RICHARD WEST — AN APPRECIATION

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RICHARD GILBERT WEST — AN ACADEMIC BIOGRAPHY

Richard West was born on the 31st of May 1926 at Beckenham in Kent. His father, Gilbert West was a physicist and later a broadcasting engineer, at one time a research assistant of Lord Rutherford in the Cavendish Laboratory at Cambridge, and then worked in the early days of public wireless and television broadcasting with both the BBC and with John Logie Baird, who was a family friend. Richard was educated at King’s School Canterbury, which, however, had been evacuated to the Carlyon Bay Hotel near Par in Cornwall for the duration of the Second World War. Here, his interest in botany and geology was stimulated by long rambles along the Cornish coast and encouragement by his biology master. He also met and fell under the influence of Charles Singer, Professor Emeritus of the History of Medicine at
University College, London, who had retired to live nearby. Singer was a figure of considerable eminence and a prolific writer on the history of science, as was his wife Dorothea.

Britain, however, was still at war, when Richard left school, and in 1944 at the age of 18 he began his army service with the Royal Signals. This subsequently took him to India, where he was posted to the Urdu Instruction Unit and later became Administrative Officer at the Signal Officers' Training School in Mhow in Central India during the tense period leading to the independence and subsequent partition of the country.

Returning to England and civilian life, his reintroduction to science was marked by a brief and extraordinary period dissecting and drawing the internal anatomy of Rhesus monkeys for Charles Singer. This was part of the background investigations for Singer's account of the second-century Greek physician Galen (Singer, 1956) in which Richard's assistance is duly acknowledged! He then, in 1948, went up to Clare College, Cambridge, his father's old college, opting particularly to study Botany and Geology for Part I of the Natural Sciences Tripos. Supervised by A.G. Brighton, he was strongly tempted to read Geology for Part II of the Tripos, but finally plumped for Botany, whereupon he not only obtained First Class Honours but also won the Frank Smart Studentship, awarded to the best botanical student of the year.

As a research student under the supervision of Harry Godwin, first Director of the Subdepartment of Quaternary Research and Reader in Botany at Cambridge, he commenced his now classic investigations of the stratigraphy and palynology of Pleistocene interglacial deposits in Suffolk, first at Hoxne and then at Bobbitshole near Ipswich.

In 1954, shortly after the successful completion of his Ph.D. thesis entitled Pleistocene Vegetation History in East Anglia, he was elected a Fellow of Clare College, Cambridge. Continuing further research not only into organic interglacial and interstadal deposits, but also on the properties and stratigraphy of tills and permafrost structures, he was appointed a University Demonstrator in the Department of Botany at Cambridge and Lecturer in 1960. In the same year he spent several months in the United States as Visiting Lecturer at the University of Minnesota.

Now began an intensive period in Richard West's career, lecturing both to students taking the Botany courses for Part II of the Natural Sciences Tripos and to the inter-faculty Quaternary Era course, supervising a series of research students and extending his own research on Quaternary palaeoecology and stratigraphy, particularly to the Lower Pleistocene Crag Formation and — and even more complex challenge — to the unravelling of the Cromer Forest-bed Formation of the Norfolk and Suffolk coasts.

One of the strengths of West's research then and now has derived from his ability to interpret with equal facility both the biological and geological aspects of Quaternary sequences. However, he recognized early the great importance of multidisciplinary collaboration in Quaternary studies, his work on tills and permafrost structures was developed jointly with J.J. Donner, and their great friendship has been marked over the years, right to the present day, by a series of joint projects and papers. Other important collaborators in the development of the biostratigraphic framework of the British Pleistocene have been the late B.W. Sparks, B.M. Funnell and P.E.P. Norton.

In 1966, on the retirement of Professor Sir Harry Godwin, Richard West became Director of the Subdepartment of Quaternary Research and, shortly thereafter, was appointed to a Readership. Readerships in Cambridge are, of course, awarded for excellence in research, but now, in fact, West expanded his teaching so that he was lecturing for both parts of the Natural Sciences Tripos and further for a new course in the Department of Archaeology and Anthropology, to support the growing trend towards environmental archaeology. All these courses were naturally supported by practical work in the laboratory and field excursions, which he led with enthusiasm. He also published at this time, along with many research papers, two influential books — Pleistocene Geology and Biology (1968; 2nd edition 1977), which rapidly became a standard textbook, and, with B.W. Sparks, The Ice Age in Britain (Sparks and West, 1972). He was granted an Sc.D. by the University of Cambridge in 1973. In 1975 his outstanding record as a university teacher and research worker was recognized by the award of a personal chair as Professor of Palaeoecology. Within a very short time, however, he found himself acting Head of Department when Professor Percy Bryan took a year's sabbatical leave. In 1977 he was elected to the Professorship of Botany, a chair he accepted with perhaps a little reluctance but a strong sense of duty and purpose. He held this post for the next 14 years, until his retirement in 1991, during a period when universities began to fall under immense administrative and financial pressures, drastically affecting the traditional role and workload of heads of departments. It was also a period when fresh areas of research were expanding within the plant sciences, requiring new initiatives in staffing and teaching. It is remarkable that whilst successfully running a major university department at this critical period, Richard West maintained an active and productive involvement in research, not simply through the supervision of research students, but by active fieldwork and continued publication of results. Indeed arduous field excursions with colleagues, generally involving a good deal of digging and coring, clearly recharged the batteries temporarily drained by the administrative grind! Amongst 30 publications dating from this time are two important books on regional geology and palaeoecology: The Pre-Glacial Pleistocene of the Norfolk and Suffolk Coasts, a large volume presenting the results of the many years of field and laboratory work on the Cromer Forest-bed Formation (1980) and Pleistocene Palaeoecology in Central Norfolk: A Study of Environments Through Time (1991).
Although virtually all of Richard West’s career has been centred around the University of Cambridge, the influence and recognition of his activities have had a far wider stage. Elected a fellow of the Royal Society of London in 1968, further public honours have followed over the years, honorary membership of the International Union for Quaternary Research (INQUA), of the Royal Irish Academy, of the Koninklijke Academie voor Wetenschappen, Letteren en Schone Kunsten van Belgie and of the Quaternary Research Association (which he had helped originally to found). He has been awarded the Bigsbys and Lyell medals of the Geological Society of London and the Albrecht Penck Medal of the Deutsche Quartärvereinigung.

