BIOGRAPHICAL MEMOIRS

Frederick William Shotton, 8 October 1906 - 21 July 1990

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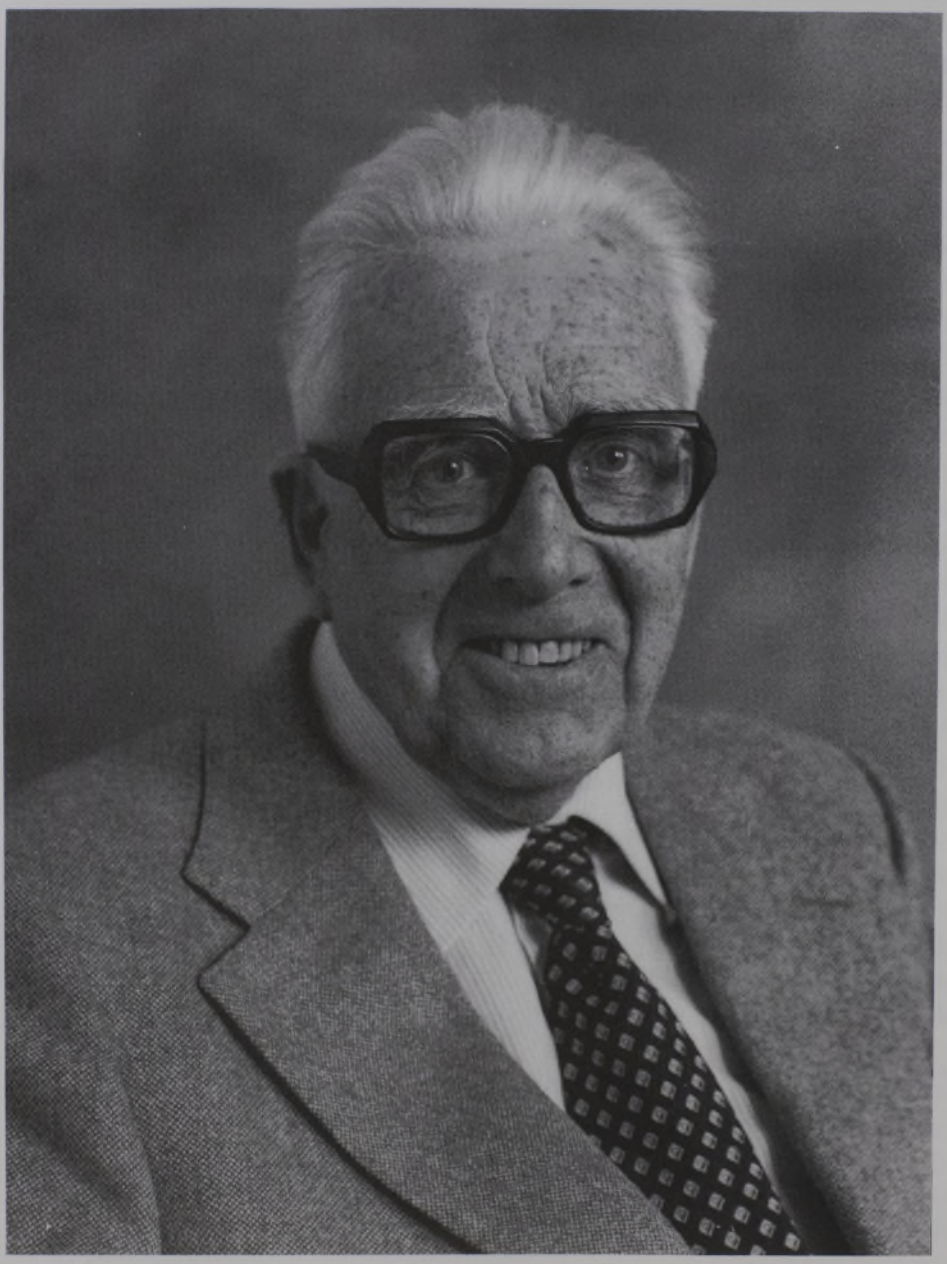

J. W. Slotton.

FREDERICK WILLIAM SHOTTON

8 October 1906—21 July 1990

Elected F.R.S. 1956

BY G.R. COOPE

FREDRICK WILLIAM SHOTTON was born on 8 October 1906 at Exhall, Coventry, the son of Fredrick John Shotton and Ada Shotton, well known figures on both the industrial and political scene in Coventry. In 1905 his father had founded the Albion Drop Forging Company at Holbrooks, north Coventry, a company that had a remarkable record for making car components and for the manufacture of munitions during two World Wars, a record of which Fred Shotton was justly proud. The family were staunch Liberals, and his father, though in his early days a socialist, was President of the Coventry Liberal Society, for four years a member of the Coventry City Council and for many years a Justice of the Peace in the city.

