ISSN 0375-7846

The North West Geologist

Published under the auspices of The Liverpool Geological Society and The Manchester Geological Association

Number 11 2004

The Liverpool Geological Society
Hon Secretary: Joe Crossley, School of Biological and Earth Sciences,
Liverpool John Moores University,
Byrom Street,
Liverpool, L3 3AF
or
2 Anderson Close,
Rainhill,
Prescot, L35 6PS.
Tel: 0151 426 1324.
Email: lgsjoecrossley@hotmail.com

Manchester Geological Association
General Secretary: Michael Aiers,
4 Tintern Road,
Cheadle Hulme,
CHEADLE, SK8 7QF.
Tel. 0161 439 7692.
Email: AMM.Aiers@ukgateway.net

Lancashire Group of The Geologists' Association
Secretary: Jennifer Rhodes
Tel: 01204 811203
Or
Email: J_rhodes@hotmail.com

Hon Editor
Wendy Simkiss
Liverpool Museum
William Brown Street
LIVERPOOL L3 8EN
TEL: 0151 478 4287
E-mail: wendy.Simkiss@liverpoolmuseums.org.uk

Other Publications

The Geological Journal by Wiley

Rock Around Liverpool
by the Liverpool Geological Society

Rock Around Wirral
by the Liverpool Geological Society

The William Smith Map
by the Liverpool Geological Society

Michel Levy Charts
by the Liverpool Geological Society *

A Field Guide to the Continental Permo-Triassic
rocks of Cumbria and North West Cheshire
by the Liverpool Geological Society

Stereographic Projections
by the Liverpool Geological Society *

*Contact Mr N C Hunt, Department of Earth Sciences, University of Liverpool, P.O box 147, Liverpool L69 3BX

Figure 2. G.H. Morton on Bidston Hill, 1886.

THE NORTH WEST GEOLOGIST
(Formerly THE AMATEUR GEOLOGIST)
Number 11

CONTENTS

Editorial

There have been few articles sent for this publication recently, but a large number of obituaries perhaps indicating the end of an era for geological science. This number does, however, contain an index of articles for past numbers reflecting an interest in local, national and international geological sites and a range of subjects within the earth sciences. My thanks go to Mary Howie from the Manchester Geological Association and to all of those who contributed to this edition of the North West Geologist.

Wendy Simkiss

Notes for Authors

Articles and suggestions for future issues are most welcome and should be sent to either Chris Hunt, Department of Earth Sciences, The University, Liverpool L69 2BX or Norman Catlow, 30 Banksfield Avenue, Fulwood, Preston, PR2 3RN or Wendy Simkiss, Earth Science, Liverpool Museum, William Brown Street, Liverpool, L3 8EN, wendy.Simkiss@liverpoolmuseums.org.uk

Articles should preferably be presented on disk, if possible in **MS Word**, and may be up to 3,000 words in length. Figures should be designed for reduction to fit a maximum frame size of 180mm by 125 mm.

Figure 1. George Highfield Morton

presented him with an illuminated testimonial, together with a "Marble time-piece and side ornaments".

He was elected to the B.A.A.S. in 1854 and became a Fellow of the Geological Society of London in 1858. He also reports that :

> In 1861, I went for examination in geology to the Science & Art Department, South Kensington [presumably the forerunner of Imperial College] and obtained a Certificate of the First Grade, and was first on the list of names. In 1864, I was appointed Lecturer in Geology at Queen's College, Liverpool. [later to become the University of Liverpool].

In addition to his work on the Triassic and glacial rocks in the Liverpool area, Morton also studied the Carboniferous rocks of North Wales, particularly the Carboniferous Limestone and the beds overlying it which he named the Cefn-y-Fedw Sandstone. He published a series of papers on these rocks - the first in 1876 dealt with the Llangollen district. This was followed by papers on Flintshire and the Vale of Clwyd, ending with a paper on the Carboniferous Limestone of Anglesey, published posthumously in 1901.

The last decade of his life was perhaps the most productive geologically. In 1891 he published the second edition of his 'Geology of Liverpool'. This was more than five times the length of the first edition which had only 55 pages. It had an extensive section on the Storeton quarries and included the first photographs of the Storeton footprints ever published. The book heralded, and perhaps even catalysed, the turn-of-the-century revival of interest in the Storeton prints.

The following year Morton was awarded the Lyell Medal of the Geol Soc of London. For Morton, it was perhaps his proudest moment; the Lyell medal was, he said "one of the greatest honours that can be bestowed on a geologist". It was also the first time that it had been awarded to a man who was not a conventional academic.

In 1899 he put the finishing touches to a work which had taken him more than 40 years. Throughout that period, he had carefully examined all exposures - temporary and permanent - in the Liverpool area and had recorded the faults and formation boundaries on the 6-inch Ordnance Survey maps. He ended up with a geological map of unparalleled detail and in 1899 he presented hand-coloured copies of this to the Geological Survey, Liverpool Library and the Liverpool Geological Society.

In all Morton read 62 papers to the LGS, almost all of them dealing with aspects of local geology. However, the last of these papers, given on 30 March 1900, only two weeks before his death, was an exception - the subject was William Smith, often referred to as 'the Father of English Geology'. In the discussion that followed, one member called Morton "the Father of Geology in Liverpool". No more appropriate memorial tribute could have been found.

OBITUARY: NICHOLAS RAST 1927-2001

By Tony Harris

Nicholas Rast died in Lexington, Kentucky, U.S.A., on 28 August 2001, five months after the symposium held to mark his contributions to geological research and teaching in the United Kingdom and in North America, and his retirement from the Hudnall Chair of Geology at the University of Kentucky.

Born in Teheran, his early education culminated in a diploma in Industrial Chemistry (1947) and first place in the competition for training in the United Kingdom (1948). He graduated from University College London in 1952, and took up an Assistant Lectureship at the University of Glasgow where he spent two years, carrying out the research for his PhD supervised by Basil King. The PhD was awarded in 1956 for his work on the structural and metamorphic history of the Dalradian rocks of the Schichallion Complex, Perthshire, Scotland by which time had taken up an appointment as Assistant Lecturer/ Lecturer in the Department of Geology at U.C.W. Aberystwyth (1954). Publications that followed related the history of porphyroblast growth to the polyphase tectonic history of the Schichallion rocks and established him as a major player in metamorphic geology. His thinking in this field had been greatly influenced by his scientific mentors, Robert Shackleton, C.T. Clough, Sir Edward Bailey, as well as by Basil King.

In the Aberystwyth Department, Nick's dynamism made a major impact on teaching and research into structural geology, metamorphic petrology and Precambrian stratigraphy. After a year or so he also began research on the Snowdon Ordovician acid volcanics, supervising research students in all these fields. Showing the same attention to detail that had been a feature of his metamorphic work, he recognised that many of the Snowdonia rhyolitic rocks, formerly believed to be lavas, contained eutaxitic texture and, hence, that many were sub-aerially erupted ignimbrites. From this he inferred that Snowdonia's Ordovician deposits must have been laid down in shallow water rather than deep. This early work on metamorphic and igneous rocks in the British Caledonides was recognised by the award of the Geological Society of London Lyell Fund (1962), by which time he had moved from Aberystwyth to Liverpool.

His appointment by Robert Shackleton to the University of Liverpool (1959-1971) led to a broadening and maturing of his interests in the nature and causes of orogenesis and in the mechanisms of magma emplacement. At the same time his interest in Dalradian structure and stratigraphy and Ordovician vulcanicity, particularly in Wales, continued, supported by a large postgraduate group. From his position in Liverpool, given the work of Robert Shackleton, Wallace Pitcher and Bernard Leake, Nick could appreciate how important was Ireland to understanding the Dalradian Superg roup and he interested himself in the 1960s Dalradian work in Ireland, based at Trinity College and the Geological Survey.

He involved himself in the activities of the Liverpool Geological Society and with others helped to pioneer the extremely successful ***Special Issues***, many, if not all, of which arose from important national symposia held in Liverpool. Of these, **Controls of Metamorphism and Mechanisms of Igneous Intrusion,** in particular, come to mind. The Liverpool Geological Society awarded him its silver medal (1964) and he became its President (1966-1967).

His editorial contributions to international journals began during his time at Liverpool and he began to use his fluent Russian to translate scientific texts. He translated and edited the first comprehensive account of the geology of the U.S.S.R. (by Nalivkin), and served on the editorial boards of several journals, such as the *Journal of Geodynamics*.

In 1970, since 1965 a Reader in the Liverpool Department, he was appointed, for nine months, Royal Society Professor in the Graduate School of Geology at the National University of Mexico.

In 1971, he recognised, as did many others, that the Caledonian orogenic belt continued across the Atlantic through Newfoundland into the Appalachians. In persuit, he accepted a professorship and the Chairmanship of the Department of Geology, University of New Brunswick, Fredericton, Canada, while from 1979, he held the Hudnall Chair at the University of Kentucky.

During his time in North America he published numerous papers on the Variscan Front and the Avalonian Volcanic Arc. Collaboration with his friend and colleague Jim Skehan began in 1976 when they co-organised a G.S.A. Penrose Conference in New Brunswick that applied plate-tectonic theory to international circum-Atlantic correlation. He subsequently became Coordinator of the International Geoldynamics Project on the structure and geophysics of the Appalachian/Caledonian orogenic belt. He was founding Vice President, subsequently President, of the International Division of the Geological Society of America.

Apart from his contributions to Geology, Nick will be remembered for his generous and impulsive nature, and for his love of food and wine. He enjoyed entertaining and demonstrating his culinary skills. His views on all matters were held with an intensity and enthusiasm that was often infectious.

He is survived by his first wife, Audrey, and their son, Nicholas; his second wife, Diana, herself a geologist, who continues to live and work in the University of Kentucky and is mother to Nick's children, Elizabeth Morgan, Alexander and Andrew.

Tony Harris
December 2002

continue to hold meetings at No. 7, London Road. During the Society's first session, fourteen members were enrolled. This was almost a full complement, since it had been agreed that the number of members should be limited to 18 - presumably the largest number that Morton's house could accommodate!

Ten years later, in the first of his two terms as the Society's President, Morton admitted:

> When the first meeting was held in December 1859, it was neither intended nor expected that the Society would become one of the prominent institutions of Liverpool for the cultivation of Physical Science. The experience of a few months, however, was sufficient to prove the desirability of holding the meetings in a public building instead of the residence of one of the members.

The opening of William Brown's new civic Museum and Library on what was then Shaw's Brow provided a more commodious meeting place. From December 1860 the Society held its meetings there, enabling the limit on the number of members to be abandoned. In October 1864, however, the venue was changed to the Royal Institution in Colquitt Street where access to the geological collections could more easily be made available. By then the membership totalled 58.

Even before the founding of LGS Morton had told the Liverpool Lit & Phil of his discovery of glacial striae on rocks in the neighbourhood of Toxteth Park and one of his first papers to the new Society was "On the surface markings near Liverpool supposed to have been caused by ice". It was delivered in 1862 and based on the striated surfaces at Toxteth Park and in the brickfields at Kirkdale - both exposures long since built over. He published further papers on the local glacial striae in 1870 and 1887.

In 1863, the Liverpool Naturalists Field Club published the first edition of Morton's book 'The Geology of the country around Liverpool' - an expanded version of an address that he had given to the Club two years earlier. Illustrations included a section through Storeton Quarry which he had produced to accompany the first LGS visit there in July 1862.

In March of the same year, 1863, Morton read a paper to the Society in which he turned his attention to two of the specimens acquired from Storeton by the short-lived Liverpool Natural History Society in 1838 and subsequently housed in the Royal Institution Museum. He proposed two new species : the most characteristic hand-like footprints from Storeton were named Chirotherium storetonense - so distinguishing them from the broader Chirotherium barthii prints from Germany. The ribbed plant stems found in association with the footprints were compared to the modern horsetail Equisetum and named Equisetites keuperina.