Just as noteworthy are the responsibilities and public service undertaken on behalf of the scientific community. Since 1965 he has been co-editor of the New Phytologist and, following in the illustrious footsteps of Sir Arthur Tansley and Sir Harry Godwin, has served as Chairman of the New Phytologist Trust since 1983. He has played an active role on the editorial boards of such diverse periodicals as the Journal of Ecology, Quaternaria, the Journal of Archaeological Science and the Journal of Quaternary Science. Those interested in popular natural history books will have appreciated his continuing work as one of the editors of Collins’ well-known and much loved New Naturalist series. The administration of Science on a national level has claimed a good deal of his time. He has been successively a member of the National Sub-Committee for Botany (1965–1975), the U.G.C. Biological Sciences Sub-committee (1970–1974), the Council for Scientific Policy (1971–1973), the Natural Environment Research Council (1973–1976), the Science and Engineering Research Council (SERC) Science-based Archaeology Committee (1977–1983), latterly as Chairman, the Science Board of SERC (1980–1983), of the Ancient Monuments Board for England (1980–1984) and lastly from 1983–1990 a member of both the National Committee for Geology and the IGCP Committee and Chairman of the National Quaternary Research Sub-committee.

Less well known is his membership of the Army Emergency Reserve Geologists Pool between 1961 and 1967, which took him both to the Canadian Arctic and to Malaysia on advisory trips in company with other distinguished academic “military geologists”.

His determination to continue research into his retirement years has resulted in further notable publications, particularly on the Quaternary geology of the Fenland basin. However, his retirement itself was a relatively quiet affair, reflecting the modesty of the man himself, though he was persuaded to give a valedictory lecture giving his personal view on ‘Plant Sciences teaching and research’. Many of his colleagues and former students in the field of Quaternary Research have felt that a more public tribute should be made to the man who has contributed so much to the development of this multidisciplinary branch of science in Britain, both as a teacher and as a research worker.

It is now presented as a special double issue of Quaternary Science Reviews and dedicated to him in affectionate appreciation of the man and his many achievements.

**RICHARD WEST AND THE INTERPRETATION OF THE QUATERNARY STRATIGRAPHIC SEQUENCE IN BRITAIN**

By 1951, three years after its formal institution, the Subdepartment of Quaternary Research at Cambridge had already established itself as a very busy and productive research unit. Its Director Dr Harry Godwin (“the Chief”) had already established the basic pattern of vegetational and climatic development for the post-glacial period in Britain and was now keen to apply not only pollen and plant macrofossil analysis, but a range of expertise, through collaboration with other scientific disciplines, to different aspects of the Quaternary. He himself was working actively with archaeologists in the Somerset Levels, in the Vale of Pickering and elsewhere, establishing the stratigraphic relationships and palaeoecology of human settlements from the Mesolithic to the Roman period. He was already planning the development of a radiocarbon laboratory in Cambridge, to provide essential chronostratigraphic dating by this newly-developed method.

Godwin had gathered around him and was training a small group of research students to tackle what he saw as outstanding problem areas in the British Quaternary. Donald Walker was working primarily on Lateglacial sequences in northern England, extending the record of that interval following Ann Conolly’s studies at Hawk’s Tor, Cornwall and Godwin’s own work at Nazeing in the Lea valley, Essex with the amateur archaeologist Hazzeldine Warren. By nature full of energy and enthusiasm, Donald was soon also involved in a range of other sites, such as the archaeological excavations at Seamer and Flixton and, later, the interglacial deposits at Histon Road, Cambridge. Stan Seagriff, from South Africa was working on postglacial sites in southern England, such as Elstead in Surrey. Alan Smith had begun to work on postglacial deposits in the Trent Valley with particular reference to the effects of sea-level changes. Godwin’s help had been sought with a number of older sites, with samples of interglacial material being sent in by K.S. Sandford from the Oxford area and Professor F.W. Shotton from Nechells near Birmingham. Sue Duigan, from Australia, was set to work on this material and later extended her studies to the Cromer Forest-bed outcrops of the north Norfolk coast. The team also included laboratory staff, such as Miss Robin Andrew, the one member of the Subdepartment of Quaternary Research who continued her pollen analytical work right through from its earliest days until its closure in late 1994, and Miss Jean Allison, who worked on plant macrofossils. This group was cemented by the excitement of new discoveries, new sites reported to Godwin.
as the Subdepartment's reputation grew, by the comrade
ship of coring excursions and fieldwork and by the
ever-present ever-enthusiastic encouragement and advice
of Godwin himself.

Harry Godwin was well aware that interglacial
deposits in Britain offered a potentially rich but hitherto
totally neglected field of Quaternary research. More
than 20 years previously Jessen and Milthers (1928)
had published detailed studies on the stratigraphy and
vegetational history of interglacial deposits in Denmark
and Northern Germany. This had stimulated further
pollen analytical studies in Germany and in The Nether-
lands, but in Britain nothing had been achieved since the
pioneering work on interglacial plant macrofossils by
Clement and Eleanor Reid. The first real opportunity
came in 1949 when sewer trenches along the Histon
Road, Cambridge yielded shelly interglacial deposits.
These also contained organic lenses from which plant
macrofossils and pollen were extracted and which, from
comparisons with Eemian sites on the Continent, suggested a last interglacial age (Hollingworth et al.
1950). In 1950 Godwin together with Hazzledine
Warren and Kay Pike, another Australian research
student, put down boreholes on the cliff top and sea
front at Clacton-on-Sea, Essex, to sample the well-
known Clacton interglacial channel-deposits (Pike and
Godwin, 1953). These ventures, together with Sue
Duigan's projects, convinced Godwin that not only
pollen analytical and plant macrofossil expertise but
also a thorough understanding of the geological context
was necessary for the proper evaluation of these sites.
He also realised that this would involve far heavier
fieldwork than for postglacial sites.