In 1930 Fred married Alice Louise Linnett at St Paul's Church, Foleshill, Coventry with whom he shared a common interest in natural history. Alice was the only daughter of John and Alice Linnett who kept a drapers shop in Smithford Street, Coventry. Later John Linnett opened a ribbon making factory on Foleshill Road, Coventry with which Alice Shotton retained an interest well into the post-war years. They had two daughters, Anne Elizabeth and Margaret Alice, who are both married with sons and daughters of their own. Alice Shotton died in 1979. Fred Shotton remarried in 1983 to Lucille Bailey of Portland, Oregon, who provided him with tender loving care during the last years of his life when gradually failing health kept him from his field work and to a greater and greater extent confined him to home. He died on 21 July 1990. Lucille survives him and still lives in their house in Dorridge near Solihull.

EARLY DAYS

Reminiscences about his childhood days always left me with the impression that this must have been an idyllic time both for himself and his only sister, some two years older than he was. Although his parents were both keen on natural history, he always credited his boot repairer friend Jack Edwards with introducing him to the subject and to fossils and archaeology in particular, enthusiasms that remained with Fred Shotton throughout his life. He was particularly moved when Jack Edwards died of a heart attack whilst actively engaged on an archaeological excavation. Bearing in mind the splendid example set by Jack Edwards, Fred Shotton continued his interest in the geology, archaeology and natural history of the English Midlands to the end of his life, working on the critical Pleistocene sections at

Waverley Wood Farm Pit in his final months.

At the age of 13, in the belief that he was of fragile health, a scarcely credible belief in view of his subsequent long and dynamic life, his local doctor recommended that he spend a short period in Switzerland to take advantage of the rejuvenating air. So he and his mother spent three months at Montreux where Fred used his time well, collecting butterflies and admiring the snow and ice of the mountain scenery. These experiences must have provided another potent influence directing his interest towards geology and in particular to the study of Ice Ages that was to become one of the main themes of his later scientific career. In connection with his visit to Switzerland, Fred was always ready to recount the story of his return home when he was stopped at the French border by a suspicious customs officer who had spotted his butterfly treasures all neatly packed in plain white triangles of paper. Even in those days customs officers were clearly alert to drug trafficking and Fred's paper triangles came under immediate suspicion. Package after package was opened and scrutinized before the exasperated officer, with an emphatic gallic shrug, declared 'toutes papillons'.

Fred Shotton's knowledge of natural history was remarkably broad, and his expertise covered not only geology but also entomology, in particular butterflies and beetles. He was a first class botanist with a particular interest in fungi, an enthusiasm which he claimed he had caught from his wife Alice. They published a joint paper on the larger fungi of the Tile Hill nature reserve near Coventry in the *Proceedings of the Coventry Natural History and Scientific Society* in 1940. Like so many other natural historians of his day, he was an excellent scientist who kept meticulous records of his observations at all times. These were augmented by excellent photographs. When in the field he was never without one of his notebooks in which he made detailed measured drawings of the numerous ephemeral exposures of Pleistocene sections – notebooks that have been a model to his students and colleagues alike.

Education

From 1913 to 1917 Fred Shotton attended Broad Street Elementary School, Coventry, and in 1917 was awarded a scholarship to Bablake School, Coventry. Between 1921 and 1923 he amassed an impressive array of scholarships including a Cambridge University Scholarship, Coventry Major Scholarship, Bablake School Governors Scholarship, Warwick County Scholarship and a State Scholarship. However, owing to his father's income, he was only allowed a scholarship to Sidney Sussex College, Cambridge. There he read Part 1 in Natural Science, Geology, Mineralogy and Chemistry, obtaining first class marks and the Wilshire Prize. In Part 2 he read Natural Science in Geology and in 1927 was awarded his BA with First Class Honours and the Harkness Scholarship. In 1947 he was awarded a Sc.D. on the basis of his published work.

Research

Professor Shotton's scientific career began at the tender age of 15 when he put on an exhibition for the Coventry Natural History Society of Silurian fossils that he and Jack Edwards had obtained from the Corley Conglomerates in the barren red measures at the top

of the Carboniferous of the Warwickshire Coalfield. This association with the Coventry Natural History and Scientific Society was to last for the whole of his life and he published frequently in their Proceedings. His work on these conglomerates was read as a paper to the Geological Society of London in 1927 whilst he was still an undergraduate at Cambridge.

Further work on the New Red Sandstone of the Midlands was undertaken when, much later in the early 1950s, Fred Shotton returned as head of the Geology Department at the University of Birmingham. Involving undergraduates as field assistants, he investigated the direction of current bedding in the Permian dune sandstones of the West Midlands showing that they represented barchans driven by a consistent east wind. This study represents an example of the way in which Professor Shotton involved undergraduates from the very start of their scientific careers in doing real science and thereby infecting them with his enthusiasm for the subject and, at the same time, with the necessary discipline to draw valid inferences from accurate observations.