Morton continued to be the main driving force of the LGS for 40 years. He was Secretary from 1859 - 1868, when he became President for two years; he then reverted to the post of Secretary for a further 15 years until his second term as President from 1885 - 87. On his retirement from the post, members of the Society and Wales, with some excursions to Scotland, Ireland, France and Belgium.

In addition to building up his geological collection, Morton became a member of various local societies, most of which were only short-lived. His more serious work began after the visit to Liverpool of the British Association in 1854. The following year he joined the Liverpool Literary & Philosophical Society and in 1856 delivered to that Society his first major paper on 'The subdivisions of the New Red Sandstone between the River Dee and the Rise of the Coal Measures east of Liverpool'.

Other papers followed until December 1859, when Morton organised the inaugural meeting of what would become the Liverpool Geological Society. The Geol. Soc. of London had been established over 50 years earlier in 1807 and there were already a number of provincial clones - in Edinburgh, Yorkshire, Manchester, Dudley and, most recently, Glasgow.

Despite these successful precedents, the viability of a Liverpool society was in some doubt. It was felt that the local area was devoid of geological interest since the predominant rocks were the almost unfossiliferous Triassic sandstones. Years later, when the success of the Society was beyond question, its then President, Thomas Mellard Reade, could jest :

> The district is doubtless looked upon with horror by geologists whose sport is Palaeontology; for, saving a few footprints, there is not a fossil to be found in the New Red Sandstone.

At the time of its formation, however, such doubts posed a real threat to the new Society. One potential member, invited by Morton to attend the inaugural meeting, declined because :

> Such a Society in a district of the country which offers so little to be worked out that is not already known, and moreover in a town purely commercial, where with few exceptions the people are too much engrossed with other pursuits, and care little or nothing for science in any shape, would be too contracted to permit of its existence beyond a very limited period.

Despite such misgivings, nine gentlemen met at Morton's house in London Road on 13 December 1859. They were :

Henry Duckworth
Thos Urquhart
F.H. Kirby
S.B. Jackson
Thos Moore
C.S. Gregson - Plumber of Fletcher Grove
Geo Thomas
F.P. Marrat [the dealer in minerals & fossils who helped the young Morton]
George Morton

They agreed to found a society "to investigate the structure of the Earth, the character of its past inhabitants, and the changes now in progress on its surface". Henry Duckworth was elected as President, George Morton as Secretary. It was proposed to

OBITUARY: PROFESSOR ROBERT MILLNER SHACKLETON 1909 – 2001
By Bernard Elgey Leake

Robert Millner Shackleton died peacefully at his home at East, Hendred, Oxfordshire, on May 3rd 2001. He was born on 30th December 1909 in Purley, Surrey, the son of John Millner Shackleton (an electrical engineer of Irish derivation, who at one time worked for the Post Office telephones) and Agnes Mitford Shackleton (nee Abraham). He was very distantly related to the Antarctic explorer, Sir Ernest Shackleton.

Robert Shackleton first joined the Liverpool Geological Society (LGS) in December 13th 1927 while an undergraduate; he rejoined in 1948 and was President in 1951-2 & 1952-3, his Presidential address being 'The structural evolution of North Wales'. He was the major driving force behind the re-vitalisation of the LGS from 1948 onwards and ensured the LGS met rent-free in the Jane Herdman building for many years. His evening extra-mural lectures attracted many to become LGS members and it was during his Presidency of the Society that 'The Liverpool & Manchester Geological Journal' was initiated, with Part 1 of Volume 1 appearing on 18th March 1952. He was awarded the Society's Silver Medal on 25th May 1956, when he lectured on Moel Hebog; he was made an Honorary member on 14th March 1978 when he lectured on 'The Precambrian of Brazil' and he gave the first Distinguished Visitor's address on 17th Novemember 1981, when he gave the lecture on 'Across Tibet—from Lhasa to Katmandu', a thrilling lecture illustrated with outstanding slides, including views of such truly active thrusts as ones which rained debris down onto the principal road! In view of his quite exceptional service to the LGS, it is appropriate to record an unusually extended obituary notice.

After attendance at the Quaker school of Sidcot, Somerset, Shackleton entered Liverpool University in January 1927, and graduated with a First Class Honours BSc in Geology in July 1930 under P.G.H. Boswell CBE (the first George Herdman Professor of Geology), being only the fourth student in the history of the Department to achieve First Class Honours. Shackleton's first visit to Africa was as an undergraduate in July to September of 1929 to attend the 15th International Geological Congress in Pretoria, South Africa. Shackleton always remembered Boswell's help and how he had persuaded him to go, even sharing a cabin on the ship to South Africa with him to reduce the cost, at a time when few Professors would have done so. Shackleton saw the Karroo, the Kimberley diamond mine, the Witwatersrand mines, the Bushveld, Rhodesia and the Drakensberg etc.

Shackleton began his PhD in 1930, on the Moel Hebog area of North Wales. This was part of a systematic programme to re-survey North Wales, encouraged by Boswell, and followed surveys of Snowdonia by David and Howell Williams. However, in 1930, Boswell, an Imperial College (IC), London, man moved back there to the Chair, and Shackleton followed him as Beit Research Fellow (1932-34). Shackleton's mapping of Moel Hebog, between Tremadoc and Nantlle, included examining some cliff faces never before scaled by any geologist. In his 1956 LGS lecture he casually pointed to a layer, shown in the slide only by a very narrow, intermittent ledge on a vertical cliff face, where he had found the only fossils ever found in that part of the succession. He obtained his Liverpool PhD in December 1933.

Shackleton was one of a number of Liverpool students, including the writer, who from the 1920's onwards did part of their PhD work at IC. He had a petrological training, having been taught silicate analysis by A. W. Groves at IC, but the petrological interpretation of his PhD area was hindered by the fact that ignimbrites had not yet been recognised and only a few chemical analyses could be completed. The published account of his thesis work did not appear until 1959, and then only because of the devoted help given by Dr J. C. Harper.

Shackleton went on briefly to become Chief Geologist to Whitehall Explorations Limited, working in Fiji from 1935-6, when he returned to IC as an assistant lecturer in geology. In a typically prescient and discerning manner, in a time when most of the geological establishment were scornful of continental drift, he ambitiously started to examine the geology of the whole west coast of Ireland with a view to ascertaining whether it could be matched with the geology of North-eastern USA and Eastern Canada. In particular, in 1936, he started mapping in Connemara on a 1:10560 scale, in then unrecognised Dalradian rocks on the north side of the Twelve Bens, which had not been examined for nearly 70 years. He became increasingly interested in the structural and tectonic geology of metamorphic rocks, and was helped enormously by Gilbert Wilson, (who joined IC from Reading in 1939, being appointed by H. H. Read, who followed Boswell at both Liverpool and IC) particularly in appreciating the value of small-scale folds and lineations in indicating the larger-scale structures. Shackleton's first published work (1940) was 'an inspired contribution' (Holland, 2001) demonstrating the overturning of some of the Silurian succession in Dingle, South-western Ireland. The techniques involved, that of ascertaining way-up from sedimentary structures, (including cross-stratification, graded bedding, ripple marks and desiccation cracks), combined with the use of cleavage-bedding relationships and mapping the stratigraphy and fold hinges, were to subsequently form the basis for several of his most original contributions.

From 1940-5, as part of the wartime search for strategic minerals and gold, Shackleton was a geologist in the Mining and Geological Department of the Kenyan government. He mapped the Nyeri, South Nyanza and Maralal map sheets, the last two being immense areas, and published reports 10, 11 and 12 including studies of the Migori gold belt. On many occasions his physical prowess narrowly saved him from death, including being charged, and deeply gored in the thigh, by a maddened rhinoceros. In 1945, following this hospitalising incident, he returned to the teaching staff at IC, but by now, Africa was a magnet to him. He returned with the 1947 British-Kenya Expedition to map in detail part of Rusinga Island in Lake Victoria (which had abundant anthropoid remains worked on by Dr L. S. B. Leakey), its complex Miocene volcanics (which included melanite nephelinites), and also much of the surrounding Kavirondo Rift Valley in Western Kenya. Although the promised petrology never appeared, the stratigraphy, structure and tectonics were completed with remarkable speed for a man notorious for tardy publication, being read to the Geological Society of London in November 1948 and published in 1951.

GEORGE HIGHFIELD MORTON : FOUNDING FATHER OF THE L.G.S.
By Geoff Tresise

George Highfield Morton was born in Liverpool on 9 July 1826. He was educated, first at the Paddington Institute, then at the Mechanics Institute in Slater Street and finally at the Liverpool Institute in Mount Street.

By his own admission, his school-day interests were limited to "living things in ponds". It was not until 1845, at the age of 19, that :

> I purchased 'Knight's Store of Knowledge' because there was an article in it entitled 'The Mineral Kingdom'. Before I obtained the book there did not seem to be anything worth my attention, although time hung heavily on my hands; but as soon as I began to read the pages on the Geological History of the Earth, a change came over me, for I had found a subject of engrossing interest, something worth living for.
>
> In those days there were no Science Classes, and few Text-books on Scientific subjects, so that a youth out of the Society of Scientific and literary circles could not easily find out what were the best works on Geology or Natural History. The only men in Liverpool who could tell the name of a fossil or mineral were the late Francis Archer, a surgeon of Rodney Street, and two dealers in such specimens, Mr F.P. Marrat, and Mr B.M. Wright, and I obtained my earliest information from them.

Morton began to collect minerals, fossils and shells, and over the next 40 years, he built up one of the largest private collections in the country. From the start, he seems to have been admirably methodical. After his death, his daughter wrote:

> Every specimen in his collection, which contained several thousand objects, was numbered; each had its place in a small cardboard tray on the interior of which was recorded the name of the specimen, the name of the place from whence it came, the date and other information. And then in catalogues, of which he had duplicates, the same description was entered with such wonderful accuracy that enabled him to find any and every object without trouble.....
>
> All the specimens were as nearly alike in size as was possible; the little trays that contained them were exactly similar to each other and he made every one himself. His cabinets were made to his own design and were practically dustproof. Periodically he went through each drawer, sometimes rearranging them or changing them for better examples, and at the close of each examination he recorded the fact in his notebook kept for that purpose.

In 1849, Morton set up in business as a house painter and decorator based in London Road. The following year he married 21-year old Sarah Ascroft but neither business nor domestic affairs could diminish his interest in geology. In his old age, he wrote :

> During all the years of business activity, and of births, marriages and deaths, and of domestic pleasures and pains, all the leisure time was appropriated to geological pursuits, including study at home and in various parts of England

Triassic-Cretaceous Formations mentioned in the text

PERIOD	AGE	FORMATION
Cretaceous	Maastrichtian	Berda
	Campanian	Berda
	Santonian	Aleg: Bireno Member
	Coniacian	
	Turonian	Gattar
	Cenomanian	Fahdene
	Albian	Chenini
	Aptian	
	Barremian	
	Hauterivian	Boudinar
	Valanginian	Meloussi
	Ryazanian	Sidi Khalif
Jurassic	Portlandian	
	Kimmeridgian	
	Oxfordian	Ghoumrassen
	Callovian	
	Bajocian	
	Aalenian	
	Toarchian	
	Pliensbachian	
	Sinemurian	
	Hettangian	
Triassic	Rhetian	Bhir
	Norian	
	Carnian	
	Ladinian	
	Anisian	Ouled Chebbi
	Scythian	Mastoura

REFERENCES

Moody, R. et al (2002). The Geology of the Saharan Platform, South and Central Tunisia, 19 September - 2 October 2002. *Geologists' Association Field Excursion Handbook*

Ben Ferjani, A., Burollet, P.F. and Mejri, F. (1990). *Petroleum geology of Tunisia*, Tunis.