It was a very happy coincidence then that at precisely
this time Godwin had in his final year botany classes
a mature young student, who not only possessed a good
working knowledge of the British flora and its ecology
but also a great interest and sound training in geology,
and so, possible research projects were discussed.
Richard West's outstanding Tripos results confirmed
Godwin's best hopes and it was agreed that he should
commence research on Pleistocene interglacial deposits
of East Anglia and particularly on Clement Reid's
old site at the Hoxne Brick Works in Suffolk.

Today students often expect a long summer holiday
before starting research, but there was no question of
Richard waiting for the new university year. Summer
is the ideal time for fieldwork, and he was as eager,
as was Godwin for him, to get down to work out
in the open air. Again there was then no regular access
to motor transport for research students. To reach
Hoxne from Cambridge it was generally necessary for
Richard to take the train to Diss, accompanied by
his very sturdy bicycle to which a soil auger and
extension rods could be strapped, so that he could cycle
the last few miles to Hoxne. There his friendly and
unpretentious nature ensured that he was soon on
excellent terms with the Banham family who were the
proprietors of the Hoxne Brick Works. Indeed he
was able to lodge with the family when it became clear
that he needed to spend long periods of fieldwork
in the pit and surrounding countryside.

Brickmaking has been going on at Hoxne for
centuries and abandoned brickpits cover an area several
hectares in extent on either side of the Eye–Hoxne road.
In 1951 the Banhams were still producing agricultural
drainage tiles and actively working one area in the
western or Oakley Park pit. One of the first tasks which
Richard carried out, with the help of his brother, Chris
West, was to make a detailed large-scale survey of the
area using levelling and plane table. The next
priority was to make a completely new geological
survey of the Quaternary deposits in the vicinity of the
brickworks. The older accounts of Clement Reid
(1896) and Reid Moir (1926, 1935) had to be reinter-
preted, their sections located and, if still extant, cleaned
up. The main task here, however, was to put down a
network of auger holes. The existing soil auger was
too weak an instrument, so Richard devised a system
with a one and a half inch open spiral shipwright's
auger, stronger rods and a large manual jacking lever.
This auger could not only penetrate easily to 10 m
and be raised by a single operator, but between its coils
it could take sediment samples undisturbed enough
for pollen as well as lithological analysis. In all, over
90 auger holes were put down around the Hoxne
brickpit, an enormous physical undertaking.

He was active in the laboratory, too, learning the
techniques of pollen analysis and beginning to identify
plant macrofossils. Here he achieved his first notable
success, recognizing the fossil megaspores of the water
fern Azolla filiculoides for the first time from British
Quaternary deposits and furthermore the microsporangia
with their anchor-shaped glochidia on his pollen slides. It
may seem extraordinary that the Reids, who examined
fossil plant material from many Early and Middle
Pleistocene sites, failed to find or recognize Azolla. They
also failed to record Juncus seeds, and the conclusion
must be that they simply used sieves too coarse to retain
the finer plant macrofossils.

His initial pollen results indicated that a substantial part
of an interglacial sequence was present at Hoxne, and it
soon became clear that it apparently represented the
Holsteinian, "Great" or Mindel–Riss Interglacial of
Continental Europe. A successful application to the Royal
Society provided funds for hire of a drilling rig so that a
borehole yielding 4 inch diameter cores could be put
down. This borehole provided the major pollen sequence
from Hoxne.

The results of the investigations at Hoxne were in
due course presented in a formal lecture to the Royal
Society and, in 1956, published in a long paper in their
Philosophical Transactions. Here Richard West demon-
strated, for the first time in the British Pleistocene,
the development of a vegetational sequence beginning
with open-ground conditions prevailing after the melting
of an ice sheet, through the development of pre-
temperate boreal woodland to a mixed-oak forest and
then to late-temperate forest in which hornbeam Carpi-
nus and silver fir Abies played major roles. He also
described the very unusual high non-tree pollen phase that interrupted the early-temperate vegetational zone, and which has since been recognized at other sites in southern Britain and northern Germany. He distinguished and counted, though did not publish, the still unidentified pollen grain known as 'Type X', which is now seen as characteristic of Hoxnian pollen diagrams. His careful study of the lithology of the sediments enabled him to recognize that the upper parts of the lacustrine deposits at Hoxne were brecciated and contained reworked pollen and macrofossils.

The upper, post-lacustrine deposits at Hoxne only survive in a very restricted area and were very poorly exposed in the 1950s. Following Baden-Powell, West interpreted these in part as decalcified till and later as solifluxion deposits. The more recent excavations of Singer et al. (1993) have shown a much more complex series of fluvial sediments to be present at this level, but ice-wedge casts confirm the cold-climate depositional environment of the uppermost part of this sequence.

A further aspect of Richard West's studies at Hoxne concerned the evidence for Palaeolithic occupation of the site. During the course of his work he found a small number of artefacts including two hand-axes. He invited the eminent Cambridge Palaeolithic archaeologist Charles McBurney to collaborate with him in investigating this material, and a small excavation was carried out.

Whereas West and McBurney (1955) concluded that the occupation level at Hoxne was a single one, coinciding with the high non-tree pollen phase, the more recent excavations have cast doubt on this finding and certainly shown that at least two, possibly three, episodes of Acheulean occupation have taken place at the site with typologically distinct industries, all probably post-dating the interglacial. However, weaknesses in the palynological and stratigraphic work during the later excavations (Turner and West, 1994) still leaves the precise age and environment of the Lower Industry at Hoxne unclear.