Whilst at Cambridge in 1927, Professor J.E. Marr had suggested that Fred Shotton should undertake an investigation of the Cross Fell Inlier; an intricately faulted and overthrust complex of Lower Palaeozoic rocks east of the great Pennine Fault and west of the main scarp of the Carboniferous rocks of the Pennine chain. This required detailed mapping on a fine scale and involved subtle recognition of both sedimentary and volcanic rocks as well as an appreciation of the role that fossils could play in stratigraphical correlation. It is a salutary observation that the map he produced still stands as the best interpretation of this complex area available at the present day almost 60 years later. In my own experience of using the same area as an undergraduate mapping exercise I can vouch for the precision of the Shotton map and for the fact that he never missed an exposure or feature in his field searches. Incidentally, the people of Dufton, where he had his field lodgings, remembered him with extraordinary affection. 'Mr Shotton' as everyone called him, was popular in the village pub as a raconteur and purveyor of baffling tricks with matches. The overwhelming impression was of a man with immense charm who had seemed to be able to explain to hill farmers and shepherds the intricacy of the geology under their feet. His ability to teach at all levels was one of the most lasting memories that I retain of him. The report on the Geology of the Cross Fell inlier was published in 1935 in the *Quarterly Journal of the Geological Society of London*.

Apart from this single excursion into the north of England, Fred Shotton concentrated most of his field work in the West Midlands and particularly around Coventry. Thus in 1927 he published a detailed account of the conglomerates of the Enville Series of the Warwickshire Coalfield; essentially an update of the work that he had begun in his 'teens in the stimulating company of Jack Edwards. In this paper he was able to show that the fossiliferous pebbles in the conglomerates indicated the directions from which the deposits had been derived – the Arley Exhall Conglomerates from the west and the Corley Conglomerates from the east of Coventry.

His detailed field mapping then took him to the area south of Coventry, towards Kenilworth, the results of which he published in the *Quarterly Journal of the Geological Society of London* in 1929. This paper includes a number of field sketches and maps in his own neat handwriting with a style that persisted throughout his working life. However,

although he mapped the familiar 'solid' geology, Fred Shotton included an excellent map of the 'superficial', i.e. glacial deposits of the area. He comments that earlier accounts of such deposits had never been accurately located with a precision that was of much use. It is typical of him that he took into account all aspects of field geology and this included the Pleistocene deposits, often seen by other geologists as a rather inconvenient blanket covering the genuine geology underneath, an attitude perhaps epitomized by the remark of Professor Charles Lapworth at the beginning of this century: 'the Pleistocene stinks of varnish'. It was the challenge of these superficial sediments that was to intrigue Fred Shotton to the end of his life.

No doubt the most seminal paper of Shotton's career and the one which most geologists remember, is his work on 'The Pleistocene deposits of the area between Coventry, Rugby and Leamington and their bearing upon the topographic development of the Midlands', which he published in the *Philosophical Transactions of the Royal Society of London* in 1953. It is easy to see how this paper grew out of his earlier work on the Pleistocene deposits of the Kenilworth area. What is not so readily understood is the enormous labour that the mapping involved. Exposures were rare and almost always confined to sand and gravel pits which by their nature provided ever changing ephemeral evidence. He therefore embarked on an extensive programme of hand-drilled auger holes, some many metres in depth, and to this end he charmed his friends, students and colleagues alike into lending a hand. Each auger hole had to be accurately located and the sediments brought to the surface and meticulously logged. The map he produced has stood the test of time almost unscathed. This is all the more remarkable because his geological interpretations of this complex stratigraphy were put to such stringent tests shortly afterwards. The great increase in the post-war construction industry meant that these Pleistocene deposits were extensively exploited for sand and gravel exposing his views to intimate scrutiny. The predictive value of his stratigraphical interpretation thus had considerable commercial potential.

Today the area he described is dominated by the Warwickshire Avon that runs from northeast to southeast meandering in a broad valley. On the high ground on either side of the present day valley are remnants of sedimentary sequences laid down on quite a different land surface. Shotton was able to demonstrate that these older deposits, largely riverine sands and gravels, were laid down in a broad valley that graded northeastwards; the exact opposite direction of the inclination of the present day Avon valley. Into this ancient valley came ice from the north east that dammed up a large ice marginal lake which he named Lake Harrison in honour of W. Jerome Harrison, a pioneer figure in Midland glaciology. He saw the history of this ice-dammed lake as complex, with several overflows operating over the Cotswold scarp at different times and levels. Although Shotton envisaged Lake Harrison as a great expanse of water extending from Leicester in the north, Birmingham in the west and almost to Moreton in Marsh in the south, modern reinterpretators of the evidence now believe that many of the deposits which he saw as evidence of one great lake may be better interpreted as a number of discrete ice marginal pools, each probably of short duration. The ice advance which impounded the northeastward drainage, he named the Wolstonian Glaciation. In a temporal content he saw this as a cold period that postdated an earlier ice advance across East Anglia, whose deposits extend down to the northern outskirts of

London, an episode now called the Anglian Glaciation. The evidence for his chronological relationship was always rather weak since little mapping had been done between the Coventry-Leamington area and the classic sequences of East Anglia. It is scarcely surprising, therefore, that the Shotton view has recently been challenged by officers of the Geological Survey and Professor J. Rose amongst others who equated the Wolstonian with the Anglian Glaciations. Fred Shotton found it impossible to agree with this alternative view and fought a spirited rear guard action in defence of his original interpretation in *Quaternary Science Reviews* in 1983. Be that as it may, the mapping and description of the glacial deposits in the Coventry-Leamington area set a landmark in Pleistocene field practice.