ACKNOWLEDGEMENT

My thanks to Professor Richard Moody for reading and commenting on the text, his general encouragement, and for loaning me his valuable copy of *Petroleum Geology of Tunisia.*

At IC he lectured in petrology, mostly metamorphic petrology. Alec Trendall writes: 'To me, as an 18-19 year-old undergraduate [at IC], the best single word to describe Robert's lectures is "inspirational." His arrival was like a blast of invigorating fresh air after the rather pedagogical style of most of the other staff. I suppose he had a 60-minute slot for his lectures in the official timetable, but he would stride in with a pile of reprints, and would talk informally and fluently about their contents, not uncommonly for 90 minutes or more. I listened with absolute attention, not noticing the passage of time. We felt that we were being initiated as co-workers at the coalface of geology, and in retrospect that is because that was how he structured his teaching: I don't think he worked from a planned sequence of lecture notes, but swept up from his desk whatever papers he happened to be reading at the time and used them as a basis for his lecture. He expected the complete dedication from his students that this approach necessitated, and I can clearly remember his coming in with a thickish work by Sederholm "Om granit och gneiss"—and saying, more or less "You should read this—you'll find the Swedish quite easy to understand as you go along". It was the same with German (Niggli) and French (Lapadu-Hargues)—we were expected to tackle everything. Of course, this was not a formal course in "petrology" at all, but a series of seminars among equals about the way rocks are formed, altered, and deformed—all as a basis for understanding how the Earth works. This was reflected in his final exam paper for the year, which started unusually with the rubric "Answer question 1 or any 5 others". Question 1 was, as nearly as I can recall the words: "Compare the petrology, metamorphism and tectonic evolution of the Alps and the Scottish Highlands" (A. Trendall, personal communication, 19 March 2002).

Shackleton's abilities in systematic instruction, particularly at an elementary level, or his teaching of those who were weak, or other than keenly-absorbed and highly-motivated, were much poorer. The lack of formal organisation to his lectures made learning more difficult for such students; also he was almost disinterested in those who were not keen to learn, as he saw no reason why they should be forced to do so.

Shackleton energetically plunged into mapping the Dalradian rocks of Fanad, Co. Donegal and used this area for some IC mapping classes, and, subsequently, Liverpool ones also for a time.

In October 1948 Shackleton became the George Herdman Professor of Geology at Liverpool University, following the short, ill-fated tenure of F. Coles Phillips, who resigned in December 1947. Ironically, Shackleton was the exact opposite of Phillips as regards dedication to fieldwork. The Department was semi-moribund after the war. Shackleton rapidly built it up with the appointment of outstanding, but often eccentric, staff and entry into new fields, such as sedimentology, geochemistry and geophysics. The last programme eventually culminated (when Wallace Pitcher had succeeded Shackleton in the Chair, and in collaboration with Professor J. M. Cassells FRS), in the establishment of the first BSc degree in geophysics to be offered in Britain. Shackleton's research now embraced mapping Fanad and Connemara; drawing long N-S sections down the west of Ireland, which were difficult to interpret before the terrane concept was known and so were never published; synthesising the overall structure of N. Wales (1954); revising Greenly's (1919) interpretation of the stratigraphy and structure of Anglesey, and Matley's (1928) ides on the structure of SW Lleyn (1956a), both the latter with "wholly novel inversion of orthodox assumptions" (George, 1970). Most important of all, however, was Shackleton's unravelling of the structure of the Highland Border complex in Scotland and, in particular, the downward facing direction (a term first applied by him to the direction, normal to the fold hinge-line, along the axial plane in the direction of younger beds) of the Aberfoyle antiform. The essence of the last he had deduced by Easter 1952, but complications delayed reading the paper until June 1956 and publication until 1958. This work was prompted by Shackleton's perceptive realisation of a fundamental inconsistency in the previous work, namely that major anticlines in the southern Dalradian rocks were erroneously supposed to face in opposite directions. Correcting this not only had profound implications for the study of the Tay Nappe, but the methods Shackleton introduced opened a door to their world-wide application, and showed the fallacy of using cleavage—bedding relationships to deduce way-up as distinct from the positions of fold hinges.

Shackleton's ability to detect logical error in geological mapping was remarkable, as was his energy, and dedication to field geology under almost any physical discomfort. His biggest contributions were made in the field at, or often on, the outcrop; in critical discussion after the reading of papers; in late, and very late, night discussions; and by choosing to put students on crucial areas, the full significance of which they themselves did not always appreciate. For the best students, this provided a marvellous training, but for the poorer-trained or less well-motivated student, it could be a disaster, as they were expected to teach themselves. Shackleton suggested research projects to, or formally supervised, so many postgraduate students that, with his workload, long periods of benign neglect would alternate with sessions of thoughtful cross-examination, informed suggestions, and renewed inspiration within the student. It has to be remembered that in the 1950's, the traditional PhD (in which the student completed *an entirely independent piece of work*), was rapidly being replaced by one in which instruction, guidance and regular supervision became more and more important and, in this respect, Shackleton was best as a traditional 'supervisor'.

In 1955 Shackleton started work in Spain, but although little of this was published, what was highly significant e.g. Ries and Shackleton's (1971) synthesis of the structure of the Northwest Iberian Peninsula recognised for the first time a major (>150 km of movement) folded thrust of Precambrian complexes onto Silurian sediments during the Hercynian Orogeny.

He was well known for contributing to discussions after the reading of papers by asking penetrative questions which revealed fundamental errors or by proposing alternative interpretations which the authors of the papers had usually not even thought of, still less evaluated. Of his many contributions to discussions, that of 25 May 1955 after the reading of H.H. Read and O.C. Farquhar's (1956b) paper on the Buchan anticline of Northeast Scotland was typical. In a simple, roughly-drawn sketch, he linked the overturned Huntly basic mass with the flat Cabrach-Insch body and the Haddo House and Belhelvie intrusions to provide a structural synthesis involving a single sheet of basic rock folded around the Turriff syncline and the Buchan anticline. This theory dominated work on these intrusions for two decades.

The synthesis of the broad sweep of Shackleton's British and Irish Caledonide work came firstly, in his grasp of the Tay Nappe and the recognition (with C. Kilburn and W. S. Pitcher) in 1965 of the continuity of the Portaskaig Boulder Bed from NE

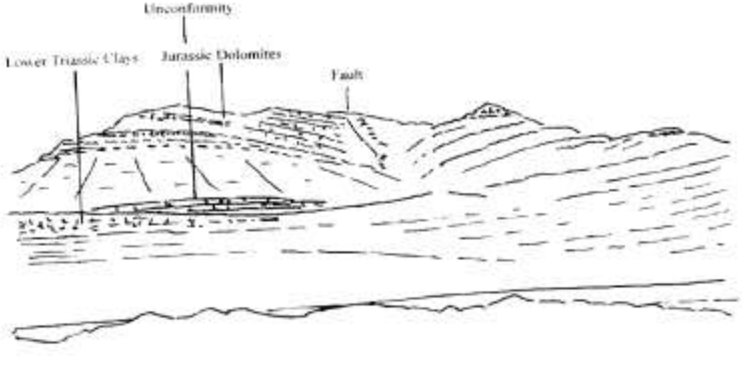

Figure 2

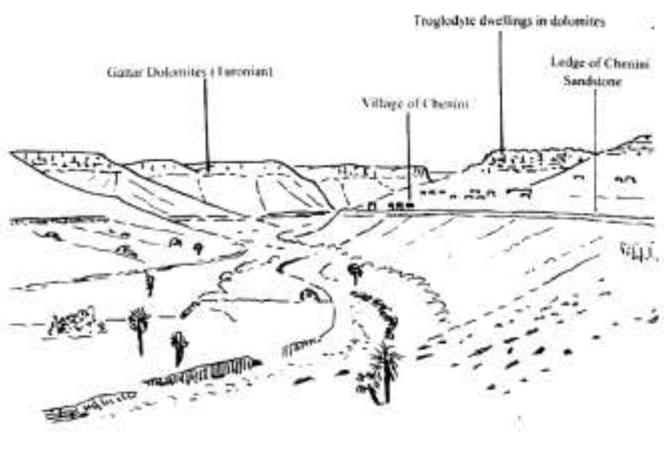

Figure 3

Scotland to Connemara, and secondly, in a remarkable paper with J. F Dewey in 1984 which linked the Caledonides and the Appalachians and in which Shackleton's detailed knowledge, accumulated over 50 years, of the British and Irish Caledonides was synthesised. Some of his work, like the study of Fanad—which was partly used in W. S. Pitcher & A. R. Berger's (1972) compilation of the geology of Donegal—was never completed. Shackleton's study of Connemara developed into the detailed mapping over long distances of very thin intricate and tightly folded successions, which was not his forte. Nevertheless his coverage of the relatively remote, high, quartzite mountains of the Twelve Bens was magnificent, and enabled the work to be eventually completed, after over 40 years, by collaboration with P. W. G. Tanner (1979).

Shackleton's forte was regional synthesis of the tectonics of substantial pieces of the crust, based on critical examination in the field of the crucial structural closures and thrusts. He had the critical insight and vision to see the problem, the dedication and physical energy to collect the evidence, the imagination to deduce the solution, and the discipline to ensure that this solution was really compatible with all the field evidence. It was not arm waving. He would go to immense pains to ensure that any apparently conflicting evidence was resolved before publication, hence the publication delays, which were sometimes exacerbated by his seeming loss of interest when the problem was solved and other problems pressed for attention or solution. He was notorious for undertaking fieldwork in new areas while still having uncompleted studies elsewhere, and for publishing little but knowing much. For instance, his work in Spain started in 1955 at a time when his uncompleted work in Rusinga Island, Donegal, Connemara, the Tay Nappe and Highland Border, and his still unpublished PhD study, all should have had priority.

In his first decade in the Chair in Liverpool, it was common to find him running from one meeting in the University to another or bounding up the stairs two, and even three, at a time to the departmental library. With his craggy face, charisma and virile figure, he inspired an astonishing number of students to become geologists, and he made the Geology Department strong in field studies; e.g. the writer spent 22 weeks in the field in a three-year degree course (16 weeks field mapping in five widely-differing locations and 6 weeks on excursions). The field classes he led were normally chosen so that they contributed to a research problem which he was working on; the spin-off to the better students was involvement in solving the problem and the knowledge that this was not another oft-repeated excursion but one where even the leader was discovering the ground. The less enthusiastic students suffered from a lack of systematic instruction. Shackleton admired Sir Edward Bailey and like him, commonly wore shorts, sped up and down the topography and appeared seemingly tireless and oblivous to the elements. Long before universities developed paranoia about safety in fieldwork, Shackleton would nonchalantly demonstrate to many what was on the 'inaccessible cliffs' marked on their maps.

He had a phenomenal ability to consume alcohol for much of the night, remain *compos mentis* but be first out in the field, and the most awake, the following morning; a proficiency that he developed much more in his later years as Professor than in his earlier ones. He was disinterested in power, wealth or possessions, quite content with a battered old car and honed by African driving, he would drive fast on rough winding roads, survive by quick split-second decisions and promote the development of steely nerves in his passengers. Considering he disliked administration, the Department was moderately well run because he supplied the vision while Dr J. C. Harper made it work, implemented the paper shuffling and acted as the frequently-needed lifeboat when absence, forgetfulness, tardy response or sheer devilish indifference precipitated a not uncommon crisis. Knowing the value of being able to undertake chemical studies of rocks, he wangled special chemistry practicals for geology students taking chemistry so that they were taught the rudiments of rock analysis by J. P. Riley, then in the Chemistry Department.