Already, as Richard West was beginning his work at Hoxne, news came from Harold Spencer of Ipswich Museum of a new organic interglacial deposit discovered during excavations for sewage treatment works at Bobbitshole in the valley of the Belstead Brook near Ipswich. Samples were collected from open sections and again from 4 inch diameter cores. Under the skilled guidance of Colin Forbes from the Sedgwick Museum in Cambridge, the Quaternary team were mastering the operation of a light percussion drilling rig, a procedure not only very useful for obtaining samples large enough for both pollen and macrofossil analysis at many subsequent sites, but also hard and occasionally hazardous work that in itself produced a great feeling of achievement and comradeship. The Bobbitshole deposits produced a pollen diagram clearly very different from that from Hoxne, covering the first part of an interglacial deposit, which comparison with pollen diagrams from The Netherlands, northwest Germany and Denmark immediately suggested to be of Last Interglacial (Eemian) age. Subsequently Bobbitshole was defined as the stratotype of the Ipswichian Inter- glacial in Britain. The abundant macroscopic plant fossils, particularly of aquatic species such as seeds of Lemna cf. minor, Hydrocharis morsus-ranae and megaspores of the water-fern Salvinia natans, indicated that the most temperate part of the interglacial was warmer in summer than in southern Britain at the present day. This finding was supported by the collaborative work of Bruce Sparks (1957) on the freshwater and terrestrial molluscs from the site and eventually by Russell Coope's report on the beetle fauna (Coope, 1974). The results of the Bobbitshole investigations were again communicated as a lecture to the Royal Society and published in the Philosophical Transactions of the Royal Society of London.

Richard's co-operation with Bruce Sparks at Bobbitshole was the beginning both of a long series of important collaborative studies and of a lifetime friendship, broken only by Sparks's death in 1988. Having studied the first half of the Ipswichian Interglacial at Bobbitshole, they now decided to make a more detailed study of the Histon Road interglacial deposits at Cambridge, where the latter part of the interglacial succession was represented. Another coring party was
organized with the assistance of Colin Forbes and most of the able-bodied members of the Subdepartment (Fig. 1). The results of this re-investigation (Sparks and West, 1959) provided the first truly integrated, interdisciplinary palaeoecological study of British Quaternary deposits.

Over the next decade Richard West and Bruce Sparks together investigated an important series of Ipswichian deposits, not only in East Anglia at Sutton, Suffolk (Sparks and West, 1964), Wortwell (Sparks and West, 1969) and Wretton (Sparks and West, 1970) in Norfolk, but also on the south coast of England at Selsey, Sussex and Stone, Hampshire and at the same time on the opposite side of the English Channel in Normandy (West and Sparks, 1960). These studies not only greatly increased our knowledge of the climate and vegetational and faunal development of the interglacial but also of sea-level change. At Iford (West et al., 1964) this interdisciplinary approach was strengthened by analysis of the extensive plant macroflora by Camilla Lambert (now Camilla Dickson), and Hoxnian lacustrine deposits in the vicinity of Hatfield, Hertfordshire were also studied by Richard West and Bruce Sparks, together with Maree Ransoms and Rendell Williams (Sparks et al., 1969).

At the same time Richard West was turning his attention to the pre-glacial Pleistocene. Clement Reid (1882, 1890) had done a great deal of work on the stratigraphy and plant macrofossil content of the complex 'Cromer Forest-bed Series' of the Norfolk and Suffolk coast which lies clearly stratified beneath the oldest tills of East Anglia. In the 1950s Suzanne Duigan had made a series of pollen diagrams from these deposits (Duigan, 1963), attempting to arrange them within a single interglacial cycle. The older Pleistocene, and in part Pliocene, deposits of East Anglia were the sandy and shelly marine Crag deposits, which to most authorities looked highly unpromising for pollen analysis. In 1950 a water supply borehole had been put down near Ludham, Norfolk. Material from this borehole was obtained for analysis of Foraminifera by Brian Funnell, then working at the Sedgwick Museum in Cambridge. Funnell was aware that the lithology, though still largely sand, was much more clayey than Crag deposits from surface exposures; he also found that the Foraminifera showed distinct indications of climatic changes. Samples were passed to Richard West, and pollen analysis showed not only assemblages including the presence of the exotic conifer Tsuga, indicating an Early Pleistocene or Neogene age, but also variations in the percentage representation of the pollen of different trees, suggesting vegetational change during the deposition of the sequence.

With Godwin's help the Royal Society were again persuaded to grant funds for sinking a new borehole. The resulting pollen diagram (West, 1961) was another landmark in the decipherment of the British Quaternary sequence. Evidence was presented for climatic cycles during the Early Pleistocene, similar in form though definitely not in intensity to the glacial/interglacial cycles of the Middle and Upper Pleistocene. Three temperate stages were recognised by Richard West, the oldest being defined as the Ludhamian, the next the Antian, the uppermost probably representing the Pastro- nian of the north Norfolk coast. These were separated by two cool but non-glacial stages, the Thurnian and the Baventian. The vegetation record is very different from that of the later parts of the Pleistocene, since not only do exotic taxa, such as Tsuga and Pterocarya occur during the temperate stages, but heathland with an abundance of crowberry, Empetrum, seems to have been a major vegetation type during the cool stages, a situation for which there is really no analogue today. Richard found it difficult, as it still is today, to decide to what extent these pollen assemblages had been affected by processes of transport and deposition in a marine environment. Brian Funnel and Richard West also worked together on the coastal sections of the Crag sequences at Easton Bavents, Suffolk (Funnell and West, 1962), reinforcing the interpretation of the upper part of the sequence described from Ludham. Possible correlations between the Ludham/Easton Bavents sequences and the Netherlands Early Pleistocene sequences were first presented at that time, and recently a British and Dutch discussion group, led by Richard West and Waldo Zagwijn, have been able to make firmer suggestions on this topic (Gibbard et al., 1991).

Once it was realized that argillaceous layers within the Crag deposits might be susceptible to pollen analysis, Richard West focused his attention on the whole sweep of the Crag deposits from north Norfolk to Essex. Once again his ability to appreciate both the geological and biological aspects of the subject have been invaluable, but even more so his talent for close collaboration with other workers, so that a truly multi-disciplinary understanding can be achieved. His closest collaborators in work on the Lower Pleistocene have been Brian Funnel and Peter Norton, but he also maintained strong links with local experts in the field, notably the late Harold Spencer and Bob Markham both of Ipswich Museum, and more recently with British Geological Survey geologists such as Jan Zalasiewicz, also working in the area.