A new direction was added to Fred Shotton's research interest when, in early 1955, I found a remarkable fossiliferous deposit at Upton Warren, near Droitwich, Worcestershire. Here were numerous bones of mammoths and other large vertebrates present, but of greater interest to us, though smaller stature, there were enormous numbers of fossils of molluscs, insects and seeds that clearly must have lived at the same time as the great Pleistocene mammals. Here was a chance to combine his passion for natural history and enthusiasm for Pleistocene geology. An account of this site was published in the *Philosophical Transactions of the Royal Society of London* in 1961. This presented an integrated reconstruction of the palaeoenvironmental conditions in the English Midlands about 40 000 years ago, based on both stratigraphical and geochronological information and a broad spectrum of fossil data; one of the first multidisciplinary approaches to the understanding of Pleistocene ecology and climate.

With the appointment of Peter Osborne, a professional entomologist from the Hope Department at Oxford, to the Birmingham team, Fred Shotton recognized the great potential in insect remains from Quaternary sediments as valuable clues to both ecological and particularly climatic reconstructions of this, the most recent period in geological time. Several important papers soon followed. Notable amongst these was the report on a borehole funded by the Royal Society, through Hoxnian Interglacial deposits at Nechells, Birmingham that was published in the *Philosophical Transactions of the Royal Society of London* in 1965. In contrast to the Upton Warren report which is essentially based on a single episode in time, the Nechells sequence showed the development of the flora and fauna through the first half of an interglacial period again integrating a broad spectrum of fossil data to interpret the ecological history.

A further report on the insect fauna from Brandon near Coventry from within Shotton's Bagginton-Lillington gravels and thus of early, or even pre-Wolstonian age appeared in 1969 also in the *Philosophical Transactions of the Royal Society of London.* At this site there was a puzzling mixture in the insect fauna of arctic-continental species and others of quite temperate geographical ranges at the present day. This enigmatic association was only resolved in recent years when faunas and floras in a similar stratigraphical context were discovered nearby at Waverly Wood Farm Pit. Here the 'cold' and 'warm' elements could be shown to succeed one another in time and were not therefore strictly contemporaneous. Fred Shotton discovered this site and was intimately involved with stratigraphical interpretation of its complex sediments but unfortunately died before seeing the fruition of his efforts. The report was published in 1993 in the *Journal of Quaternary Science* with

Shotton as senior author.

In keeping with his life-long fascination with natural history, Fred Shotton published widely on other Pleistocene fossil groups. For example, in 1972 he published on Post-Glacial mollusca from deposits of the Warwickshire Avon near Bidford in the *Proceedings of the Coventry and District Natural History and Scientific Society*, comparing the fossil assemblage with the fauna of the present day river and suggesting changes in the riverine regime that had taken place in the last 3000 years. In 1973 in the *Geological Magazine* he discussed the critical mammalian fossils from the Stretton Sands, north of Moreton in Marsh, one of the oldest Pleistocene deposits in the Midlands and orginally thought to be equivalent in age to the early part of his Wolstonian Glaciation. In this paper he suggested that the evidence favoured a Hoxnian Interglacial age for these fossils. They became of pivotal importance in the discussion of the age of the Wolstonian series of deposits in the Waverley Wood Farm Pit section, in particular the occurrence of the giant deer *Megaloceros* which would swing the evidence toward a later date as proposed by Shotton and against a pre-, or even early Anglian age, as preferred by other workers on the site. In 1980 he published in the *Proceedings of the Coventry Natural History and Scientific Society*, an account of a giant deer, an antler fragment which he had found in a gravel pit at Middleton, Warwickshire, and which he dated by radiocarbon to almost 11 500 years ago. This account was accompanied by a detailed discussion of the occurrence in the wider context of *Megaloceros* in the British Isles. In 1976. he reported in the same *Proceedings* on the occurrence of lion in the gravels of the Warwickshire Avon. In the last decade of his life he published a paper on impressions of wings of Trichoptera preserved in calcareous tufa in Elder Bush Cave near Wetton, Staffordshire in the *Quaternary Newsletter* for 1982, making meticulous drawings of the wing venation of both the fossils and their nearest living relations. The climatic significance of these is discussed in the light of the other fossils from the same layer of tufa which included rodents and an impression of the leaf of *Acer monspessulanum*, a Mediterranean maple, all representing an apparent mixture of northern and southern elements. A very tentative uranium/thorium date of about 50 000 years would have placed these deposits in a glacial context and was considered unreliable. This involvement with palaeo natural history thus lasted the whole of his working life but to it he brought scientific precision in the recording of his basic information and discipline in the inferences that he drew.

