

Burrin, P.J., 1982b. Loess in the Weald (rejoinder). *Proc. Geol. Assoc. London* 93, 317.

Carter, R.W.G., Barrier breaching. *Quaternary Newsletter* 38, 29-32.

Catt, J.A., 1978. The contribution of loess to soils in lowland Britain, in Limbrey, S. and Evans, J.G. (eds). The effect of man on the landscape; the lowland zone. *C.B.A. Res. Rep.* No. 21, 12-20.

Jennings, S. & Smyth, C., 1982a. A reply to 'the coastal deposits of the southern Weald'. *Quaternary Newsletter* 38.

Jennings, S. & Smyth, C., 1982b. A preliminary interpretation of coastal deposits from East Sussex. *Quaternary Newsletter* 37, 12-19.

Jones, D.K.C., 1971. The Vale of the Brooks. In Williams, R.B.G. (Ed.) *Guide to Sussex Excursions*, 43-46, Inst. Brit. Geog.

Jones, D.K.C., 1981. *Southeast and southern England.* Methuen, London.

ABSTRACTS OF RECENT Ph.D. THESES

As noted in Newsletter No.38 it is hoped to publish the abstracts of recent Ph.D. theses and notice of registration of research topics for the degree of Ph.D. or M.Phil. Those having completed such theses or who have registered for a Ph.D. since 1981 are invited to send the details to the editor.

THE VEGETATIONAL AND LAND USE HISTORY OF THE WEST OF ARRAN, SCOTLAND

D.E. Robinson

Ph.D. Thesis, University of Glasgow, 1981

Peat sections and soil samples relating to the excavation of a group of Bronze Age monuments on Tormore, in the west of Arran, were analysed for their pollen, charcoal and plant macrofossil content in conjunction with the similar analysis of a long peat section from Machrie Moor, 1 km to the east.

The analyses provided information about the vegetation and land use history of the area during a period from the last glacial until approximately 500 years ago. The vegetation developed along broadly similar lines to that in other areas in south-west Scotland, with any differences being due to the local conditions of climate and exposure and possibly very early interference by human populations.

Mesolithic hunter/gatherers may have been active, at least on a seasonal basis, from as early as 8500 bp. There are also indications of very early Neolithic settlement, with pastoral agriculture and some cereal cultivation becoming established well in advance of the elm decline. Following a reduction in human activity in the late Neolithic there was renewed forest clearance for the purposes of mixed agriculture in the Bronze Age. This reached a climax around 2800 - 2900 bp, resulting in a virtually treeless landscape. The main occupations of the Tormore monuments span the period of the Bronze Age.

In the later Bronze Age, soil deterioration and peat growth became serious problems, contributing to a marked reduction in agricultural activity which persisted into the early Iron Age. In the later Iron Age there was a resurgence in pastoralism during which field banks and associated ditches were constructed on Tormore to act as grazing boundaries.

Human activity in the Dark Ages which follow, was confined to isolated episodes of pastoral and arable agriculture. This remained the case until Viking/Mediaeval times when there was a resurgence in mixed farming to levels similar to those in the Bronze Age. These practices continued at a reduced level into the later Middle Ages.

THE STRATIGRAPHY AND CHRONOLOGY OF LATE QUATERNARY RAISED COASTAL DEPOSITS IN RENFREWSHIRE AND AYRSHIRE, WESTERN SCOTLAND

W.E. Boyd

Ph.D. Thesis, University of Glasgow, 1982

Despite the breadth of research in sea-level change and coastal evolution during Quaternary times in Scotland, certain parts of the coast have been largely neglected in recent years. One such area comprises the Renfrewshire and Ayrshire coasts of the Clyde Estuary and the Firth of Clyde. The work presented here partially rectifies this omission. Late Quaternary coastal history in two areas, one around Linwood (Renfrewshire) and the other between Irvine and Kilmarnock (Ayrshire), has been studied, using a multidisciplinary approach.