Peter Norton came to Cambridge as Richard West's research student to work on the marine Mollusca of the Ludham borehole. It is a measure of Godwin's breadth of vision that he welcomed both Peter Norton, working on fossil marine invertebrates, and Nick Shackleton making oxygen isotope analyses of deep ocean cores into his Botany Department at this time. Alas, things are no longer the same today! In their paper on the Icenian Crag of Suffolk (West and Norton, 1974) Richard and Peter put together observations on a group of classic Lower Pleistocene sites in that area to make the first new synthesis of their stratigraphy since the work of Harmer, and similarly at Bramerton, Norfolk and Covehithe, Suffolk, Richard West, Brian Funnel and Peter Norton all collaborated together to provide a basic revision of the Norwich Crag and its
wider correlations (Funnell et al., 1979; West et al., 1980). A minor, but nevertheless significant success in this field was that of Robin Andrew and Richard West (1977) in obtaining a small pollen diagram from the Coralline Crag of Orford, Suffolk and thus demonstrating its long-suspected Brunssumian (Pliocene) age.

Already by 1960 Richard West had begun to look at the Cromer Forest-bed deposits on the East Anglian coast. Although Suzanne Duigan had begun work on these, it soon became clear that the stratigraphic sequences were so variable and so complex, that a comprehensive geological investigation of the sequences, combined with biostratigraphic studies, would be necessary to make any progress. Important biostratigraphic material included not only pollen and plant macrofossils, but also vertebrate remains.

Those who visit West Runton today, emerging from the warmth of the cafe at Woman Hythe gap to inspect the West Runton Freshwater Bed, usually clearly exposed on the shore, even on a brisk winter day get little or no impression of the rigours of investigating the full extent of the Cromer Forest-bed Formation as it was—from time to time—exposed during the 1950s and 1960s. Outcrops of this Formation occur intermittently, outcropping beneath the till, over about 35 km of coastline in Norfolk and a further 15 km in Suffolk. At present some of this coastline is largely inaccessible because of the construction or attempted construction of coastal defences.

In fact the study of the Cromer Forest-bed Formation proved to be an enormous undertaking, with field work spanning a period of 19 years. The sediments and sedimentary structures of well over 100 sections were logged and, where appropriate, samples taken both for pollen and macrofossil analysis. In some places the Forest-bed sequences outcrop for kilometres along the foot of the cliffs, in others just a few metres are preserved, but for most of the time these outcrops were almost entirely obscured by landslips and mudflows and only visible and hopefully accessible after severe storms, generally at the height of winter. This meant fieldwork at the bleakest time of year, on a bitterly cold coast, when daylight hours were few. A phone call from a local resident to say that cliff sections had been scoured clean might mean a rapid emergency early morning drive from Cambridge in the hope of tracing sequences that had not been recorded since the time of Reid. It also meant the ever-present danger of getting cut-off by the tide on some inaccessible part of the coast. Another hazard was the still uncleared Second World War minefield at the foot of the Trimmingham cliffs, but good liaison with the military authorities—Richard West being a member of the Army Emergency Reserve Geologists’ Pool—meant carefully guided access and recording of these critical sections too. An equally daunting task was that all these sections also had to be levelled in, often from distant benchmarks way above beach level.

In the laboratory there were sediment samples to analyse, and over time many hundreds of pollen samples to be counted, a task Richard West initially carried out exclusively himself but with which later he had the greatly experienced help of Robin Andrew. The Natural Environment Research Council was persuaded to grant funds for Guy Wilson to come to Cambridge as a research assistant to work on the growing mountain of plant macrofossil samples.

Bringing such a project to fruition was not, of course, simply a matter of the successful and systematic study of samples in the field and the laboratory, nor of the skill of interpreting the results in a very broad multi-disciplinary environmental context, nor yet of the formidable task of assembling all this knowledge into a relatively compact monograph The Pre-Glacial Pleistocene of the Norfolk and Suffolk Coasts (West, 1980). It involved a vast amount of organization in which personal relationships and approaches played a very important role. Working at a distance, from Cambridge, cultivating the good will of local council officials and landowners and gaining the cooperation of amateur Norfolk geologists and interested natural historians, who could keep a sharp eye on the foreshore was essential. So too was enthusing colleagues and students and, indeed, his wife Hazel, who would be prepared to help with the ever arduous tasks of section logging, collecting and then carrying samples and holding a surveying staff in a cutting Arctic wind. Of major importance, of course, was collaboration with other specialists, particularly Richard Hey with his expertise in sedimentology, Peter Norton in the sampling and study of marine Mollusca and likewise Bruce Sparks with freshwater and terrestrial Mollusca. He strongly encouraged Tony Stuart’s interest in the revision of the Forest-bed fauna (Stuart, 1975) an interest that has currently been bearing further fruit in the excavation of an early mammoth skeleton from the West Runton Freshwater Bed (Stuart, 1993).

Clement Reid’s stratigraphy for the Cromer Forest-bed Formation was clearly no longer tenable. Richard West’s reinterpretation (1980) recognized two major temperate phases; the younger he named the Cromerian (sensu stricto) and the older the Pastonian. The intervening Beestonian Stage was one of cold climate, on the evidence of pollen, plant macrofossils and periglacial structures. However, by 1980 he was already advancing the probability that there were hiatuses within the Beestonian, so that this might represent more than one cold stage. In the West scheme the Anglian cold stage, including strata with arctic plant remains below the Cromer Till succeeding the Cromerian Interglacial, and the less clearly defined pre-Pastonian cold stage preceded the Pastonian Interglacial. Initially he regarded both the Cromerian and the Pastonian as interglacial stages belonging to the early Middle Pleistocene, but it was already clear in 1980 that there was no clear correlation between either of these interglacials and those described by Zagwijn (Zagwijn et al., 1971) from his ‘Cromerian Complex’ in The Netherlands.