In 1960 Fred Shotton published in the *Geological Magazine* an account of large scale patterned ground revealed by differential ripening of crops showing as subtle colour contrasts in aerial photographs taken in late July 1958. These colour differences were clearly a reflection of different drainage properties of the soil causing ripening to occur slightly earlier in some patches than to others close by. The pattern produced clearly resembled those caused by ice wedge formation in perennially frozen ground in the far north at the present day. These crop markings could thus be seen as ghosts of ice wedge formation during some previous glacial episode. Though this was not the first time that such markings had been recognized, they were the most detailed yet recorded and provided evidence that they were generated during the maximum of the Irish Sea (Devensian) Glaciation.

In his presidential address to the Geological Society of London in 1965 Shotton described

examples of normal faulting (i.e. tensional features with vertically displaced fracture planes) in Pleistocene deposits which in places penetrated into the Mesozoic bedrock. This is an intricate paper in which two competing mechanisms are examined in detail. At Stretton on Foss he believed that the tension and consequent vertical movement was caused by shrinking of already frozen ground during periods of intense winter cold. The much larger fault features encountered during the construction of the M45 and M1 in Northamptonshire and Leicestershire respectively could not be explained in this way and were viewed as reactivation of old fault lines during isostatic recovery after the retreat of one of the Midland ice sheets. This paper illustrates the value that Fred Shotton put on the continuous watch that must be kept on quarries or temporary exposures in the neighbourhood if irreplacable information is not to be permanently lost.

In his second presidential address to the Geological Society of London in 1966, Professor Shotton tackled the difficult problem of absolute dating of Pleistocene deposits. This was a wide ranging discussion of geochronological techniques as they apply to relatively recent sediments concentrating almost entirely on the decay rates of radioactive elements. To the unspecialized user of dates this was, and is, one of the most lucid and readable accounts of the potentialities and limitations of these techniques. At about this time he set up in the Geology Department at the University of Birmingham, a radiocarbon dating laboratory whose initial aim was to obtain dates from near to the technical limit of the method (namely just over 40 000 years ago) using large volumes of gas in a proportional counter. It speaks well for the laboratory that consistent dates were obtained at this level of precision when, as he pointed out in the 1966 paper, the minutest amount of contamination by modern carbon could so easily invalidate any result. Birmingham University Radiocarbon dates were published regularly for ten years, initially in conjunction with Professor Derek Blundell who was largely responsible for the designing of the laboratory in the first place and later Roger Williams who was responsible for its day-to-day running. At all times, however, Fred Shotton took an active interest in the activities of the laboratory so that rarely a day passed when he did not pay his customary visit doing lightening calculations on the back of cigarette packets with enviable expertise. Without his input of enthusiasm and encouragement the laboratory ran into financial difficulties inherent in the ever spiralling cost of yet higher and higher technology necessary to keep abreast of other dating facilities and in 1988 it was closed, much to Fred Shottons consternation. It was the end of an era.

In 1973 he contributed to a benchmark paper 'A correlation of Quaternary deposits in the British Isles' published as a special paper by the Geological Society of London and co-authored by G.F. Mitchell, L.F. Penny and R.G. West. This was an excellent state-of-the-art compilation but, of course, suffered from the fundamental difficulty of all such reviews: that it was immediately out of date as soon as it was printed. From Shotton's point of view it enshrined his Wolstonian Glaciation as a separate event after the Hoxnian Interglacial and pre-dating the Ipswichian Interglacial. This is the belief that he sustained, and ably defended to the end of his life in spite of an increasingly popular alternative view that the Wolstonian series of sediments pre-dated the Hoxnian and were broadly equivalent to the Anglian glacial deposits. Nevertheless, the 1973 correlation provided a secure springboard from which to mount constructive criticisms – the essential prerequisite for any

scientific progress.

Throughout his scientific career, Fred Shotton always maintained an enthusiasm for archaeology, presumably dating back to the inspiration of Jack Edwards. He was especially interested in the distribution of palaeolithic hand-axes that occur in various clusters on the terraces of the Warwickshire Avon. In particular, he was fascinated by the implements made out of quartzite 'Bunter' pebbles, a particularly intractable material yet one of the only rocks of any durability available in the neighbourhood. He took great delight in making first class drawings of these hand-axes – another manifestation of his exact and meticulous approach to recording basic data. One of his latest publications was of some stone tools from the base of his Wolstonian deposits at Waverley Wood Farm Pit which included, amongst the usual pebble tools, two elegant and almost identical ovate hand-axes made of andesitic ash. This report, co-authored with J.J. Wymer records some of the earliest evidence of human occupation of the British Isles if we adopt the majority opinion as to the pre-Anglian age of the Wolstonian sediments.