At Linwood Moss -- a fragment of formerly more extensive peat overlying inorganic raised coastal deposits -- peat and pollen stratigraphy is studied in three cores. A late Flandrian history of local vegetation is established and the results of the stratigraphical analysis, together with data derived from a field survey of sedimentary exposures and a theoretical model to aid discussion, are used to construct a model which relates local patterns of peat stratigraphy to patterns of sea-level change, coastline movement and marine deposition during the Flandrian Age. An approximate position of the shoreline of the so-called "Linwood-Paisley Embayment" is suggested, indicating the extent of the middle Flandrian marine transgression in this area. Earlier suggestions regarding the stratigraphy in this area are reviewed and certain palaeotidal consequences are discussed.

In the Irvine-Kilmarnock area, a wider-ranging approach is used to establish a stratigraphical and chronological model for change of sea level and coastal environment since Late Devensian deglaciation in the area. A sedimentological study indicates that during the Flandrian Age the shoreline remained in approximately the same location, that is c. 1 to 2 km inland from the present shoreline. This suggestion is reinforced by stratigraphical and palynological investigations at Shewalton Moss -- a major peat body on raised coastal deposits -- which indicate that earlier views regarding the extent of the Flandrian marine transgression require to be revised. Sedimentological, micropalaeontological and geomorphological analyses provide input for a coastal-change model for the Late Devensian sub-age and the results of further stratigraphical, sedimentological, palaeontological and palynological research refines the model provided for coastal change during the last 15,000 years. The model is presented as a series of maps representing the coastal palaeogeography at certain periods, especially in relation to contemporaneous sea level. A generalised sea-level curve is also presented, and the entire model is discussed within the context of previous models for the same area and existing models for other areas in Scotland. The model suggests palaeoenvironmental conditions which contribute significantly to Mesolithic archaeological interpretation in the area. The feedback from archaeology and radiocarbon analysis provides independent support for certain parts of the model.

In synthesis, suggestions for further work are made and discussion is concentrated on concepts used and developed within the research.

HUMMOCKY AND FLUTED MORAINES IN PART OF NORTH-WEST SCOTLAND

David M. Hodgson

Ph.D. Thesis, University of Edinburgh, 1982

The thesis is concerned with the formation and significance of moraines produced c. 11,000-10,000 yrs. B.P. by the glaciers of the Loch Lomond Advance. The moraines have a variety of forms but they have previously been divided into two groups: fluted and hummocky moraines. Fluted moraines have been shown by previous work to be subglacial landforms produced by active ice whereas the majority of hummocky moraines have been attributed to deposition from the surface of stagnant ice.

Associations between fluted and hummocky moraines raised the suspicion that some of the latter may have been formed subglacially. Detailed sampling revealed that all the hummocky moraines studied contain a large proportion of material that was picked up from the valley floors and carried only a short distance during the Loch Lomond Advance. These findings together with other evidence lead to the firm conclusion that the hummocky moraines studied were produced by active ice. This conclusion is accompanied by discussion of the mechanisms by and the conditions under which the moraines could have been formed and could have survived. It is suggested that the material was, at least in part, pushed up by the advancing ice front and subsequently passed over by the ice which reworked it to varying degrees.