As a teacher in Liverpool Shackleton was indifferent, indeed poor, in systematic elementary instruction, as indicated above. However, at Honours and postgraduate level his illumination of the Lewisian and Dalradian rocks, the structure of the Appalachians, of the crossed orogenic-belts in Africa, the Moine thrust belt, etc. were immensely stimulating, not least because he focused on the unsolved problems raised by the facts he had outlined, usually with a geological map spread out and all grouped round.

Shackleton was unconventional in dress and habit and many stories were retold of nocturnal incidents, and others, such as leading a British Association excursion in which he and Sir Edward Bailey and a few others were so far ahead of most of the party that they were able to plunge naked into the sea and re-appear to surprise the catching-up rearguard. He was amiable and had a sharp sense of puckish humour, often prefaced by his habit of quizzically raising both eyebrows and projecting his lower lip as you spoke, and before he replied. Normally courteous and kind, as many former students have affirmed, he could be quite rude and while quick to praise good performance, he could be scathing and outspokenly critical, especially of what he considered to be untenable but also of the mediocre. He had the ability to illuminate what we didn't know and then ask for your solution in a tone that was not that of an examiner, but of someone who wanted your help and considered it possible that you might have the answer. He was instinctively permissive in his attitude and response to the behaviour of others and himself. Tall, lean, strongly masculine and possessed with renowned physical prowess, he was highly attractive to women, but constitutionally and persistently unfaithful to them. Above all, he was unbelligerently tough and dedicated to geological field-research and many stories proving this could be included. I recall him plunging naked into a mountain stream on a bitterly cold pouring wet day, at an elevation of nearly 2000 feet in Connemara, to successfully retrieve with his feet a dropped hammer in a gorge. Wallace Pitcher remembers following him with a hammer, swimming out from the base of the cliffs of Scarba to examine, naked and blue with cold, a rock in which 'worm tubes' had been reported.

The extent to which Shackleton was a penetrative original thinker outside of field geology is a matter of some difference of opinion. There is no doubt that a corollary of being a dedicated field-mapper is the belief that the answer probably lies in the field, if it can be recognised. Thus, there was a tendency to think that enlarging the area covered would provide the solution—it would always be round the next hill. Consequently Shackleton's international reputation and his renown among those who did not know him personally is inferior to many (such as Norman Bowen or Arthur Holmes) whose writings and theories have been read world-wide by many and discussed and argued about at all levels. This was partly because he was not a prolific publisher, and partly because he did not have a comparable theory

There were many good examples of longitudinal sections of these fossils packed together, and a small cave gave us a unique section into the heart of a reef. The main rib of reefal limestone here was almost vertical. A fossil collecting frenzy got under way, which higher up in the succession yielded *inoceramids* and abundant beautiful small *micraster* in friable, nodular limestones.

1 October

The night was spent at Sbeitla, the Roman city of Sufetula, which was then, and still is, in the centre of a rich olive growing region. The site and museum opened at 7.00 am so that an early start was possible. This is a stupendous site with magnificent remains, particularly the paved forum with its three temples of the second century AD towering over the site, entered through the Antonine Gate; the remains of an oil press; some beautiful mosaics in the baths and temples, and the triumphal Diocletian arch at the entrance to the city.

From Sbeitla a chain of mountains runs NNE-SSW, part of the Atlas suite of Alpine orogeny. The mountain edge is marked by the Cretaceous/Tertiary unconformity. While some engaged in fossil collecting (bivalves, ammonites, gastropods, echinoids, oysters), others followed a fairly strenuous up and down trail for a kilometre or two southwards into the Fahdene beds (Cenomanian).

Running parallel are the Bireno limestones (Turonian, Aleg Formation) forming a sharp ridge steeply dipping south. A small Roman quarry here provided a convenient gap through the ridge. This quarry provided rock for a Roman aqueducts scheme, remains of which could be seen below, unfortunately recently ruined by a modern irrigation scheme. There were dense accumulations of oncolites (rolled algal accumulations) in the Bireno beds here. The walk terminated with a superb view westwards over a spectacular unconformity at the mountain edge with the plain acting as a backcloth. Oligocene/Miocene beds (Fortuna Formation) lie at a high angle of dip upon Cenomanian rocks, so that the whole of the Campanian and Maastrichian is missing here, as well as the Palaeocene and Eocene.

Over forty sites had now been visited in fourteen days and our last day ended in the area around El Houareb, where there has been extensive quarrying of the massive dolomites of the Nara Formation, which in central Tunisia makes up most of the Jurassic. So much quarrying in fact has taken place that a series of low hills between the plain and us has been completely removed. A fine roadside section here provided an appropriate background for a photograph of our two leaders.

means of a 2metre high causeway, built originally by the Romans. From it, there were several mirages shimmering in the heat. The absence of recent rain allowed us to walk over the surface to study the evaporites deposited under sabkha-type conditions. The leader dug a trench through the upper alluvial layers to show us the underlying salt. Ignoring the 'camels' apparently turned, like Lot's wife, into salt for the benefit of tourists, we walked across the surface noting the well developed salt polygons and tepees -the salt lifts up forming long sinuous hollow ridges or circles.

At end of causeway, looking north were a number of mountain ranges running W-E where the folded rocks have been twisted round parallel to the margin of the Saharan platform. The route took us up into this mountain edge, arriving at a view on the mountain road approaching Tamerza on the southern boundary of the mountain range. The edge of the mountain front faces over the Chott plain. The steeply dipping rocks can be seen in places to have been back thrusted over themselves. Inland, there was a view of so-called 'chevron folds', which were in fact steeply dipping, almost vertical, gullied strata, highly misleading at first sight, a textbook example of the influence of relief on structural outcrops.

The ranges are cut by a number of fantastic gorges such as the one at Chebika, 16 kilometres south of Tamerza, a region made famous by the film 'The English Patient'. This Berber village along with the two others was destroyed in a three-week period of torrential rains in 1969, and now the remains stand deserted, a remarkable 'ghost village'. As a result of the extraordinary stresses resulting from the Alpine movements, in the sides of the gorge were spectacular vertical beds, thrusts, cut-outs, and overfolds. From the higher reaches of the gorge was a spectacular view of the Senonian/Eocene unconformity.

30 September

Overnight was spent in the oasis town of Tozeur. In this region a common sight were steam vents venting from hot water artesian wells below, and soon after leaving, we stopped to investigate one with a cooler.

Travelling northeast, we crossed the WSW-ESE Gasfa Fault, and it could be seen that the structures had swung round to either a NNE-SSW or N-S alignment. Above the Sidi Khalif beds, are the steeply dipping (to the north) Meloussi Formation deposited in a shallow marine shelf. A very rough road took us up into the mountain ridge into the Boudinar Formation, with cross bedded sands representing fluvial conditions with braided streams.

On the way to the next ridge, we then crossed a large ancient dry agricultural plain, with scattered farms and hamlets and their characteristic flat-roofed, windowless, clay or stone houses. Children came running out to greet us as we passed. A notable crop was the huge prickly pear cactus, which grows up to several metres high and is used for hedging as well as for its fruit. Heaps of tobacco leaves lay drying on the fields.

In the Djebel Merfeg on the southwest flank of Djebel Kebar,we stopped to study reefs of the Merfeg Formation (Campanian-Maastrichian) with spectacular rudistids, large coral-like, aberrant lamellibranchs (including *Hippurites* and *Vaccinates*), aboresecent accumulations acting as sediments traps and reef builders.

to propound rather than a series of, albeit important, solutions to particular crustal situations. Gravitational sliding, e.g. as a mechanism for emplacing the Tay Nappe, seemed at one time to interest him so much that he might have developed the theory in some detail because of its probable wide application in tectonics, but the latent possibility never came to fruition, nor did another interest, in how crossed-orogenic belts developed. Shackleton's main influence was by word of mouth in the field following his discernment of some crucial feature, overlooked or not even looked-for by others, which enabled critical interpretation of the structure.

In 1962, at the age of 53, Shackleton resigned from his position at Liverpool to become Professor of Geology in the University of Leeds and in the Research Institute of African Geology, which W. Q. Kennedy headed. With Kennedy's retirement, in 1965, Shackleton became the Professorial Director of the Institute until he too 'retired' in 1975. The call of Africa and the opportunity to be funded for field work there was what had attracted Shackleton to Leeds, rather than the well-established Department that it was with three coursework MSc's (geochemistry, geophysics and engineering geology), isotopic facilities, a large undergraduate and postgraduate enrolment and substantial accommodation. Shackleton, who was also departmental head, introduced staff meetings, was always approachable and amiable and got on very well with the students who responded to his informal manner. He led a vigorous programme of field research in Africa, particularly East Africa, with structural studies across orogenic belts in Tanzania, Zambia and Malawi; major studies across the Limpopo Belt and the Archaean greenstone belts of Zimbabwe, Botswana and South Africa; and later, post-'retirement,' worked in Egypt, Sudan and Kenya again.

Shackleton was not one for small talk or chatting up Directors of Geological Surveys in smart, comfortable offices. He would arrive from an overnight flight ready and dressed for field work, and expect to be out looking at the rocks as fast as possible, and for as long as feasible, providing an inspiration to those who had slogged away for months or years in the bush. However, he did not have the industrial fund-raising and business abilities of Kennedy, who had obtained substantial funding for the Institute, albeit initially through his chance meeting on an aircraft of Sir Ernest Oppenheimer. About 1970, when the funding of the Research Institute was due to be renewed by Anglo-American, the company representative was alleged to have gone back to London with the cheque still in his pocket and the 70's saw the Institute decline financially. Also, as bureaucracy spread in the Universities, he became less effective as a Head of Department—too often away in the field doing research and even when in the University, his interest was not in committees, answering letters, manipulating returns, (even his *Who's Who* entry contains errors) or in wielding power, but in being a research professor, which is what he became when he passed the headship of the Leeds Department over to Peter G. Harris in 1969. Harris continued until Shackleton attracted John G. Ramsay to Leeds in 1973.

From the late 1960's Shackleton attained almost guru status, exemplified by the number of younger geologists he attracted, almost like a honey-pot, to long, semi-liquid, late night and early morning discussions after the formal meetings of the Tectonic Studies Group. In a sense, his lack of identification with any one theory increased his popularity with the young, as his responses were far less predictable than those of most men of his age. Shackleton was always open to new ideas. His immense experience of having *perceptively* seen so many rocks in so many different places from the Arequipa Massif in Peru (Shackleton *et al.* 1979), the Precambrian of Brazil, the Caledonides and the Variscides in Europe, innumerable East and Southern African Precambrian and volcanic complexes, to the rocks of the Himalayas and Fiji, made him an icon of *investigative field geology*, and gave him an authority of speaking about rocks in the field that no other British geologist has matched since the death of John Walter Gregory in 1932.

During his last 25 years, Shackleton became more and more insistent, and despondent, that Government bureaucracy, 'accountability' and the need to apply for research grants to obtain the resources to do even modest research projects, had ruined the spontaneity needed for much of the best research, and had trapped scientists into time-wasting grant application production rather than doing research, while at the same time limiting the resources actually available for research because of the expense of supporting an ever-increasing bureaucracy.