The second important aspect of Fred Shotton's archaeological research was in the petrological investigation of neolithic stone axes. These differ from palaeolithic axes, not only in the use of grinding to give the tools a smooth finish and a resharpenable edge, but also in the fact that many were initially roughed-out near to the location of a restricted outcrop of acceptable source rocks. Several of these so called 'factory sites' have now been located. By detailed petrological investigation of thin sections cut from the axes themselves, it was hoped to trace the axes to their original 'factory sites' and thus infer neolithic trading patterns. From 1950 onwards, Fred Shotton published reports on the programme of axe identification recognizing new groups as coming from hitherto unsuspected outcrops. One of these source rocks was the olivine picrite from a small outcrop near Cwm-Mawr farm just to the south of Corndon Hill in Montgomeryshire (now Powys). This group of implements was entirely made up axe-hammers and small battle-axes, but in spite of the large number of products and the smallness of the outcrop, no evidence has yet been found of the manufacturing debitage that would undoubtedly identify the factory. A further source rock, also exclusively confined to the making of axe-hammers, clearly comes from one of the camptonite sills that penetrate the Cambrian rocks of the Nuneaton area. Here again no actual factory site has so far been discovered. However, in spite of the failure to locate the precise place where the implements were made, the restricted nature of the outcrop makes the primary object of the investigation a realistic proposition. By mapping the find spot of each implement as its ultimate destination and the outcrop of its source rock as its point of origin, some assessment of the neolithic trade pattern can be inferred.

This resumé of the research activities of Fred Shotton has naturally had to be very selective (he published about 150 scientific papers altogether) but it has been intended to give an overview of the breadth of his interests and the depth of treatment that he achieved. One feature in common to them all is the precision of his observations and recording. He brought discipline to his observations and imagination to his interpretations; that subtle combination of fact, flair and fortune that is the essential recipe for good science.

Military service

With the outbreak of war in 1939 there was a marked change in emphasis in Shotton's scientific work towards the highly practical needs of the war effort. Whilst he was an undergraduate at Cambridge, Fred Shotton had been taught by W.B.R. (Bill) King who had gained experience as a military geologist in World War I. They became close friends. With Shotton's return as a lecturer to Cambridge in 1936 and with the gradual build-up of the war clouds over Europe, King realized that he would become involved once again as a military geologist and saw Shotton as his assistant should war actually break out. So in 1938 Fred Shotton joined the Army Officers Emergency Reserve, thus avoiding the risk of being classified as having a 'reserved occupation' as a civilian lecturer. In May 1940 he was called up and after initial training at Colchester and Clapton, he was commissioned as a Second Lieutenant in the Royal Engineers on 21 September. King had been called up earlier and became the senior military geologist in the British Army throughout most of World War II. Since the army did not seem quite sure what to do with geologists, Shotton and King carried out ground investigations of anti-aircraft gun sites. The army's uncertainty did not last long.

In May 1941 Shotton sailed for Cairo to take responsibility for all the geological activities in North Africa and the Middle East under the army Director of Works, Major General E.C. Tickell. His main object was to locate adequate water supplies for the army – no mean task in so arid a region. The most reliable source would clearly have to be underground water reached by boreholes from the surface. Before his appointment the new boreholes put down by the army had production results that fell short of those expected by mere chance in spite of the services of a water diviner. All this was to change with the deployment of Shotton's geological expertise.

A practical account of the problems encountered, and the techniques adopted to overcome them, was given in Shotton's inaugural address on his appointment to the Chair of Geology at the University of Sheffield in 1945. In his talk he sets out in the concise manner of a military report how the field geologist must utilize a broad spectrum of experience and training in order to make the best of the scant available data upon which vital (literally) decisions had to be made. It is typical of Fred that he made use of his feeling for natural history in precisely relating the distribution of plants in the desert to their abilities to exploit underground water and thus as contributory clues to locating these sources and the depths at which they could be reached. He even used his appreciation of archaeology to indicate where water had been found and exploited in ancient times even though the desert sands had long concealed their sources. Above all, however, it was the classical methods of the field geologist coupled with the newly burgeoning techniques of exploration geophysics that provided the hard data upon which sound predictions could be made.

One example will have to serve to illustrate the crucial importance of Shotton's skills in finding water in the desert. Two old wells yielding drinkable water, yet situated only 38 feet above sea level, were located near to Fuka railway station, east of Mersa Matrup. This was sufficiently unusual to suggest to Shotton that a thorough geological investigation of the immediate neighbourhood would be worthwhile. He found evidence for an underground basin-like structure where limestones and clays had been folded in such a manner as to hold fresh water separated from any influence of saline contamination. The army drilled new

boreholes along the axis of the basin in rather more productive positions than the ancient wells, and these new wells functioned for many months coping with a demand of 110 000 gallons per day, becoming one of the most important supply points along the Western Desert road. These wells became of vital importance after the battle of El Alamein. As the Allies retreated to El Alamein the wells at Fuka were obviously destroyed to deny them access to the enemy. After the battle and the subsequent advance re-took Fuka, 70 miles forward of El Alamein, such was the geological precision of Fred's investigations that within 48 hours of the enemy's departure, the army had its first well drilled to its predicted depth, had it lined and delivering drinking water at 5000 gallons per hour. For his services in North Africa, Shotton was awarded the MBE (mil) and was three times mentioned in dispatches.