A COMPARISON OF THE LANDFORMS AND SEDIMENTARY SEQUENCES PRODUCED BY SURGING AND NON-SURGING GLACIERS IN ICELAND

Martin J. Sharp

Ph.D. Thesis, Aberdeen University, 1982

Two outlet glaciers of Vatnajokull, Iceland, experienced a single period of Holocene glacier expansion between the 16th and 19th centuries A.D. During this period, their detailed responses differed considerably as Eyjabakkajökull surged on at least four occasions while Skalafellsjökull did not. The landforms and sedimentary sequences deposited by the two glaciers during this period also differed considerably, and it is suggested that the observed differences are related to the occurrence or non-occurrence of glacier surges. Detailed studies of processes of debris entrainment, transport and deposition by the two glaciers suggest three characteristic features of surging glaciers which may cause them to deposit distinctive landforms and sedimentary sequences. Intense longitudinal compression near the glacier margin during surges results in the formation of arcuate thrust structures along which debris-rich regelation ice is elevated above the glacier bed and it thus permits the formation of supraglacial meltout tills and sediment flow deposits. When combined with the meltwater floods often associated with surges, rapid loading of pre-existing sediments as the glacier advances may result in the development of excess pore pressures in buried aquifers, in liquefaction and failure at depth, and in glacitectonic thrusting of cohesive sediments. The glacier stagnates between surges so that the arcuate debris-bearing thrust planes do not propagate upglacier as the

glacier retreats, and supraglacial debris release and sedimentation are confined to a relatively narrow zone immediately inside the limit reached by a surge. Post-depositional deformation of tills beneath the stagnant glacier is restricted to the flow of the surface layers of lodgement tills in response to differential overburden pressures to form crevasse-fill ridges. Analysis of the landform and sediment types deposited by 16 other Vatnajökull outlet glaciers shows that the above criteria can distinguish surging glaciers from non-surging glaciers, and suggests that it may be possible to identify former glacier surges from geological evidence.

DRUMLIN LANDFORMS IN KIRKCUDBRIGHTSHIRE, SCOTLAND

W.B. Kerr, Supervisor: Dr. J. Rose

Ph.D. Registration, Birkbeck College, University of London

REVIEWS

Pleistocene Vertebrates in the British Isles. By A.J. Stuart 1982 Longman, London. 212pp. Price £16.50 (hard cover)

Research on Pleistocene vertebrates has a long history in Britain. The early investigations of Buckland were followed by contributions from workers such as Boyd Dawkins, Newton and Hinton. Their work has inevitably become dated and the study of Pleistocene vertebrates has received renewed attention in the last twenty years. Not only has this been due to development and synergism of related fields such as Pleistocene chronology, palynology and stratigraphy, but changes in approach to the study of the vertebrates themselves have also played a role. Thus, typological methodology in taxonomy has given way to studies of characters in populations, the importance of processes by which living organisms become converted to fossils has been realised, and attention has been given to palaeoecology. Finally, there has been a corresponding growth in the continental European literature which has provided information of direct relevance to Britain.

For the specialist, drawing together the literature in this field is hindered by two major difficulties : the variation in the taxonomy and nomenclature of the vertebrates, and the differences in interpretation and usage of terminology in Pleistocene stratigraphy. For the non-specialist it may be no exaggeration to view these difficulties as insurmountable handicaps to understanding.

However, help is now at hand. Here is a book which provides a clear outline of the vertebrates and the stratigraphy as part of a comprehensive, up-to-date and very welcóme review.

The text begins with an overview of the Pleistocene of the British Isles dealing with the sediments, stratigraphy, succession, chronology, climatic change and vegetational history. This provides a sound context for the reviews of the vertebrate faunas which occupy the remainder of the book. Separate chapters with useful summary tables are devoted to Lower Pleistocene faunas; Middle and Upper Pleistocene interglacial faunas; and Middle and Upper Pleistocene cold-stage faunas. Changes through the Pleistocene are drawn together in chapters on Faunal History and Evolution. Special attention is paid to taxonomy and identification, and there are numerous photographs, line illustrations and references to descriptions in the literature. A separate chapter on taphonomy draws the reader's attention to this relatively young field, and emphasises its relevance to interpretation of fossil assemblages. The palaeoecology of the vertebrates is covered in some detail, making use of distribution maps. Finally, there is a short chapter on Man in the Pleistocene of the British Isles. The emphasis here is on the relationship between man and the rest of the fauna.