In 1970 Shackleton was awarded the Murchison Medal of the Geological Society "as an outstanding structural geologist whose influence in published work is immense but in personal inspiration goes far beyond publications" (George, 1970). Shackleton's reply is one of the few written records illustrating his sense of humour: "I may at times have seemed flippant—indeed one of your predecessors in the Chair once took me aside after a meeting and asked if I was drunk—in my efforts to deflate what I felt to be the excessive formality of the discussions"(In George, 1970). Much better known was his verbal summary of Derek Flinn's (1962) classic paper on three dimensional deformation of rocks: "Dr Flinn's attitude to folding was that simple shear was simple nonsense and pure shear was pure nonsense" In 1970-1 he was Royal Society Leverhulme Visiting Professor to the Haile Sellassie I University in Ethiopia, which gave him access to the northern part of the Rift Valley and the Afar Depression. Eventually, in 1971, his immense research contributions were recognised by election to a Fellowship of the Royal Society.

Although Shackleton formally retired in 1975, he continued researching as vigorously as ever. Through his links with Ian G. Gass, he became an Honorary Research Professor and then a Fellow of the Open University. During the late 60s, the 70s and into the early 80s, he was closely associated with Alison C. Ries and then also with Michael P Coward, e.g. in unravelling the Variscan structures in Southwest England (1982). Ries and Shackleton, with others (1983), recognised late Precambrian ophiolites and ophiolitic melanges and outlined the overall structure of the Eastern Desert of Egypt, as part of an ambitious project to test the island-arc accretion models of Gass and Shackleton.

In his 70s Shackleton took up windsurfing off East Africa, and at the age of 76 years he was joint leader of a traverse in Tibet, which because of the high altitude, caused some of the party to be evacuated to lower elevations, but he continued, oblivious and seemly indestructible in his climbing and enthusiasm for examining the rocks. In his late 70s he was a Visiting Professor at Imperial College (1985-7). In his eighties he continued working on the map collections in the Geological Society but was increasingly hampered by his declining eyesight, including double cataracts, which he had removed. His last project was as ambitious as ever, being the compilation of a sheet of the Structural Map of the World for Northeast Africa, the Saudi Arabian Peninsula and Southern Iran which he was unable to complete. He found more time for art, music and gardening in later years. It is unlikely that we

wind and much blown sand across the 'road' caused the drivers difficulties, which they overcame very skilfully.

At one locality, leaving the vehicles on the plain, the party stepped, almost literally, onto the mountain front and made its way up into a gulley cut into alternating limestones and shales. Here the evaporites yield superb quartz geodes of museum quality broken from a bed in the upper part of the gully and washed down by floods.

The drive continued and eventually we reached our furthest point south in the country, with a spectacular view over the great sand sea, and a photo opportunity of our drivers standing in front. Here was the oasis of Bir Tieret adjacent to the huge dunes.

One locality on the edge of the sand sea had been for days held up before us like a carrot, Ross counting down the kilometres with the aid of his GPS. It made one realise that before such days of satellite navigation, geologists would presumably have had to erect a series of siting poles for triangulation or even fall back on the techniques of ocean navigation. At this famous spot, fossil dunes have been locally stripped away to reveal myriads of beautiful desert roses *in situ*, lying loosely on the ground. Here is a former playa lake, the site of early hominids. The lake oscillations are shown by anhydrite layers. There is much evidence for early man with lakeside dwellings and remains of fires. Many worked chert flakes and cores were found on the surface (perhaps 15 000 BP) and one member found an arrow head.

28 September

After a night spent at the company's 'motel' in a desert pumping station, the long drive back towards the north commenced. There were beautiful views all round, with isolated hills in the Upper Limestones sitting on the ochreous beds. Late afternoon brought us to the remarkable oasis of Ksar Ghilane, a former Roman desert outpost. Hot springs bubble up feeding a small pool shaded by tamarisk trees, while date palms provide shelter for a variety of fruit trees and vegetables. Camels, horses, cafes, shops with stacks of desert roses outside, and some very basic tent 'hotels' serve the tourists arriving in their four-wheeled drives. Impressive barchan dunes stretch out to the western horizon, the edge of the Grand Erg Oriental. The journey from here was long and arduous driving over and through sand dunes swept across the road by the storm.

29 September

Overnight was spent at Douz, the gateway for tourists into the Sahara. In the early morning on the edge of the desert dozens of camels waited for custom, and if one was uncertain about risking the rocking motion, there was always the opportunity of riding a sand buggy or going hang gliding. There is an enormous palmeraie here sheltering a variety of vegetables, and it is the availability of artesian water which has made cultivation possible in such places. From such green oases in Tunisia come some of the finest dates in the world.

From here we drove northeastwards into the region of the Chotts and onto Chott Jerid, an immense salt lake, almost 5000 square kilometres. One crosses it by clays and sands. They were mantled by great screes and gullies, relics of a period with a much different climate.

A long drive southwards took us to the completely isolated legionnaire-type fort and prison of Borj Bourghiba. White against a blue sky, visible from miles away, it stands on a mesa, a residual fragment of a resistant unit resting on red claystone of the Aleg Formation. We were now above the Gaattar dolomites for the first time.

Driving south there is an almost imperceptible climb up the succession from Turonian to Upper Maastrichtian marked by a series of low ridges divided into several lithological units, including algal limestone laminates, gastropoidal faunas, banded dolomites, and cinder beds. The highest scarp was particularly distinctive above a featureless plain. From it could be seen extraordinary ring structures, circular to ellipsoidal folds either synform or antiform, and of problematic origin. They have been interpreted as possible giant tepee structures and even impact craters have been suggested, but not with much conviction. Typically, they are 85-125metres in diameter.

Arriving at our desert camps, the superb facilities provided by CGG were waiting for us - 2-4 person tents, mobile kitchen, toilets, showers and a terrific staff. Our dinner table (with wine) was waiting for us, laid out under floodlights. Beyond, the desert stretched away into the night under a myriad of stars.

26 September

We drove north, the road following convenient tracks and seismic lines descending into an alluvial plain. Here an anticlinal structure, the Sanhra anticline, may be superficial, disconnected from the Saharan platform which forms a stable plate below. It may be due to the reactivation of very ancient faults. The base of the Upper Limestone is marked by a conspicuous marker bed, an ochreous claystone at the foot of the scarps with talus in front.

A diversion was made to visit to a single isolated nodding donkey, a low production well. Although exploration for petroleum in Tunisia commenced before the first world war, the first discovery was not made until 1964 at El Borma in the far south near the Algerian border. Tunisia's deposits are much smaller than those of its larger neighbours and production is not sufficient to prevent it being a net importer of petroleum products.

There followed a long journey across a sandy and rocky plain, The superficial deposits include wind-blown sand and small dunes, gravel plains, recent fluvial sands, and *croute*, a recent semi-lithified to indurated breccio-conglomerate. Occasionally, small groups of camels could be seen wandering about. Although in the middle of nowhere, these must have belonged to someone as apparently there are no wild camels in Tunisia.

27 September

We had a disturbed night with a huge sandstorm and the tents flapping all night. An early start to the south took us up to highest beds on the platform. Strong

shall see again such extraordinary intellect, enthusiasm, and physical energy combined with such extensive and perceptive field experience, as field geology becomes displaced by satellite, laboratory and computer studies. He used to say he belonged, not to the computer or typewriter ages, but to the pre-typewriter age; others said he had a streak of the Precambrian in him which in part reflected his emphasis on retaining the fundamentals of all Earth Science; field geology.

Shackleton became a member of the Geologists' Association in 1934, the Geological Society of London in 1938 (Vice President 1966), and was elected to the Royal Society in 1971. Fittingly, he was awarded the Clough Medal of the Edinburgh Geological Society in 1975.

Shackleton was three times married and twice divorced, and had five children. With his first wife, Gwen Isabel Harland, whom he married in 1934, he had Nicholas, (later knighted and FRS), Annabel and Penny; with his second wife, Judith Wyndham Jeffreys, whom he married in 1949, he had Jason and Chloe. There were no children of his third marriage in 1984 to Peigi Gwendoline Margaret Wallace who survived him by only 13 days.

I acknowledge with thanks information and assitance from Adrian Allan, University of Liverpool Archivist, Joseph D. Crossley, John F. Dewey, Joseph McCall, Wallace S. Pitcher, Alec F. Trendall, Michael P. Coward, John C. W. Cope, John W. Leake, Wes Gibbons, Richard J. Howarth and those who wished to be anonymous.

REFERENCES

Dewey, J. F. & Shackleton, R. M. (1984). A model for the evolution of the Grampian tract in the early Caledonides and Appalachians. *Nature*, **312**, 115—121.

Flinn, D. (1962). On folding during three-dimensional progressive deformation. *Quarterly Journal of the Geological Society*, **68**, 385—433.

George, T. N. (1970). Presentation of the Murchison Medal to R. M. Shackleton. *Proceedings of the Geological Society of London*, 1664, 270-271.

Greenly, E. (1919). The Geology of Anglesey. *Memoirs of the Geological Survey*; HMSO, London.

Holland, C. H. (ed) (2001). *The Geology of Ireland*. Dunedin Academic Press, Edinburgh, 531p.

Kilburn, C., Pitcher, W. S. & Shackleton, R. M. (1965). The stratigraphy and origin of the Portaskaig Boulder Bed Series (Dalradian). *Geological Journal*, **4**, 343—360.

Matley, C. A. (1928). The Pre-Cambrian complex and associated rocks of the south-western Lleyn (Caernarvonshire). *Quarterly Journal of the Geological Society of London*, **84**, 440-504

Pitcher, W. S. & A. R. Berger (1972). *The Geology of Donegal*. Wiley-Interscience, London, 435p

Ries, A. C. & Shackleton, R. M. (1971). Catazonal complexes of NW Spain and N. Portugal: remnants of a Hercynian thrust plate. *Nature, Phys. Sci.* **234**, 65—68.
Ries, A. C., Shackleton, R. M., Graham, R. H. & Fitches, W. R. (1983). Pan-African structures, ophiolites and mélange in the Eastern Desert of Egypt: a traverse at 26°N. *Journal the Geological Society*, **140**, 75—96.

Shackleton, R. M. (1940). The succession of rocks in the Dingle Peninsula, Kerry. *Proceedings of the Royal Irish Academy*, **46B**, 1—12.

Shackleton, R. M. (1951). A contribution to the geology of the Kavirondo Rift Valley. *Quarterly Journal of the Geological Society of London*, **106**, 345—392.

Shackleton, R. M. (1954). The structural evolution of North Wales. *Liverpool & Manchester Geological Journal*, **1**, 261—297. [Presidential address to Liverpool Geological Society]

Shackleton, R. M. (1956) a. Notes on the structure and relations of the Pre-Cambrian and Ordovician rocks of South-Western Lleyn (Caernarvonshire). *Liverpool & Manchester Geological Journal*, **1**, 400—409.

Shackleton, R. M. (1956) b. Discussion in Read, H. H. & Farquhar, O. C. The Buchan anticline of the Banff nappe of Dalradian rocks in North-East Scotland. Quarterly *Journal of the Geological Society of London*, **112**, 131—156.

Shackleton, R. M. (1958). Downward-facing structures of the Highland Border. *Quarterly Journal of the Geological Society of London*, **113**, 361—392.

Shackleton, R. M. (1959). The stratigraphy of the Moel Hebog district between Snowdon and Tremadoc. *Liverpool & Manchester Geological Journal*, **2**, 216—252.

Shackleton, R. M., Ries, A. C., Coward, M. P. & Cobbold, P. R. (1979). Structure, metamorphism and geochronology of the Arequipa Massif of coastal Peru. *Journal of the Geological Society*, **136**, 195—214.

Shackleton, R. M., Ries, A. C. & Coward, M. P. (1982). An interpretation of the Variscan structures in SW England. *Journal of the Geological Society*, **139**, 535—544.

Tanner, P. W. G. & Shackleton, R. M. (1979). Structure and stratigraphy of the Dalradian rocks of the Bennabeola area, Connemara, Eire. In: Harris, A. L., Holland, C. H. & Leake, B. E. (eds) *Caledonides of the British Isles—Reviewed*. Geological Society, London, Special Publications **8**, 243—256.