The scene of Shotton's activities now shifted. In September 1943 he was recalled to England after spending a few weeks in Malta planning sites for boreholes for water to supply the advance into mainland Italy. Back in Britain, Fred became Geologist Adviser on the staff of the Chief Engineer Major General Sir J.D. Inglis, with the rank of Major. His main task now was to investigate geological aspects of possible invasion beaches in northern France. W.B.R. King had wondered if Pleistocene deposits on the beaches would present problems in any attempt to land armies with their heavy vehicles. Fred Shotton with his interest in Pleistocene deposits was ideally placed to evaluate their significance, so with a small team (Professor Bernal and Lieutenant Colonel Johnston) he prepared maps of the coast showing outcrops of peat and other sediments which could not be repeatedly crossed by tanks or heavy wheeled vehicles. Unfortunately all this mapping had to be re-done in March 1944 after a storm blew up from the east and completely changed the distribution of the beach sediments and thus the suitability of the access places that had already been selected. In the course of mapping of the potential landing beaches, numerous aerial sorties had to be flown and, so as not to draw attention to the selected beaches, about 20 others had to be surveyed as well. The action of the Germans in pressing the local farmers to use their carts to carry obstacles to be placed on the beaches unwittingly gave Shotton much confirmatory information because the depth of the wheel ruts indicated the bearing strength and distribution of the different types of sediment which would have to be crossed when the actual invasion took place. Since ground verification had to be made of the interpretations based on the aerial photographs, daring visits were made to the beaches by Combined Operations Pilotage Parties who made detailed measurements of the thickness of the non-consolidated beach sediments. It was one of Fred Shottons favourite stories that, on one of these visits, when a soil auger had been accidentally left behind on the beach, there had been a protracted discussion as to whether aircraft should be deployed to drop soil augers on all likely beaches from Denmark to Biscay in order to distract attention from the actual landing places. Copies of the maps as given to the ships of the invasion fleet when the landing took place in June 1944 are deposited in the archives of the School of Earth Sciences of the University of Birmingham.

After the invasion of Normandy, Fred Shotton was involved in locating suitable water supplies for camps in northern France and on the location of new airfields. He was also consulted in the likely geological problems that might arise in the crossing of the Rivers Meuse and Rhine.

Economic geology

Shotton's war time experience, particularly in the siting of boreholes to tap underground sources of water, ensured that in the post-war period he was in great demand back in the English Midlands. His consultancy work in this respect involved numerous boreholes that penetrated the Triassic sandstone aquifers that are still some of the most important suppliers of good clean water in the region.

His work on the Pleistocene deposits, so extensive in the whole of the English Midlands, also meant that he was involved in the location and exploitation of the sand and gravels at a time when industry was greatly involved in post-war reconstruction. Few geologists could have been better placed both in location and timing to advise on these much needed resources.

I well remember within a few weeks of my appointment in the Geology Department at the University of Birmingham, Fred took me to a site on the banks of the River Severn where land slipping endangered a water pipeline fetching water from Wales to the Birmingham conurbation. He discussed the origin of the problem and how best it might be resolved 'for the good of my geologic soul'. Fred always believed that geological education should be a subtle mixture of practical as well as academic experience – the one leading to a better understanding of the other.

Appointments

Shotton was appointed as an assistant lecturer in the Geology Department, University of Birmingham in 1929 following the illness of Professor Boulton. In 1930 he was promoted to lecturer. In 1936 he was invited by Professor O.T. Jones to apply for a lectureship at the University of Cambridge, and after his appointment he was affiliated to his old college of Sidney Sussex and had connections with Clare, Girton and Newnham Colleges for supervision. Between 1940 and 1945 he was on leave of absence from Cambridge University serving in the Royal Engineers as a military geologist.

With the ending of hostilities in 1945, Shotton was appointed to the Sorby Chair of Geology at the University of Sheffield, where he remained until 1949 when he returned to the English Midlands as Lapworth Professor of Geology and Head of Department at Birmingham University, a post which he maintained until his retirement 25 years later in 1974. Fred's teaching philosophy was reflected in his running of the Department. He believed that Geology could only be taught from a broad and integrated base where students were instructed to a high level in all aspects of the subject and the inter-relationship of each aspect was emphasized, in particular under field conditions. Such was the extraordinary breadth of his knowledge and experience, and his acute ability to spot non-sequiturs in discussions or presentations that he made a truly formidable head of department whether as adversary or ally. I well remember during the 20 years that I served under him at Birmingham, how he scrutinized every exam question for possible ambiguities in its wording and spotted those practical exam specimens that were not adequately comparable. He was the shrewdest reader of manuscripts that I ever encountered but, at the same time, he was always constructive in his criticisms. Although, in those days, university departments were not run on democratic lines, they were sufficiently small for the head of department

to maintain a close contact with staff and students alike and thus to govern by some unwritten consensus. Alas how things have changed! He could never reconcile himself to the idea of huge, cumbersome 'schools' of the present day with their disjunct subject units and modular courses. They may make sense in purely financial terms but undergraduate tuition was suffering as a consequence.