Obviously it is not possible in a book of this nature to review in detail all records of Pleistocene vertebrates from the British Isles. It is clear that emphasis has been placed on records from open localities rather than from caves, and this is understandable since open sites yield more palaeobotanical and stratigraphic evidence. This book is about British faunas. Although reference is given when appropriate to continental European faunas and localities, no attempt has been made to review systems for mammalian biostratigraphy of the European Pleistocene. Lastly, as may be expected in a broad review of this nature, it has been necessary to limit discussion of areas in which there are differences of opinion. For example, the treatment of the Late Pleistocene presents a single interglacial, the Ipswichian, between the Wolstonian and the Devensian cold-stages.

The method of division of the subject matter of the book has necessitated a certain amount of repetition and separation. For example, mention of a certain locality or taxon may be found in several chapters, each dealing with a particular aspect. Such information can be drawn together by the excellent index which includes Latin and common names.

Tony Stuart is to be congratulated for producing the first recent book to satisfactorily cover Pleistocene vertebrates in the British Isles and for writing a reference work suitable for use by both the specialist and non-specialist. It deserves a place in many institutional libraries and private bookshelves. The 387 references will assist those who wish to read further.

D.F. Mayhew
Roggebotstraat 101
Purmerend
The Netherlands

Climate and History. Studies in past climates and their impact on Man. Edited by T.M.L. Wigley, M.J. Ingram and G. Farmer. Cambridge University Press, 1981. 530 pp. ISBN 0521 239028. Price £30.

Nobody is more aware of the intricate links between climate and history than Professor Hubert H. Lamb. It was appropriate, therefore, that the founder and first director of the Climatic Research Unit at the University of East Anglia provided the inspiration for a conference with the theme 'Climate and History', which was held in Norwich in 1979. The conference was concerned with historical sources of evidence for former climatic change, notably the influence of climate and weather on human history. It was the first forum at which the whole spectrum of those interested in the inter-relationships of climate and history-meteorologists, climatologists, botanists, archaeologists, geographers and historians, were assembled.

The book evolved from contributions to, and ideas generated by the conference. It is organised in four sections. The editors chose to place their review of the subsequent, rather weighty subject matter in an introductory section. Whereas the reviewer prefers such necessary summaries as concluding features in compilations of this kind, Wigley, Ingram and Farmer manage quite skilfully to emphasise the major thrust of the forthcoming information on climatic reconstruction, the recognition and estimation of the influence of climate on former societies and their adjustment to the constraints imposed by it, and human perception of climate and climatic change.

Part two, 'Reconstruction of Past Climates', contains ten chapters, the first seven of which deal with methods used to elucidate climatic changes for the whole or parts of the last 5000 years; the remainder are case-studies illustrating the use of such methods. Gray explains the principles of stable isotope analysis and shows how its application to lake and ocean sediments, polar ice-sheets, speleothems, peat deposits and tree-rings can yield climatic estimates. Glaciological evidence of Holocene climatic change is examined by Porter. Glaciers are useful palaeoclimatic indicators because their positional changes can be documented and their ice and deposits investigated. Discrepancy between the age of a phenomenon produced by a climatic change, and the time of that change, is a recurrent problem in palaeoclimatology. Porter points out that a lag effect is operative in glacier mass balance changes, so that a dated glacial deposit may not reflect the date of the climatic event related to it. Birks addresses himself to the reconstruction of past climates by means of pollen analysis. With the premise that present ecology is the model for that of the past, and that floras and vegetation are loosely related to climate, the floristic indicator species and vegetational multivariate approaches are outlined. In the latter, mathematical transfer functions are employed to relate contemporary pollen assemblages and climates. Fossil pollen data are then transformed into quantitative estimates of former climates by use of the functions. Climatic variations over a seasonal to century time-scale from the study of tree-rings is the concern of Fritts, Lofgren and Gordon. They indicate how tree-ring width, structure and chemical composition yield climatic information, discuss statistical treatment of the data and point to the temporal precision and spatial application of the techniques. Archaeological evidence for climatic change during the last 5000 years is considered by McGhee, who contends that as climatic variations over this time-span have been relatively insignificant, social, political or cultural factors may have exerted comparable influences upon human activities. People of low technological and economic status, inhabiting areas marginal for human survival, are likely to offer most hope of identifying man-climate interaction. Archaeological evidence for climatic shifts is best illustrated in extreme environments. The clustering of settlements along desert watercourses, may, for example, indicate increased aridity in the locality. Documentary sources are tackled by Ingram, Underhill and Farmer. They point out that from <u>circa</u> AD 1100 to the commencement of instrumental meteorology in the late seventeenth century is the major documentary period. Sources, and the pitfalls of using them, are examined. Pioneers of documentary climatology - Brooks, Flohn, Manley and Lamb are mentioned, along with the initial apathy of other scientific climatologists to such research. Pfister's analysis of the Little Ice Age climate of Switzerland exemplifies the combination of numerous documentary sources in the production of a detailed account. Nicholson, examining the historical climatology of Africa, in which movements of the Inter Tropical Convergence Zone seem to have been important, draws upon a range of scientific and documentary evidence. Shao-Wu and Zong-Ci use documents to characterise and date six types of drought and flood distribution in China, also discussing these events in respect of atmospheric circulation.