Bernard Elgey Leake

centuries the inhabitants of these regions have scraped together a living from such dry-land farming techniques.

23 September

Returning north of Ksar Haddada, first thing in the morning, an unscheduled stop was made by permission of the Governor to a dinosaur locality discovered by our leaders Dick and Ross. A level hilltop of Chenini Sandstone was covered with desert varnish fragments. Two life-sized model Iguanodons on top of the hill added a rather bizarre note to the scenery.

Staying at this stratigraphical level, the next locality was in cross-bedded sandstones below the Gattar dolomites (Turonian). This was described as the best dinosaur locality, for dinosaur fragments were washed downstream from the Saharan platform and are now found in friable sands and abandoned channel clays below. Sharks teeth were also found - our leader pointing out that they then swam up the rivers as they do in Australia today. There were large chunks of fossil wood lying around at this locality - a broken-up tree.

ENE of Tataouine just west of the village of Kirchaou, thick evaporites of the Bhir Formation (Lower Jurassic) outcrop. They are mainly sabkha-type deposits of gypsum and banded chicken-wire anhydrite which have built up from the top of the Triassic into the base of the Jurassic. Further east, south of Smar, a site in the Ouled Chebbi Formation (Middle Triassic), is a sequence of fluvial deltaic clastic rocks, capped by small barchan dune surface deposits. Below the Saharan platform these rocks represent the main reservoir rocks for hydrocarbons.

24 September

Arrangements to leave for the desert safari were postponed owing to unforseen difficulties with documents at the checkpoint. The opportunity was taken to visit Douiret, a former Berber village, once about 3 kilometres circumference with circa 5000 people, dating from around 500 AD. As at Chenini, the houses are built into the clay beds along terraces contouring round the hill. It has been partly refurbished by a local conservation group - the 'Centre international de recontres et d'etudes de Douiret'

A 3 dimensional diagram of the region, displayed to the party by Prof Habib Belayouni, set out clearly the stratigraphy of the region we had been studying and provided a useful recapitulation before we passed next day upwards into the Cretaceous succession on the Saharan platform.

25 September

After splendid piece of negotiation by our host Jean-Marc Houssaye, the resident manager of CGG in Tunisia, we were able to leave Tatouine about midday, a day later than originally planned, to climb up onto the Saharan platform immediately south of Remada, where the fault-bounded front rises almost vertically out of the Jeffara plain. The top of the platform is marked by wonderful isolated mesas of the very distinctive massive Gattar dolomites up to 80metres thick with underlying red

red shales of the Mastoura Formation, overlain unconformably by horizontal Jurassic dolomites marked the front of the Saharan Platform. The contrast in dip was notable (Figure 2). The clays are quarried and used locally for brick making for housing.

Further west from Medenine lies the Djebel Tebaga a WSW-ESE trending mountain range capped with a broken ridge of biohermal limestones over 100m thick. A fault bounded pass through this ridge providing a unique section in this Upper Permian strata.

The hills west and south west of Tataouine and Medenine have long been the centre of Berber culture, ever since those tribes were driven from the Jeffara plain by the Hilalian invasions of the 11th century .We visited Ksar Hallouf, a Berber hilltop village. A Ksar is a fortified village and granary almost always on a hilltop in a natural defensive position. The distinctive *ghorfas* or long, narrow vaulted cells are built in rows three or four storeys high to form a stockade around a central courtyard. Just north of the village a 300-400metre scarp marks the boundary fault between the Jeffara Plain and the Saharan Platform.

22 September

The excursion was very generously supported by CGG (Compagnie Generale Geophysique Tunisie) who were to provide the camping facilities in the desert,, and the opportunity was taken to visit their HQ near Tataouine to see the highly impressive seismic survey equipment, $100million worth we were told. Particular interest was shown in the huge mobile vibrators (150hertz), whose working methods along seismic lines up to 70 kilometres in length were explained.

Just south of Tataouine on the way to Chenini, an unscheduled stop was made to a locality underneath the Gattar member (Lower Cretaceous) with superb plant remains, ferns and the gymnosperm *Ginkgo*. Near Chenini, deep valleys have been cut into the Chenini escarpment revealing details of the Cretaceous succession (Figure 3). The Chenini Sandstone (Lower Cretaceous) forms a distinctive horizontal ledge below a great escarpment capped by Turonian dolomites of the Gattar Member (Zebbag Formation). The coarse sandstones are cross-stratified into superb truncated sets, representing fluvio-deltaic conditions. The party enjoyed themselves seeking out the liberal fragments of fossil wood, crocodile, freshwater fish, and dinosaur bones.

Chenini village is the best known of the Berber villages. The houses are cut out of the shales underlying the dolomites which provide, literally, the roof rock. Above, are the caves of the Berber troglodytes. Another fortified village, Ksar Haddada which was also visited, was used for Star Wars IV. It was no longer a hotel, and was in rather a distressed condition. Just to the north of the village, a roadside stop gave a view into a deep wadi showing a section of well developed biohermal mud mounds with quaquaversal dips deforming the surrounding strata, typical of the Middle Jurassic Upper Ghoumrassen Member (Tataouine Formation).

A common feature of the arid landscape around these and other mountain villages in south and central Tunisia are ancient dams of rough stone walls built across watercourses and backfilled with soil. A pocket of land is thus able to benefit from any flow of water from seasonal rains. The water is held up by the dam and soaks down through the soil before flowing on to the next dam downstream. For

OBITUARY: MICHAEL EAGAR, 26th NOVEMBER 1919 – 19th FEBRUARY 2003

By John R. Nudds

Richard Michael Cardwell Eagar was born in November 1919 at Thornhill near Wakefield. He attended Aysgarth and Shrewsbury schools before winning a place at Magdalen College, Oxford, to read Classics, switching to Geology halfway through his course.

The outbreak of the Second World War was suddenly to rewrite the script of his life; whilst in an army camp at the age of 21 he caught cerebro-spinal meningitis and, although lucky to live, was left permanently and totally deaf. Michael Eagar was a fighter and in the words of his son, "he wasn't going to let his sudden isolation put him in the background". After gaining a First at Oxford he moved to Glasgow where he worked under A.E. Trueman on the non-marine bivalves of the Upper Carboniferous, being awarded a PhD in 1944.

In October the following year he joined The Manchester Museum as Assistant Keeper of Geology, (succeeding Dr J. Wilfred Jackson who had held the post since 1907), his title being changed to Keeper in 1957. Michael held this post for 42 years, eventually retiring in July 1987, although often later bemoaning that had he realized that his contract allowed it, he would have stayed until September!

For all of this time Michael developed his research on freshwater mussels, working initially in northern England, then in South Wales and Ireland, extending into Western Europe (Spain and Portugal) and eventually to North America, becoming the world expert in this important field.

In the years immediately after World War II, when Britain was rebuilding her industrial base, an accurate knowledge of the Coal Measures stratigraphy was vital to the exploration of sufficient coal to fuel those industries. Freshwater mussels were clearly very common in these rocks and because of their rapid evolution, different species were confined to narrow zones within the coal-bearing strata of the Upper Carboniferous. It was clear that they were the key to the understanding of the stratigraphy that could facilitate the correct identification of the richest coal-bearing strata. But the different species were so similar and seemed to merge into one another, that specific identification was difficult.

Eagar pioneered the use of the "pictograph" in order to unravel the systematics of this fauna. The pictograph is constructed initially by placing the varying lateral profiles of shells in lines or series which demonstrate gradual change in one or more characters, such as height/length ratio or degree of curvature of the ventral margin. In any series of variable shells, one or two shells will be found to be common to several series, with the result that crossing of the series takes place as arrangement proceeds. The common shell at the crossing is the norm, the centre or focus of the variation. It is likely to be relatively small and without strong features.

Common trends in variational direction bring series into proximity with one another, so that morphological intermediates can be found places between these series.

By these methods the systematics of the freshwater mussels was unravelled and a series of zones and subzones was established, especially within the Westphalian Series, in which the different species of *Carbonicola, Anthraconaia, Anthracosia* and *Anthraconauta* were used in coal exploration to identify the precise position within the Upper Carboniferous succession.

Eagar's name became synonymous with non-marine bivalves and with The Manchester Museum where his collection now comprises approximately 20,000 specimens including more than 500 status specimens. From 1976 to 1977 Michael was also Acting Director, and from 1977 until his retirement, was Deputy Director of The Manchester Museum.

Michaels' retirement did not mean the end of his research. Right up until his death he continued to publish new research; his final paper (his 101st, and which he had promised us all would be his last!) will be published in the next issue of *Geological Journal* and is a monumental work, in many ways a summary of his life's work.

But Michael will be remembered for much more than his research and for his huge contribution to the University of Manchester. He was the archetypal University eccentric, absent-minded and totally engrossed in his current research, and many anecdotes are related, most of which seem to include an enormous bunch of keys. He was also a charming man and a warm man, full of respect for others and respected by all in return. His particular sense of humour is evidenced by his own parody of Carroll's *Father William*:

"You are old, Dr Eagar, a student can tell,
And your hair has become very white.
Yet you work all the day and the evening as well,
And they say you work much of the night."

"In my youth, I replied, I examined with care
The dark life of the freshwater clam.
I measured each shell when I came up for air,
And then had it on toast with smoked ham."

Michael received many honours for his work including awards by the Daniel Pidgeon Fund (1943) and the Lyell Fund (1952) of The Geological Society, the Silver Medal of the Liverpool Geological Society (1962), the John Phillips Medal of the Yorkshire Geological Society (1970) and the degree of DSc from Glasgow University (1969). He was made a Life Member of the Manchester Geological Association.

He is survived by his wife Enid, their two children, Richard and Jennifer, and by four grandchildren.

(I am indebted to Michael Bishop's article published in *The Geological Curator*, volume 4, 1986, and to his son Richard for providing additional information.)

TUNISIAN GEOLOGY
9 September-2 October 2002

Derek Brumhead

Two leaders and 18 members set out very early from Heathrow on this two-week excursion to Tunisia, with the promise of a four-day safari camping in the desert in the south of the country not normally open to tourists. Professor Richard Moody and Ross Sandman were the leaders, aided in Tunisia by Professor Habib Belayouni. By early afternoon (having travelled *via* Zurich), we were installed in the luxurious surroundings of the Golden Tulip hotel in La Marsa, near Tunis.

Friday 20 September.

Mid-morning, a short walk from the hotel took us to a viewpoint looking across the Bay of Tunis to Cap Bon. With the aid of a large geology map of the country, the leaders summarised the main structural terrains of Tunisia. The mountain chains of northern and central Tunisia, running SW-NE and swinging round to W-E in the south, are part of the system of Alpine fold belts which surround the western Mediterranean. They were formed as they were carried south on the European plate and rammed up against the ancient stable African plate. In the south of the country, the Saharan platform, with which the field excursion would be particularly concerned, is a flat plateau dipping gently to the south-west where it is overlain by dunes of the Grand Erg Oriental. It is underlain by Pre-Cambrian and unfolded Palaeozoic strata, the succession known from the many oil wells drilled since before the first world war.

Part of the afternoon was spent inspecting Carthage, and in some ways, this most famous Phoenician-Roman site of all is sadly disappointing. The ancient city is broken up into a dozen or so sites scattered among the villas of the affluent Tunis suburbs. The baths of Antonius, on the edge of the sea are probably the most dramatic of all. A poignant site nearby is the Tophet, a cemetery for sacrificed children. At the end of the day, the party took a short flight to Djerba on the island of the Lotus Eaters south-east of Tunis.

Saturday 21 September.