The development of a new stratigraphical classification of the Cromer Forest-bed Formation on the one hand provided a stimulus for the study of other early
Middle Pleistocene deposits elsewhere in Britain, particularly the ancient Thames gravels that comprise the Kesgrave Formation which incorporates interglacial sites such as Little Oakley (Preece, 1990). On the other hand it led to a reassessment of the vertebrate fauna not only of the type Cromerian (Stuart, 1975) but also of the Cromer Forest-bed Formation as a whole. In the best traditions of the way that science progresses, this in turn has led to further modification of the proposed stratigraphic scheme for that Formation.

In 1988 Richard West, Waldo Zagwijn and their principal British and Dutch colleagues involved in active work on the Lower and early Middle Pleistocene of the two areas held a meeting at the University of East Anglia at Norwich to examine in detail both anomalies that had developed in existing stratigraphical schemes and the possibilities for reassessing correlations across the North Sea Basin during these time periods. As a result of these discussions it became clear that the Pastonian was older than originally believed and should be assigned to the Lower Pleistocene. A correlation with the Late Tiglian Stage TC5 in The Netherlands was suggested. The correlation of the Cromerian (sensu stricto) with 'Cromerian Complex' interglacials remains uncertain (Gibbard et al., 1991; Turner, 1996).

With his long-gestated work on the Cromer Forest-bed Formation published, Richard West, though much occupied with his duties as Head of the Department of Botany at Cambridge, was determined to 'relax', as he would put it, with some more strenuous fieldwork. He chose two areas, the valley of the River Wensum near Beetley in north Norfolk and, nearer home, the Cambridgeshire Fenland.

Organic deposits in the gravel pits at Beetley had first been investigated by his research student Linda Phillips in the early 1970s (Phillips, 1976), but it became clear that this small valley contained an extraordinary sequence of deposits, including organic sediments and sedimentary structures, spanning the time period from the Anglian to the Flandrian. His synthesis of this sequence, including pollen diagrams from Hoxnian, Ipswichian, and Devensian Interstadial sediments was published as a monograph *Pleistocene Palaeoecology of Central Norfolk: A Study of Environments Through Time* by Cambridge University Press in 1991.

Richard West has long had an interest in the Cambridgeshire Fenland, dating back from fieldwork there with Harry Godwin and his students. He collected samples and made notes, particularly on the March Gravels, but only in the mid 1980s did this begin to come to fruition; old sites were visited and re-sampled and large new gravel pits that were opening in the area, particularly those at Somersham and Block Fen, were regularly surveyed as the excavations progressed and sampled with great precision, in the typical West manner. The publications that have followed have greatly increased our understanding of the stratigraphy and environmental history of southern Fenland during the Ipswichian and Devensian. They also stand as testimony to his firm belief in the multidisciplinary approach to Quaternary Science, since he gathered in a range of colleagues, and indeed friends, to bring their expertise to bear on these sites and synthesise their work with his own—Mary Pettit on plant macrofossils, Richard Preece on terrestrial and freshwater molluscs, Karen Knudsen on Foraminifera, Eric Robinson and David Penney on ostracods, as well as those stalwart members of the Subdepartment of Quaternary Research Robin Andrew and Sylvia Peglar. At the same time he collaborated with another group of younger researchers in their studies of the March Gravels at Eye near Peterborough (Keen et al., 1990).

Work on the Devensian pollen and plant macrofossils assemblages from Fenland and earlier sites stimulated another line of research. Whereas much of Richard West’s classic work has been on interglacial sites, he has now turned his attention to the palaeoecology and evolution of cold-stage floras in Britain, with the assistance of Mary Pettit. Much of the work involves the creation and interpretation of an extensive database of old records, but, characteristically, fieldwork was seen—quite rightly—as an essential part of the project. Therefore, in the year of his retirement, he made a 6 week research trip to Alaska with his old friend Kim Donner. One of the specific aims was to study the taphonomic processes that led to plant detritus being incorporated in sediments under periglacial conditions, and to see how well the tundra vegetation was represented by these detritus assemblages. Tales filtered back to Cambridge about American colleagues—though not those who knew our men well—mildly astonished at the sight of the two European professors, nearing retirement age, enthusiastically setting out with their tools to sample the Alaskan tundra instead of delegating such a task to young graduate students! This was clearly a very invigorating, as well as scientifically productive expedition.

The fruits of this recent research venture are now beginning to appear (West et al., 1993; West, 1995), but clearly there is much more yet in the pipeline, and, no doubt, fresh research avenues to open up.

**RICHARD WEST’S CONTRIBUTIONS TO THE GLACIAL AND PERIGLACIAL PLEISTOCENE GEOLOGY**

Apart from his contributions to palaeobotany and biostratigraphy, Richard West from a very early point in his career, developed an interest in glacial and periglacial geology that has endured to today. Although this interest was almost certainly developing from his own observations during the work at Hoxne and elsewhere, it was apparently brought into sharp focus during a DEUQUA excursion in North Germany that he attended in 1953. This meeting, based in Kiel, Schleswig–Holstein, was organized and led by the distinguished glacial geologist Karl Gripp and attended by many famous continental Quaternary geologists, including P. Woldstedt and F. Florschütz. This was immediately followed by a visit to The Netherlands particularly to see the famous Pliocene to Early Pleistocene deposits of south Limburg. It seems
that the sites and discussions on these trips stimulated Richard West to attempt to apply techniques and observations he had seen back in Britain. Two of the most important techniques that he tried were stone orientation and periglacial stratigraphy, neither of which it seems had been applied in Britain before.

The technique of stone orientation was not of course new in the early 1950s. It had been known for a century at that time that many stones in tills had long-axes parallel to the ice movement direction determined by striae. The first accurate measurements were made by Richter (1932) in North Germany and confirmed by Holmes (1941) in North America, De Waard (1945) in The Netherlands and Lundqvist (1948) in Sweden. Meanwhile Hoppe (1953) had demonstrated that the long-axes of stones in recent till in front of the Vatnajökull ice cap also showed a strong parallel orientation. It seemed obvious therefore that such a method could potentially provide invaluable evidence of ice movement direction in areas where other direct indicators of ice movement (e.g. striae or streamlined landforms) were lacking.