Part III, 'Towards a Theory of Climate History Interactions', has five contributions. Lamb presents an approach to the study of the development of climate and its impact on human affairs. He explores why archaeologists, historians and planners until recently mainly choose to ignore climatic change, and looks at data and analytical methods which can be used in the long-term reconstruction of climate. The climate of the last millennium is analysed with especial reference to the Medieval Warm Epoch and Little Ice Age. The transition between these climatic extremes gave rise to numerous drastic environmental and human events. A number of putative major causes of climatic change which has influenced, and now affects human activity, are also discussed. Flohn's subject is the economic role of short-term climatic fluctations. It is stressed that while minor climatic fluctuations over decades or centuries are normally related to alterations in the number of extreme events, extremity on the interannual scale often occurs in short runs, this tending to increase its effect. Harsh climatic events are related to poor harvests, food supplies and famines, and hence to social and economic development. A research strategy for looking at climatic change and the agricultural frontier is provided by Parry, who points to the weaknesses of inductive studies of palaeoclimatic and palaeoeconomic inter-relationships, and pleads for the use of a deductive strategy based on comprehension of the processes connecting climate, agriculture and settlement. Such understanding can be obtained from contemporary studies of these phenomena. The methodology is exemplified by means of investigations in south-east Scotland. Economic models of history and climate are described by Anderson, who outlines the problems involved in attempting to link climatic and economic change, and concludes that no general causal relationship has existed over the last millennium. However, the behaviour of some economic indicators seems to correlate generally with average annual temperatures. Mackay's study, 'Climate and popular unrest in late medieval Castille', illustrates how qualitative and quantitative written material was utilised to reconstruct the climate, and to correlate fluctuations in the latter with periods of social unrest. Such phenomena as feasts and famines, and popular and religious beliefs are related to climatic variations.