In the morning a caravan of six four-wheel drive vehicles were waiting for us outside the hotel and these were to be our mode of transport, together with the drivers, for the rest of the trip. With only three plus the driver to each vehicle they were very comfortable and indeed they needed to be, when in the southern desert we travelled long distances at high speed over corrugated gravel 'roads', and the vehicles slid and rolled over drifted sand in the hands of the skilled drivers. As we drove south over the huge flat sandy Jeffara plain, an enormous area opened out under olive cultivation, the trees in neat rows seeming to go on for ever.

The Triassic outcrops in the southwest of the Jeffara plain are the only surface outcrops of this age in Tunisia, other than diapiric gypsum extrusions in the north. At a locality immediately north-west of Medenine are folded Lower Triassic laminated

Miller, C.D.	1990	Book Review: The MacMillan Field Guide to Geological Structures by Roberts	13	ii	71
Treagus, J.	1990	M.G.A. Field Excursion to Tyndrum Perthshire	13	ii	73-76
Prior, I.	1990	M.G.A. Field Excursion toSouth-West Langdale	13	ii	77-78
Spencer, J.	1990	M.G.A. Field Excursion to Ravenstondale	13	ii	78-79
Broadhurst, F.	1990	M.G.A. Field Excursion to Fletcher Bank & Scout Moor Quarries, Ramsbottom	13	ii	80-82
Anon	1990	Proceedings of the L.G.S. 1987-88	13	ii	83
Anon	1990	Proceedings of the L.G. S. 1988-89	13	ii	84
Anon	1990	Proceedings of the M.G.A. 1988-89	13	ii	85
Brumhead, D.	1990	In Memoriam: Philip Dagger	13	ii	87

Dr John R. Nudds, Keeper of Geology, The Manchester Museum

A NOTE ON THE THORNSETT HEY COAL TUNNEL, NEW MILLS

by Derek Brumhead

The rocks in and around New Mills consist of the Lower Coal Measures, with five named coal seams although only two were worked - the most common was the Yard Mine, so named from its average thickness, and the less important Red Ash (Little Mine). Shale is the dominant rock often forming the roof of coal seams and a common constituent of spoil heaps adjacent to former pits or tunnels. Below the Yard Coal, the Woodhead Hill Rock, thick sandstone, forms the sides of the Torrs, at New Mills, a spectacular gorge 30m deep cut by the rivers Goyt and Sett.

The rocks are disposed in a major geological structure known as the Goyt syncline, an elongate basin with a longitudinal axis trending south north for several miles from the Roaches in north Staffordshire to Cown Edge near Glossop. Variations in the depth of the coal seams result from the inward dip of the strata in the syncline and from a number of faults. For instance, on Ollersett Moor, the Yard Coal was found at Burn'd Edge Colliery No 4 at a depth of 66 feet, whereas a few hundreds yards to the south, because of an intervening fault, the same coal was found in Burn'd Edge Colliery No 1 at a depth of 396 feet. There are other interesting effects of the faulting, as this note will show.

Although coal mining started in Elizabethan times and continued through to the industrial period, the heyday of coal mining in and around New Mills was approximately the mid - late nineteenth century. But from the mid-l880s, mines began to close and with one or two exceptions the mines had ceased production by the first decade of the twentieth century. The thin seams, the poor quality of the coal, and the competition by rail from the larger coalfields were in themselves sufficient to ensure the limited life of the New Mills coalmines. But what also contributed was the fairly rapid exhaustion of workable coal due to the methods of working arising from the thin seams. The mine abandonment plans (New Mills Library has a complete set of 40) show that the general method of working was the pillar and stall method, by which the seam was honeycombed with a grid network of tunnels from which the coal was taken, separated by pillars of coal left to support the roof. This was wasteful of coal since as much, if not more, coal, was left underground as was extracted. Some local mine plans show that the pillars of coal were robbed by working backwards from the mining boundary once it had been reached.

In July 2002, a hole in a field adjacent to Ladygate Brook about ¼ mile north of Bate Mill near the hamlet of Thornsett proved on investigation to be the lost entrance to the 750 yard-long Thornsett Hey coal tunnel, known previously only from the mine abandonment plan. It was constructed in the early 1870s to bring coal out of a mine (known as Cave Adullam (sic) or Broome's Pit) beneath Broadhurst Edge, and the shale spoil was dumped in a field next to Bate Mill (Figure 1). From the tunnel exit a horse tramroad took the coal to a wharf on Bate Mill Road, now the site of a children's play area (Figure 1). The owner of Thornsett Hey Farm, on whose land the tunnel is, contacted the Coal Authority who arranged for a firm of consulting engineers to fill in the tunnel entrance and make it secure, and he invited me to be present. A JCB broke open the entrance to reveal a fine tunnel lined in stone

Miller, G.D.		God Bless all Badgers! Or Arnold-Bemrose Vindicated?	10	i	32-35
Elder, J.	1982	Mining Hot Water	10	ii	3-10
Broadhurst, F.M.	1982	Geology in Vernon and Woodbank Parks, Stockport	10	ii	11-15
Adams, A.E. & Nicholson, R.	1982	Geology of Majorca	10	ii	16-26
Wilson, P.	1982	Quartz Sand Surface Textures from The Triassic Sandstones of Southwest Lancashire	10	ii	27-32
Tresise, G.R.		Geology and Wine in Western Europe Part 2 Germany, Spain and Portugal	11	i	3-9
Brumhead, D.		Field Excursion to the Goyt Syncline	11	i	10-15
Draper, A. & Walters, G.		Geology in the Tame Valley	11	i	16-22
Brumhead, D.		The Geology Around Haweswater and Bampton: A Field Excursion led by Dr. M.J.C. Nutt (I.G.S.) for the Manchester Geological Association, 17-18 September 1983	11	i	23-28
Miller, G.D.		Field Guides, Old and New	11	i	29-30
Anon		Index to Volumes 6-10	11	i	30-32
McMillan, N.F. & Zeissler, H.		The Tufa Deposit at Caerwys, N. Wales And its Molluscan Fauna	11	ii	3-11
Hunt, N.C.		Alternative Mechanisms of Deposition of the Shale Grit "Turbidites"	11	ii	12-15
Brumhead, D.		A Note on the Mining and Working of Green Slate at Honister, Cumbria	11	ii	16
Wilson, C.		Radon – Geological Aspects of an Environmental Problem	11	ii	17-33
Rhodes, R.J.		A Temporary Exposure of Coal Measures (Westphalian A) at Windsor St. Oldham, Greater Manchester	11	ii	34-36
Jones, A., Hunt, N.C. et al		Research on an Outlet Glacier from Vatnajokull, Iceland	11	ii	37-47
Pounder, E.J.	1986	The River Terraces in Upper Swaledale, North Yorkshire	12	i	4-12
Miller, G.D.	1986	The Unveiling of a Sill: Waterswallows 1900-1985	12	i	13-24
Adams, A.E.	1986	Making Acetate Peels	12	i	25-27
Wignall, P.B.	1986	A Guide to the Geology of Turf Moor, Rossendale	12	i	28-29
Viator Geologicus	1986	Come to Santorini!	12	i	30-33
Dearden, P.N.	1986	Research on the Soils and Vegetation In the Svinafell Area, South-East Iceland	12	i	34-54
Anon	1986	In Memoriam Carole Wilson	12	i	55
Rowson, P.F.	1988	Notes on the Prince Edward Gold Mine, Merioneth	12	ii	7-12
Brumhead, D.	1988	Geological Tour of Israel 25 October-2 November 1986	12	ii	13-24
Wignall, P.B.	1988	Geological Guide to Marine and DeltaicSediments of the Silesian Deeply Vale, North Bury	12	ii	25-30
Miller, G.D.	1988	The Calton Hill S.S.I. – an Update	12	ii	31-39
Brumhead, D.	1988	Coal Mining Leases and Mine Abandonment Plans of New Mills, Derbyshire	12	ii	40-56

so providing a unique opportunity to obtain photographs of a feature not seen since it was closed in 1885 (Figures 2 and 3).

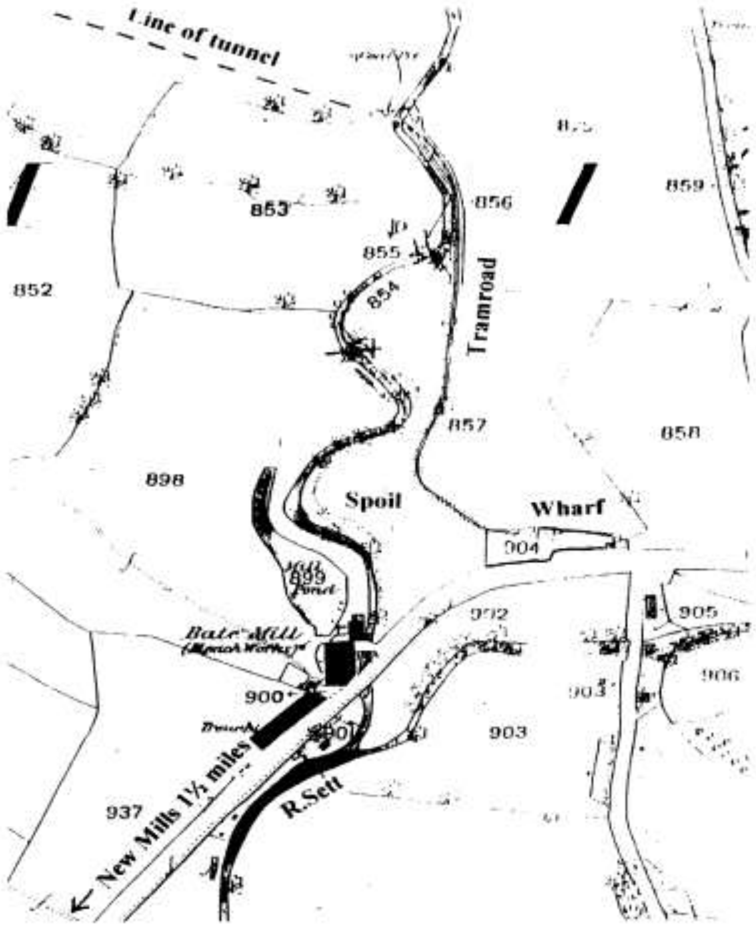

Figure 1. Tram road from Thornsett Hey tunnel to Bate Mill Road shown on OS inch map (reduced), first edition, surveyed 1879. Labels have been added.

Figure 2. First view of Thornsett Hey Tunnel when uncovered by the JCB.

Figure 3. View inside Thornsett Hey tunnel.

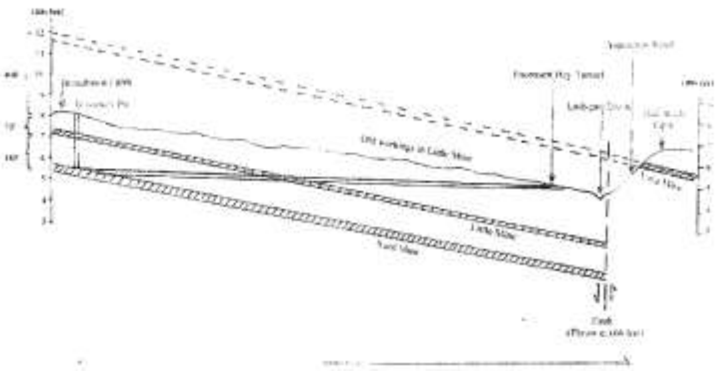

Figure 4. Geological section from west to east to show the disposition of the coal seams on either side of the great fault. Sources: Mine Abandonment Plans, numbers 1990 and 1991. Geological Survey of Great Britain, Sheet 99 (Chapel en le Frith).