What resulted was the now classic study published in 1956 which Richard West carried out with his contemporary student at Cambridge and life-long friend Joakim Donner. Kim Donner was a student of the great Finnish Quaternary geologist Professor Matti Sauramo of the University of Helsinki. He came to Cambridge to work with Professor Sir (then Dr) Harry Godwin on Scottish sea level changes and was persuaded to take a Ph.D. He was therefore in Cambridge for 3 years. Kim Donner also had a wide interest in Quaternary matters and was eager to try new techniques.

During 1954 they travelled all over eastern England making stone orientation measurements from till exposures at 65 sites ranging from Hertfordshire to Leicestershire and Suffolk to Northamptonshire. This work, carried out with the support of many eminent colleagues and local experts who pointed them to suitable exposures, was ambitious indeed, particularly given the state of Pleistocene stratigraphy at the time. It was also not without its mishaps. This extensive travel required the use of the Botany Department's vehicle, which by all accounts was an army surplus beast of solid construction. It seems that one diversion caused them to turn the vehicle around and in doing so they reversed it into a wall that promptly collapsed. In true student style, Richard and Kim (it is not clear who was driving!) did not wait to discover who's wall it was and sped off as fast as possible!

Nevertheless, the results of their long (and undoubtedly tedious) measurements led to a paper read at the Geological Society in 1955 that is still quoted today. Indeed it represents the pioneering attempt to discriminate till sheets and thus ice advances on the basis of what we now call till macrofabric. Although interpretations of the eastern English glacial sequence have changed since, much of their results remain valid because they are based upon indisputably solid data. The significance of their achievements was realised at the time with praise being offered by W.J. Arkell, S.E. Hollingworth, K.P. Oakley and F.W. Shotton, among others.

The realization of the potential of stone orientation led Messrs West and Donner to seek help from a physicist J.W. Glen to understand the theory of why stones become orientated in till. A resulting paper published in 1957 in the American Journal of Science compares the results of long-axes measurements made in the field with theoretical results. The preferred orientations obtained were shown here to be 'reasonable on physical as well as experimental grounds'.

They also made stone orientation measurements during an Oxford University Expedition to Bragneset, Nordaustlandet, Svalbard in 1955. During this expedition, the aim of which was to investigate the Quaternary history of the area and to make observations on the glacial geology for interpretation of Pleistocene deposits, Richard West and Kim Donner were joined by John Hollin. The resulting paper (1957) describes modern glacial processes, raised beaches and geomorphology. Unfortunately, no radiocarbon dating was available at the time, but this has been very recently remedied.

Investigations on Skye in the summer of 1954, presumably during an excursion for Kim Donner's field investigations led to a small paper on the occurrence of drumlins at Glen Varragill, north of Sligachan published in the Finnish geographical journal Terra.

As will already be apparent, Richard West's interests in the glacial geology and geomorphology in East Anglia were well established from the beginning of his studies. It is certain that both his approach to and enthusiasm for this work was strongly fuelled by discussions with the Oxford geologist Donald Baden-Powell. Baden-Powell's work on the lithology of the tills in East Anglia is very well known and represented one of the earliest attempts to subdivide the glacial sequence in an analytical way. Richard West was particularly interested in the Holt area of north Norfolk where a series of landforms, mostly of glacio-fluvial origin, are well developed. In 1957 he published a short preliminary paper in which he identified sandurs, kames, kame terraces and the substantial Cromer Ridge, a feature that continues to fascinate geologists today. He concluded that the Cromer Ridge was either 'built up against an ice-wall or that the deposit is a sub-aqueous delta formed in an ice-ponded lake'. Interestingly, it is not until the Geologist's Association summer field meeting of August 1958 that we find the Wiverton Down ridge being referred to as the Blakeney Esker, but following a University of Cambridge Geography Department field class in 1962, the esker was described in detail. For this study Richard West joined forces with his close friend Bruce Sparks to write a more detailed investigation of the Holt area glacifluvial landforms and geomorphology.

During the 1970s and 1980s there was a long hiatus in Richard West's work on glacial geological topics. This period was that during which there were enormous advances made in the understanding of glacial erosion and deposition resulting from the detailed investigation of modern glacial processes. These investigations provided the vitally needed analogues for the interpretation for the older Pleistocene sequences Richard and others had sought as one of the aims of the 1955 Nordaustlandet
expedition. Clearly the size of the task meant that it was for others to take up these ideas and develop them to the extent we see today. Perhaps because of this huge growth in the subject, Richard no longer felt that he ought to attempt detailed glacial geology. However, he remains fascinated by it. His resistance finally gave way in 1990 when, following the work of Paul Ventris (one of Richard’s students), whose thesis concerned the evolution of the Nar Valley, Richard noticed some new exposures at the Tottenhill quarry south of Kings Lynn. Here substantial forested gravel and sand sequences were being exposed and he invited Phil Gibbard to visit the site with him to examine the sections. The two subsequently spent many days at the quarry logging sections and collecting samples. They seem to have made a considerable impression on one of the very interested quarry workers who insisted one morning that he had dreamt about them the previous night! In spite of this, the two concluded that the sequence represented a delta formed at an ice front at the mouth of the Nar Valley in which a glacial lake was ponded. The excellent stratigraphical control at the site clearly demonstrated that the delta was post-Hoxnian and pre-Ipswichian and evidence for glaciation in lowland eastern England during the intervening cold stage generally known as the Wolstonian.

Over the last 10 years Richard West has undertaken very detailed investigations at a site near Somersham in the Fenland. Here a complex suite of sediments was exposed but of particular interest was the find in 1986 of a series of laminated (varved) lake clays filling a channel-like depression in the underlying gravels of the River Great Ouse. Richard West brought monoliths of this material back to Cambridge for detailed microscopic study and, whenever one visited him in his professorial office in the Botany School, he would bring out these substantial sediment blocks for close inspection! From these inspections he was able to demonstrate that the lake existed for a minimum of ca. 65 years; the clays containing lumps of rafted Hunstanton Till of the Late Devensian glaciation. The lake was therefore almost certainly impounded by the ice advance to form what Allan Straw (1963; Straw and Clayton, 1979) had postulated as ‘Lake Fenland’ and which in 1993 Richard renamed ‘Lake Sparks’ in honour of his friend who had died 4 years earlier.