Part IV, comprises six case-studies of climate-history interactions. Shaw, 'Climate, environment and history: the case of Roman North Africa,' suggests that palaeoenvironmental evidence indicates that the climate of the Maghrib during Roman times was similar to that of the present, and not as formerly supposed, one in which rainfall was higher. It was previously considered that high Roman agricultural production was due to a better climate than now pertains, and that climatic deterioration was responsible for its demise. Shaw contends that the decline of agriculture and settlement was more likely to have been the result of human activity. McGovern details the extinction of Norse settlements in Greenland circa AD 985-1500, concluding that this was not a direct response to a simultaneous climatic deterioration, but a result of the élite of Norse society failing to allow advantage to be taken of available alternative methods of resource utilisation. Sutherland's detailed study, 'Weather and the peasantry of Upper Brittany 1780-1789', shows that the traditional belief that the local peasantry lacked defences against bad weather and inadequate harvests, is unfounded. While there was suffering and poverty at this juncture, it was largely confined to the young, old or poor. The majority of the population survived by means of an elaborate social and economic system. 'Climatic stress and Maine agriculture, 1785-1885' by Smith, Borns, Barron and Bridges, reports a study which aimed to establish from meteorological records and agricultural change data, if there was any relationship between agriculture and climate in what is now Kennebec County, over this time-span. They consider that a climatic amelioration early in the period was connected with a substantial population influx and the initiation of commercial agriculture. Subsequent out-migration was linked to variations in the climate and to the perception of them by the local inhabitants, as well as to social and economic factors. Mooley and Pant consider Indian droughts over the last 200 years in the context of their socio-economic impact and the remedial measures taken to alleviate them. Droughts, which occur because of the failure of the summer monsoon, are random according to statistical tests on the data pertaining to their occurrence. Drought leads to shortage, increased cost and reduced intake of food, to social unrest, to lethargy, illness and death. The effect of climate fluctuations on human populations is discussed with reference to two hypotheses by Bowden et al. The first hypothesis is that of lessening, which states that societies are able to lessen the effects of minor climatic stresses (events with a return period of less than 100 years). The second, or catastrophe hypothesis, states that major climatic stresses (events with a return period of over 100 years), cannot be alleviated by technology and social organisation. The hypotheses are tested by using data from the Sahel 1910-1974, the American Great Plains 1880-1979, and the Tigris-Euphrates Valley 6000 BP to the present. The first two localities indicate that lessening occurred in the Sahel as a result of external aid. The 1930 drought on the Great Plains was a catastrophic event, with which the minor adjustment mechanism could not cope.

It will be apparent from the above resumé, that this substantial volume contains something of relevance to all those interested in the interactions of climate and history. As with all compilations of this kind, the editors faced a difficult task in striking a balance between the various aspects of the theme, and in coping with diverse styles of presentation. By and large, they have succeeded well. The text is easy to read, well-illustrated and remarkably error-free. With so many contributions, the reviewer at least, is thankful that they are succinct and may be digested en bloc. Considering its all-round usefulness and high level of scholarship, the price, at marginally less than 6p per page, may (as regrettably is not always the case in such circumstances) be justified.

R.L. Jones
Coventry (Lanchester) Polytechnic

NOTICES

Symposium on Quaternary Non-Marine Mollusca

Organised on behalf of The Conchological Society of Great Britain and Ireland and the Quaternary Research Association.

Saturday, 23rd April 1983, at the Department of Geography, University of Reading, 2 Earley Gate, Whiteknights Road, Reading RG6 2AU. Beginning at 9.30 a.m., ending by 6.30 p.m.

This informal meeting will consist of eight to ten short papers and discussion, and is intended primarily for workers actively involved in research in this field. The number of visitors will be limited to 30.

To register, write (enclosing s.a.e. please) to D.T. Holyoak at above address.

Swallow Holes in Chalk

Chalk, like other limestones is dissolved by aggressive percolating groundwater, but the usual result is only a general lowering of the chalk surface without the creation of major voids. Experience suggests that the risk of subsidence is greatest when there is a thin permeable cover to the chalk, having sufficient cohesion to span minor cavities, but which fails without warning when the void reaches a critical size or when strength is lost by internal erosion or leaching in the surface deposits. It would be valuable to identify and catalogue as comprehensively as possible, those localities prone to subsidence.

The research project is currently the subject of a CASE research studentship awarded by the Natural Environment Research Council to the Dept. of Geography at Bedford College (University of London) cooperating jointly with CIRIA, the Construction Industry Research and Information Association.

The main aim of the research is to develop a model able to predict areas upon the chalk outcrop which are liable to subsidence risk. The model depends on sufficient data being made available to the project so that it may be used to infer causal relationships with controlling factors in the local geology, hydrology and surface relief.