Professor Shotton always maintained a vigorous school of post-graduate students made up of research scientists with diverse interests; stratigraphers, palaeontologists, geophysicists and geochemists all, he felt, benefited from their association. Bearing in mind his war-time experiences, it should not come as a surprise that he was quick to appoint a full-time geophysicist (D.H. Griffiths) to the Birmingham team, one of the first such appointments in the country. Later he appointed a hydrogeologist (J.W. Lloyd). The establishment of both these subjects led to flourishing M.Sc. courses that continue to this day.

Between 1956 and 1974 Professor Shotton provided in Birmingham a home base for the geologists of the Falkland Islands Dependencies Survey (FIDS) later to become the British Antarctic Survey (BAS). Numerous postgraduate research scientists returned from their duties down south to work up their field mapping and write doctoral theses at this time, much to the benefit of home-based staff and undergraduates. D.H. Griffiths and R. Barker contributed much to our understanding of the Antarctic Peninsula and the Scotia Sea area by land and sea-based geophysics at this time thus establishing still further the role of geophysics at Birmingham.

Professor Shotton viewed the Department's activities not only as a provider of a service to the scientific community but also in a social context, that of presenting geology to the local community. This is best illustrated by his keen support of the Geologists Association which met regularly at the University for lectures and demonstrations and, of course, the much loved Christmas parties at which he was a regular star turn. Staff and undergraduates were encouraged to join and many of us were gently pressed into giving lectures or leading field excursions. It was on one of these field trips with the Midland group of the Geologists Association that Shotton discovered the critical exposure of the sub-Wolstonian fossil and archaeological site at Waverley Wood Farm Pit near Coventry. Again this illustrates the enormous value of keeping a watch on local temporary exposures and the role of a well informed and sympathetic local community.

It would be difficult to enumerate those erstwhile undergraduates and postgraduate student who owe their positions as eminent geologists or holders of other high office, to the early influence of Fred Shotton (it would be invidious too, as the number is great and I would offend some by my unavoidable selection). However, we all owe much to him for the rigour of his training and the infectious enthusiasm which is the most vivid memory of him that we retain.

At all times Shotton was intimately involved with the administration of the University of Birmingham, sitting on numerous boards and committees. Between 1957 and 1960 he was Dean of the Faculty of Science and from 1965 to 1971 he was Pro-Vice Chancellor and Vice Principal.

Shotton's administrative skills extended well beyond the confines of the University.

Between 1964 and 1966 he was President of the Geological Society of London giving two outstanding Presidential addresses on aspects of his Pleistocene research. He was Chairman of Xth International Union of Quaternary Research Congress held at the University of Birmingham in 1977, having been elected as an Honorary Member of INQUA in 1961. He was instrumental in setting up the West Midland Trust for Nature Conservation involving the counties of Warwickshire, Worcestershire and Staffordshire and was the Trust's first President. This was one of the first precursors of the County Trusts for Nature Conservation that now flourish throughout England. The trend towards separate county trusts led to the setting up of the West Midland Trust on county lines and Shotton was appointed President of the Warwickshire Nature Conservation Trust from 1980 to 1983. He was twice elected as President of the Coventry Natural History Society and of the Birmingham Natural History Society. Between 1984 and 1987 Shotton was President of the Birmingham Archaeological Society. For three years he was a member of the Council of the Natural Environment Research Council trusted with issuing Government funds to the scientific bodies under its jurisdiction. These do not account for all the demands made upon him for his skill as an administrator – he once complained to me that he had to sit on 30 committees – but they illustrate the breadth of Fred's interest and skills.

Distinctions

Fred Shotton's expertise and personality led to recognition at all levels in the scientific community. In 1944, towards the end of the war, he was elected an Honorary Member of the Society Belge de Geologie in recognition of his services as a military geologist. In 1970 he was elected an Honorary Member of the Royal Irish Academy. In March 1956 he was elected a Fellow of the Royal Society and in subsequent years he represented British Quaternary Geological interests in numerous conferences and expeditions to widespread international locations. Thus he visited New Zealand (twice), the River Ob and Yakutz area of Siberia, India (twice), Brazil, Columbia and Venezuela as a guest of the Shell Oil Company, and finally Japan and Hong Kong. In 1954 he was awarded the Prestwich Medal of the Geological Society of London and in 1967 the Stopes Medal of the Geologists Association.

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Bibliography

The complete bibliography appears on the accompanying microfiche. A photocopy is available from the Royal Society library at cost.