Richard’s interests in periglacial matters also seem to have stemmed from the north German and later Dutch field excursions and he also pursued these early studies with Kim Donner. Their first periglacial paper is only two pages long and reports frost structures (cryoturbation or gelifluction) at the top of the Cromer Forest-bed Series (Formation) and beneath the Cromer Till (North Sea Drift Formation) at Bacton, Norfolk in June 1954. It includes a photograph (West and Donner, 1958; Plate 1, Figure c) showing a side view of a 28-year-old Richard West inspecting the features.

This seems to be one of the earliest records of frost structures in a section being reported as such in this country. At much the same time a lecturer in Plant Ecology in the Cambridge Department of Botany was identifying patterned ground (polygons and stone stripes) of periglacial origin in the Breckland district of East Anglia for the first time in Britain. Alex Watt was an ecologist of great experience and stature, who taught Richard as an undergraduate in Botany. Watt’s (Watt, 1955) description of patterned ground from the Breckland followed from 30 years of detailed field studies of vegetation and landscape changes. By the early-1960s patterned ground had been identified from air photography in other parts of the country, but it was particularly well-developed and well-studied in the Breckland by Cambridge-based workers Bob Perrin (1963) and Rendel Williams (1964). These studies prompted an exhaustive investigation by Watt, Perrin and West that was published in 1966 in which they related the Breckland patterns to strikingly similar forms in Alaska.

May 1967 found Messrs West and Donner travelling along the eastern arc of the famous Younger Dryas Salpausselkä I end-moraine with Veikko Lappalainen. East of Imatra, at Immalankangas, Richard saw an ice wedge cast in a section from the car window. Inspection of the section confirmed his identification and an earlier report by Lappalainen from the same area. Following this discovery two other ice wedge localities were found and these records represented the first identification of the permafrost contraction crack structures in Finland.

In 1987 he contributed to a symposium volume on periglacial processes and landforms in the British Isles, when he was able to draw together observations he had made on the origins of small closed hollows in Norfolk over many years, including those at Beetley, described below, and others at Wretton and at East Walton Common, a spectacular site for student teaching.

The investigations at Somersham have already been mentioned. This important site has not only yielded evidence of glaciation, fluvial activity and sea level change, but also evidence of important taphonomic problems and periglacial processes. The latter are represented by at least three separate fluvial gravel and sand accumulations, but also aeolian sediment (sand-loess or cover sand) and ice wedge casts (thermal contraction cracks) and associated networks. Careful and very detailed section logging and levelling have always been the hallmark of Richard West’s work, but during his later years this has been seen to pay spectacular rewards. For example the attention lavished upon the complex internal structure and relationship to buried ground surfaces enabled him to distinguish two generations of thermal contraction cracks. Within these he distinguished three types of crack He was able to relate the main period of permafrost to the Pleniglacial in the Netherlands and Poland. He readily acknowledged the great value of visiting this site with the Belgian periglacial expert Jef Vandenbergh who influenced his ideas and interpretations.

Richard West’s extraordinary patience and commit-
RICHARD WEST'S RESEARCH STUDENTS

So far we have almost ignored another major activity of Richard West's research career and one which has also had an enormous impact on Quaternary research in Britain and abroad. Virtually from the moment he obtained his own Ph.D., he has devoted a great deal of time and effort to the supervision of graduate research students working on a very wide range of Quaternary topics. The majority of his students have gone on to teach in other universities and colleges, thus passing on his distinctive approach to research and teaching, as will be apparent from many of the papers that follow in this volume. The names and research topics of those actually supervised by Richard West are given below, but, of course, many others who have passed through the Subdepartment of Quaternary Research, now sadly no more, will have been greatly influenced by his teaching, his example and his personality.

Research Students of Richard West, Registered for the Degrees of Ph.D. or M.Phil. in Quaternary Research:

A.M. Alderton  Flandrian vegetational history and sea level change of the Waveney Valley. 1983
R.B. Beck  The Lower Pleistocene geology and vegetational history of East Anglia. 1971
F.G Bell  Weichselian glacial floras in Britain. 1969
H.H. Birks  Studies in the vegetational history of Scotland. 1969
H.J.B. Birks  The Late-Weichselian and present vegetation of the Isle of Skye. 1969
A.P. Brown  Late-Weichselian and Flandrian vegetation of Bodmin Moor, Cornwall. 1973
S.M.S. Burn  The vegetational history of ground ice features in North Norfolk. 1985
P. Coxon  Pleistocene environmental history in central East Anglia. 1979
R.J.N. Devoy  Flandrian sea-level changes and vegetational history of the lower Thames estuary. 1977
P.L. Gibbard  Pleistocene stratigraphy and vegetational history of Hertfordshire. 1974
A.R. Hall  The vegetational history and geology of Late Pleistocene deposits at Wing, Rutland. 1978
S. Hepinstall  Vegetational history in central Norfolk. 1984
R.A. Housley  The environment of Glastonbury Lake Village. 1986
P.E.P. Norton  Studies of the Pleistocene Mollusca of East Anglia. 1964
R.M. Peck  Pollen transport and deposition in Oakdale, North Yorkshire. 1975
L.M. Phillips  Pleistocene vegetational history and geology in Norfolk. 1973
J.D. Scourse  Late Pleistocene stratigraphy of the Isles of Scilly and adjoining regions. 1985
R.E. Sims  The vegetational history of East Anglia related to agricultural practice. 1976
C. Turner  Middle Pleistocene vegetational history and geology in East Anglia. 1966
P.A. Ventris  Pleistocene environmental history of the Nar Valley. 1985
D.G. Wilson  On plant macrofossils from archaeological sites in Britain. 1983
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1994. (with P.L. Gibbard) Discussion on the excavations at the Lower Palaeolithic site at East Farm, Barnham, Suffolk.