Harris, P.G.	1971	The Nature and Importance of the Mantle	5	ii	38-47
Pollard, J.E.	1971	Book Review: Understanding the Earth by Gass et al	5	ii	48
Morvan, M.E.R.	1971	Book Review: The Earth by Evans	5	ii	48-49
Curzon, B.	1971	The Salt Museum, Northwich	5	ii	50-51
Le Morvan, M.E.R.	1972	The Geology of Antarctica IV: Graham Land and the Mc Murdo Volcanics	6	i	6-15
Jackson, J.W.	1972	Fluorspar Used for Beads in Ancient Egypt	6	i	16-17
Challinor, A.J.	1972	At the Foot of Constitution Hill, Aberystwyth – a Scene Illustrating Geology	6	i	18-25
Elsdon, R.	1972	The Geology of Greenland	6	i	26-33
Wilkinson, D.G.	1972	Notes on the Preparation and Mounting of Rocks in Thin Sections	6	i	34-37
Thompson, D.B.	1972	Book Review: The Elements of Palaeontology by Black	6	i	38-39
Le Morvan, M.E.R.	1973	The Geology of Antarctica V: The Break-up of Gondwanaland	6	ii	4-14
Harpum, J.	1973	Geological Mapping: Part 1 Philosophy	6	ii	15-28
Crimes, T.P.	1973	Trilobite Tracks in North Wales	6	ii	29-33
Brumhead, D.	1973	An Excursion Guide to the Ashover Area	6	ii	34-40
Levy, D.M.	1973	Book Review: The Dynamic Earth By White	6	ii	41-42
Pollard, J.E.	1973	Institute of Geological Science Publications	6	ii	43-44
Dewhurst, N.R.	1974	Towards a Better Understanding of Slopes	7	i	4-16
Johnson, R.H.& Musk, L.F.	1974	Some Observations on the Construction of Isopleth Maps when Reconstructing Rock-Head Surface And Buried Drainage Channels	7	i	17-30
Dunkerley, P.M.	1974	Some Thoughts on Being an Exploration Geologist	7	i	31-34
Connolly, R.W.	1974	The Fluorescence of Minerals	7	i	35-38
Muller, R.J.N.	1974	A Note on a Pennine Landslip	7	i	39-43
Peacock, W.	1974	Where My Caravan has Rested	7	i	43-47
Levy, D.M.	1974	Exhibition Review: The Story of the Earth	7	i	47-48
Pollard, J.E.	1974	Face of the Earth – Sunday Times and The Geological Museum	7	i	49
Broadhurst, F.M.	1976	Geological Visit to Lyme Park	7	ii	4-10
Peacock, W.	1976	Where My Caravan has Rested - 2	7	ii	11-14
Reading, H.G.	1976	Varnishes	7	ii	15-25
Wilkinson, D.G.	1976	The Pleistocene Geology of Prestwich	7	ii	26-28
Jackson, J.J.	1976	A Field Excursion in the Patterdale Area of Cumbria	7	ii	29-36
Jackson, J.W.	1976	Obituary – Edward William James Moore	7	ii	37-40
Wilkinson, D.G.	1976	Book Review: Geological Laboratory Techniques by Allman	7	ii	41
Preece, R.	1976	Book Review: A Building Stones Guide To Central Manchester by Simpson & Broadhurst	7	ii	42
Warrington, G.		The Alderley Edge Mining District	8	i	4-13

There is some interesting geology associated with this coal mine which worked the Yard Mine and the Little Mine, both of which dip towards the east at about 1 in 7. As the section shows (Figure 4), the Yard Mine outcrops just above Aspenshaw Road, and in fact was mined by adits in the 1920s. The Yard seam here is at an altitude of about 600 feet, yet about 800 yards to the west under Broome's Pit, it was found at 258 feet below the surface. The intervening fault is calculated to have a throw of about 666 feet.

The old workings in the Little Mine, shown on Figure 4 pre-date the construction of the tunnel. They are not recorded on any plan but there is field evidence which indicates the working of coal below the surface. I walked with the farmer across this field and beneath our feet was a rectilinear pattern of lines of subsidence. These were the stalls (tunnels) of the ancient pillar and stall workings which were now beginning to show at the surface. Nearby, a pit, which probably worked the Little Mine, was discovered at the same time as the Thornsett Hey tunnel - a hole had appeared in the ground. This pit was also filled in and secured by the contractors.

Despite the fact that only thin coal seams have been removed, after more than a hundred years, subsidence is beginning to appear at the surface above shallow coal workings in the New Mills area. Recently, several farmers have had fields affected, the golf club has a troublesome pool of water on one of its fairways, and a 200 ft deep unrecorded air shaft was found fortuitously as an extension to a school car park was being made. In the latter case, there was no mine abandonment plan but a 'hairy caterpillar' on the Ordnance Survey 25 inch marked a spoil heap, which, with the aid of a JCB, proved to mark the adjacent shaft.

INDEX OF AMATEUR GEOLOGIST BY VOLUME 1966-1990

Author	Year	Title	Vol.	Part	Pages
Isherwood, K.H.C.	1966	Field Trip to the Welsh Borderlands	1	i	5-8
Pitcher, W.S.	1966	The Rocks of Merseyside	1	i	9-13
Stubbs, A.	1966	Wren's Nest National Nature Reserve, Dudley	1	i	14-19
Simpson, I.M.	1966	Temporary Exposures at Oversleyford Brickworks, Ringway, Cheshire	1	i	22-25
Howie, R.A.	1966	Notes on Some Mineral Localities Within Reach of Manchester	1	ii	6-14
Stone, I.R.	1966	A Note on Cross-Strata of the Upper Bunter Sandstone of North -Eastern Cheshire	1	ii	15-22
Bellhouse, M.A.	1966	Welsh Gold Mines	1	ii	23-33
Powell, D.	1966	Coal Measure Fossils at Agecroft	1	ii	34
White, W.H.	1966	Tour of Malham Dale	1	ii	35-37
Miller, J. & Grayson, R.F.	1967	The Geology of the Clitheroe Area	2	i	7-12
Williams, M.	1967	A Temporary Exposure of Silurian Rock at Yew Tree, Walsall, Staffordshire	2	i	13-14
Hackett, F.	1967	Museums and the Amateur Geologist	2	i	15-17
Guion, P. & Borrowdale, G.	1967	A Field Meeting at Charnwood Forest	2	i	18-23
Cooke, N.	1967	Minera to World's End	2	i	25-30
Anon	1967	What's on in the Local Geological Societies	2	i	31-33
Johnson, R.H.	1967	The Former Course of the River Goyt	2	ii	38-50
Bellhouse, M.A.	1967	Glacial Erratics of the Combs Area of Derbyshire	2	ii	51-54
Miller, J. & Grayson, R.F.	1967	Geology Around Clitheroe	2	ii	55-60
Walkden, G.	1967	Palaeontology 1984	2	ii	61-68
Anon	1967	What's on in the Local Geological Societies	2	ii	69-72
Challinor, J.	1968	The Rheidol Gorge	3	i	6-11
Newall, G.	1968	The Aymestry Limestone	3	i	12-16
Pollard, J.E.	1968	Book Review: Lakeland Geology	3	i	17
Wild, I.M.	1968	Book Review: Wren's Nest Nature Reserve	3	i	18
Challinor, J.	1968	A Note on Outdoor Geological Photography	3	i	19-20
Cullen, D.A.	1968	The Great Whin Sill	3	i	21-26
Brenchley, P.	1968	An Investigation into the Glacial Deposits at Thurstaston, Wirral	3	i	27-40
Jackson, J.W.	1969	Owen Thomas Jones 1878-1967	3	ii	6-9
Miller, J.	1969	Geology Around Clitheroe 3 Palaeontological Aspects: Trilobites	3	ii	10-18
Walkden, G. & Oppe, E.	1969	In the Footsteps of Dinosaurs	3	ii	19-35
MacKenzie, W.S.	1969	Some Optical Techniques for Identifying Minerals	3	ii	36-40
Pollard, J.E.	1969	A Day Excursion to the Shap District, Westmorland	3	ii	41-46
Wild, I.	1969	Book Review: The Amateur Geologist by Cattermole	3	ii	47-48
Wild, I.	1969	Book Review: The Science of Geology in Colour by Robson	3	ii	48
Thompson, D.B.	1969	Book Review: Geological Excursions in The Sheffield Region by Neeves & Downie	3	ii	48-50
Anon	1969	What's on in the Local Geological Societies		ii	50-51

Author	Year	Title	Vol.	Part	Pages
Diggens, J.N.	1969	A Car Journey Through Ordovician Rocks in N. Wales	4	i	6-12
Tresise, G.R.	1969	The Case of the Elusive Chirotherium	4	i	13-18
Anon	1969	Liverpool Geological Society Field Meetings	4	i	18-19
Richards, J.	1969	The Geology of the Area to the North West of Torver, near Coniston, Lancs.	4	i	20-26
Brumhead, D. & Edwards, D.	1969	A Polarising Attachment for a Slide Projector	4	i	27-29
Thompson, D.B.	1969	Book Review: Geology of the Country Around Macclesfield, Congleton, Crewe & Middlewich	4	i	30
Watson, B.A.	1969	Book Review: Practical Geology for Schools By Greensmith	4	i	31
Platt-Chance, D.	1969	Book Review: Introducing Geology, Part 1 Fossils & Part 2 British Stratigraphy by Middlemiss	4	i	32
Anon	1969	Moon Rock at Liverpool	4	i	34-35
Anon	1969	What's on in the Local Geological Societies	4	i	36-38
Derby, G.	1969	An Unconformity at Hillend Farm, Shropshire	4	i	39-40
Williamson, I.	1969	Geological Itinerary for White Coppice and Anglezarke	4	i	41-46
Le Morvan, M.E.R.	1970	The Geology of Antarctica I: Introduction	4	ii	7-18
Zussman, J.	1970	Rocks from the Moon	4	ii	19-24
Thompson, R.N.	1970	The Geology and Volcanic Activity of Mount Etna, Sicily	4	ii	25-35
Broadhurst, F.M. & Simpson, I.M.	1970	Geology in Treak Cliff Cavern, Derbyshire	4	ii	36-40
Pollard, J.E.	1970	Book Review: Lead Mining in the Lake	4	ii	41
Pollard, J.E.	1970	Book Review: New Editions of British Regional Geology Handbooks	4	ii	41-42
Dunham, A.C.	1970	Book Review: Geologists' Association Guides To the Scottish Volcanic Districts	4	ii	42-43
Grayson, R.F.	1970	Notes and News Items	4	ii	44-46
Anon	1970	What's on in the Local Geological Societies	4	ii	47-50
Crossley, J.D.	1971	Geology of Cleveland, North Yorkshire A Weekend Field Excursion	5	i	6-16
Challinor, J.	1971	A Note on the Interpretation of Certain Geological Boundaries: Unconformity or Fault	5	i	16-18
Sloan, K.J.	1971	G.H. Morton - The Ultimate Amateur - A Short Biographical Study of the Founder of the Liverpool Geological Society	5	i	18-22
Rimmer, H.E. & Rimmer, L.	1971	A Field Trip to Corndon Hill, May 1970	5	i	22-27
Ward, R.C.	1971	Book Review: Principles of Hydrology	5	i	28
Cullen, D.A.	1971	Liverpool Museum and the Amateur Geologist	5	i	29-31
Le Morvan, M.E.R.	1971	Geology of Antarctica II: The Precambrian Basement and Ross Geosyncline	5	i	32-42
Le Morvan, M.E.R.	1971	The Geology of Antarctica, III: The Gondwana Sequence	5	ii	6-17
Johnson, R.H.	1971	The Last Glaciation in North-West England; A General Survey	5	ii	18-37