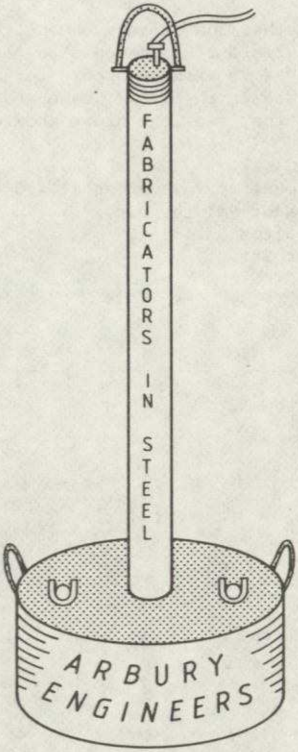
The most useful information would be observed cases of actual subsidence with or without structural damage, on sites underlain by chalk, though cases where past subsidence can be inferred (for example where an otherwise unexplained surface depression is visible) are also relevant. Important subjects related to the project are artificial cavities due to mining and the behaviour of soakaways in chalk. Any information readers have to offer please send to the following contact address:
Mr. M. Head, CIRIA, 6 Storey's Gate, Westminster, London, SW1P 3AU.

Proposal for a Palaeosol Group

In order to bring together and improve communications between workers with interests in the field of palaeopedology it is hoped to set up a palaeosol group. In order to assess support for such a group would interested Q.R.A. members please write to D.J. Case stating particular interests, and the objectives they feel the group should be based upon.

The full address is:

D. J. Case,
Department of Environmental & Geographical Studies,
Manchester Polytechnic,
John Dalton Building,
Chester Street,
MANCHESTER
M1 5GD



AE Arbury Engineers Ltd

Precision Engineering and General Machining

Prefabricated work, repetition, capstan work, turning.

Mackereth, Livingston and Russian pattern borers, auger rods, made and repaired.   Also bed load collectors, "V" notch weir plates etc.

Arbury Engineers Ltd.,
Shilton Industrial Estate, Bulkington Road,
Shilton, Coventry CV7 9JY.
0203-613889

CALENDAR OF MEETINGS

4th-7th April	Quaternary Research Association Annual Field Meeting on the "Diversions of the River Thames". Further details and a registration form may be found in the Circular issued with Newsletter 39.
10th-15th April 1983	Fourth International Flint Symposium to be held at Brighton Polytechnic, Falmer, Brighton. Local Secretary Dr. R.N. Mortimore. Further details may be found on p.48 of Newsletter 38 (November, 1982).
23rd April 1983	Joint meeting of the Quaternary Research Association and the Conchological Society of Great Britain and Ireland to present working papers on Quaternary non-marine mollusca. For further details see the notice on p.40 of this Newsletter.
24th-28th May 1983	Quaternary Research Association Short Field Meeting to Islay and Jura, Scottish Hebrides. Leader Dr. A.G. Dawson. Further details may be found in the Circular issued with Newsletter 38 and with the registration form issued with this Newsletter.
28th August - 2nd September 1983	International Symposium on Late Cainozoic Palaeo-climates of the southern hemisphere, organised by SASQUA. Organising chairman Dr. D. Price-Williams. Further details may be found on p.32 of Newsletter 37 (June 1982).
19th-26th September 1983	Anglo-French Karst Symposium. Organised by Dr. M.M. Sweeting and Dr. K. Paterson. Further details may be found on p.31 of Newsletter 37 (June 1982).

QUATERNARY NEWSLETTER

No.39 February 1983

Contents

Compiled and printed for circulation to Quaternary Research Association members and others by the Honorary Editor, Quaternary Newsletter, Dr. D.H. Keen, Department of Geography, Coventry (Lanchester) Polytechnic, Priory Street, Coventry, CV1 5FB, England.

ISSN 0143-2826.